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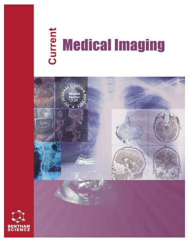

RESEARCH ARTICLE

Age and Gender-related Morphometric Assessment and Degenerative Changes of Temporomandibular Joint in Symptomatic Subjects and Controls using Cone Beam Computed Tomography (CBCT): A Comparative Analysis

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Abstract:

Background:

The temporomandibular joint diseases have been associated with various predisposing factors. Joint spaces, articular eminence height and inclination, and the shapes of the condylar and glenoid fossa have all been shown to vary in temporomandibular joint diseases (TMD) patients. Advanced imaging techniques like cone beam computed tomography (CBCT) have been employed to estimate these parameters.

Aims and Objectives:

The aim of the current study was to investigate the condylar morphology, condylar and glenoid fossa shapes, and assessment of joint spaces, such as anterior, posterior, superior, lateral, and medial spaces, through CBCT slices in coronal and sagittal planes and compare them between the control group and TMD group.

Materials and Methods:

A cross-sectional study was planned where 80 joints in 40 patients were assessed for the above parameters; group I consisted of healthy patients, and group II included those with temporomandibular joint diseases (TMDs). The articular eminence height and inclination were assessed on the midsagittal section. The condylar changes and shapes of the glenoid fossa and condyles, as well as the joint spaces, were assessed on the selected coronal and sagittal sections.

Results:

The condylar fossa had a triangular shape in the TMJ group and an oval shape in the control group. The results were highly significant (P = 0.000**). A highly significant difference in morphological parameters, such as AJS, PJS, SJS, MJS, LJS, articular eminence height, and inclination, was found between the two groups (P = 0.000**). The association of morphological parameters, such as AJS, PJS, SJS, MJS, LJS, and articular eminence height and inclination were compared with condylar and glenoid fossa shapes, where the association of superior joint space and articular eminence inclination was observed. A highly significant difference was noted between the two groups with regard to all the parameters with P=0.00*.

Conclusion:

The articular eminence inclination, as well as the superior joint space, were found to be associated with the glenoid and condyle fossa shapes in the TMJ group. These observations would, therefore, help in the early diagnosis of temporomandibular joint diseases.

Keywords: Temporomandibular joint diseases (TMD), Cone beam computed tomography (CBCT), Condylar fossa, Glenoid fossa, Saggital plane, Articular eminence.

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1. INTRODUCTION

The TMJs (temporomandibular joints) refer to highly dynamic and complicated joints and are one of the most important components of the masticatory system. They are very vigorous body joints, undergoing around 2200 motions per twenty-four hours as a result of chewing, grinding, swallowing, communicating, and snoring [1]. The morphologic assessment of TMJ has considerable usage in the arena of TMJ disease control, according to Dupuy-Bonafe *et al*. [2]. The morphological changes of the TMJ have been influenced by functional and mechanical demands and additional factors, such as age, gender, pathological process, and bite forces. As a result, precise estimation of TMJ morphologic variables would aid in understanding the internal structures and their functions [3]. The articular eminence and glenoid fossa are integral parts of the TMJ. The height and inclination of the articular eminence, as well as the shapes of the condyle and glenoid fossa, have been correlated with TMJ disorders and internal derangements [4]. The morphology of the mandibular condyle and articular eminence height and inclination were initially assessed using conventional X-rays, whereas a lateral cephalogram was used to establish the eligibility sign for requesting an effective radial tomogram of the TMJ and to examine the vital connection along with the structure of joints as well as craniofacial morphology and condylar position [5]. The use of computed tomography (CT) scans for the morphologic identification of TMJ became commonplace after that. In recent years, cone beam computed tomography (CBCT), micro-CT, panoramic radiography (PR), and magnetic resonance imaging (MRI) have all been employed to study the TMJ morphology [6]. Previously, the 2D technique was used to examine the changes in the TMJ. Due to the lack of sensitivity and overlap of neighboring structures, it was considered inaccurate. With the advancement of 3D technology, cone beam computed tomography has been used as it has less radiation exposure, high-resolution imaging, and more reliability [7]. CBCT was used to assess the face morphologic features of females with skeletal CLASS II deformity, as well as the relationship of the thickness of the posterior aspect fossa with condyle shape [5]. Because of condylar remodelling, the morphology of the condyle varies between individuals. The height and inclination of the articular eminence vary between individuals and influence condylar movements and the degree of rotation of the articular disc over the condyle [8].

Furthermore, extensive research has been conducted to assess TMJ morphology and articular disc position by evaluating various joint spaces, such as MJS (medial joint space), LJS (lateral joint space), SJS (superior joint space), AJS (anterior joint space), and PJS (posterior joint space). The researchers have tried numerous methods to assess the morphological variations in the temperomandibular joint. However, there is no conclusive evidence regarding the association of TMJ morphology and the pathogenesis of temporomandibular joints [9, 10]. Moreover, the TMD's associated degenerative bone changes, such as erosions, changes in the bony surfaces of joints, and projections such as osteophytes, also have been taken as predictive factors for assessment of TMJ morphology, which influence the occurrence of degenerative changes [11]. Age and gender have also been important factors in assessing the morphological changes in TMJ due to their inherent diversity. Therefore, in the current study, we aimed to evaluate the articular eminence height and inclination, the condylar bone changes, the assessment of condylar and glenoid fossa shapes, and the assessment of joint spaces using CBCT between the controls (Asymptomatic individuals and TMDs).

2. MATERIALS AND METHODS

The current study design was a descriptive cross-sectional study undertaken to assess the condylar morphology. It was conducted on subjects recruited from the outpatient departments of DRS Sudha and Nageswararao Siddhartha Institute of Dental Sciences, Gannavaram, India. Ethical clearance was obtained from the institutional ethical committee. The subjects' informed consent was obtained by asking them if they would be willing to participate in the study. The study sample was 20 in each group, which comprised normal healthy individuals (the control group), which was taken as Group I, and those subjects having clinical signs and symptoms of clicking sounds, pain, tenderness, hypermobility and hypomobility of the TMJ, trismus, and subluxation were included according to the taxonomic classification for TMJ disorders and the American Academy of Orofacial Pain [12]. A detailed case history of all the included subjects was taken and recorded. A total of 80 joints in 40 subjects were assessed, including both right and left sides in each subject. Both genders (65% female and 35% male) were drawn from the age groups of 18-27, 28-37, and 38-47 who were South Asians. Those having any craniofacial abnormalities, facial asymmetry, history of orthognathic surgeries, anomalies, such as condylar hyperplasia or hypoplasia, as well as patients affected by systemic diseases such as S'Jogren's syndrome, rheumatoid arthritis, *etc*., or any tumours that may alter the condylar morphology as well as the joint spaces, were all excluded. Pregnant women were also excluded. Furthermore, the dentition of the subjects was clinically examined and classified using the Eichner index, where Class A included four support zones in both the molar and premolar zones, Class B had one to three support zones in either the premolar or molar region, or support in the frontal region. The molars and premolars define the classification, and it is called supporting if there is at least one contact in either of the regions [13]. The above parameters were evaluated using the Carestream Italy CBCT machine with dental imaging CS Software version 8.0.5. Model 9600 with a maximum output of 5 mAs and an exposure time of 12 seconds, KVP 120 with a voxel resolution of 0.7 mm cu-0.15 mm cu and an exposure time of 11 seconds. Standard exposure and patient positioning protocols were followed. The mouth was opened while taking images. Two scout images were taken in the sagittal and coronal views. The subjects were made to stand in the gantry so that the head was placed in the horizontal direction, and the Frankfurt horizontal plane was perpendicular to the table, which was considered accurate positioning. The acquired slices were chosen for assessment of the morphology

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of the TMJ with the mentioned parameters using slice thickness, which was approximately 0.4 mm. Later, the reformatting was done using DICOM software. The interpretations of the CBCT images were done by two radiologists who were experienced, so accuracy in the interpretation was maintained.

2.1. Assessment of Parameters

Metric evaluation of the chosen parameters was based on previous studies done by Choudhary *et al*. [14]. Medial joint space (MJS): The length between the condyles' most medial point and the articular fossa was considered to be the MJS (Fig. **1**). Superior joint space (SJS): The superiormost line of the condyle and the length of the articular fossa were considered to be SJS (Fig. **1**). Lateral joint space (LJS): The distance between the most distal point of the condyle and the articular fossa was designated as LJS (Fig. **1**). Posterior joint space (PJS): The distance parallel to the FH plane between the posterior points of the condyle and the articular eminence outline was assessed as PJS (Fig. **1**). Anterior joint space (AAJS): The distance parallel to the FH plane between the anterior points of the condyle and the articular fossa outline was identified as AJS (Fig. **1**).

The articular eminence inclination and height were assessed on the mid-parasagittal section, which was taken for measurement in each patient. On the chosen section, two points were marked: the superior most point on the porion (**P**) and the inferior most point on the articular eminence (**E**). A straight line joining these two points was drawn using the marking toolbar. Later, the highest point of the articular fossa (**R**) was marked, and another line intersecting the other line joining the point **(R)** to the inferior most point of the articular eminence (**E**) was marked. The angle at this intersection was depicted as articular eminence inclination and was measured using the angle toolbar of the software (Fig. **2**).

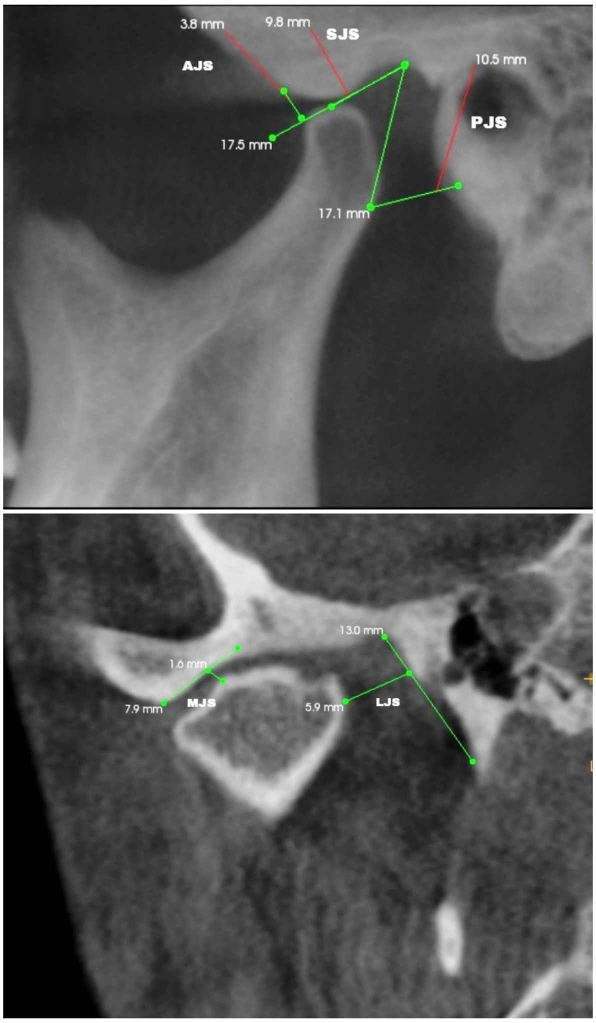

Fig. (1). Measurement of AJS, SJS, PJS, LJS, and MJS in the coronal plane of CBCT images.

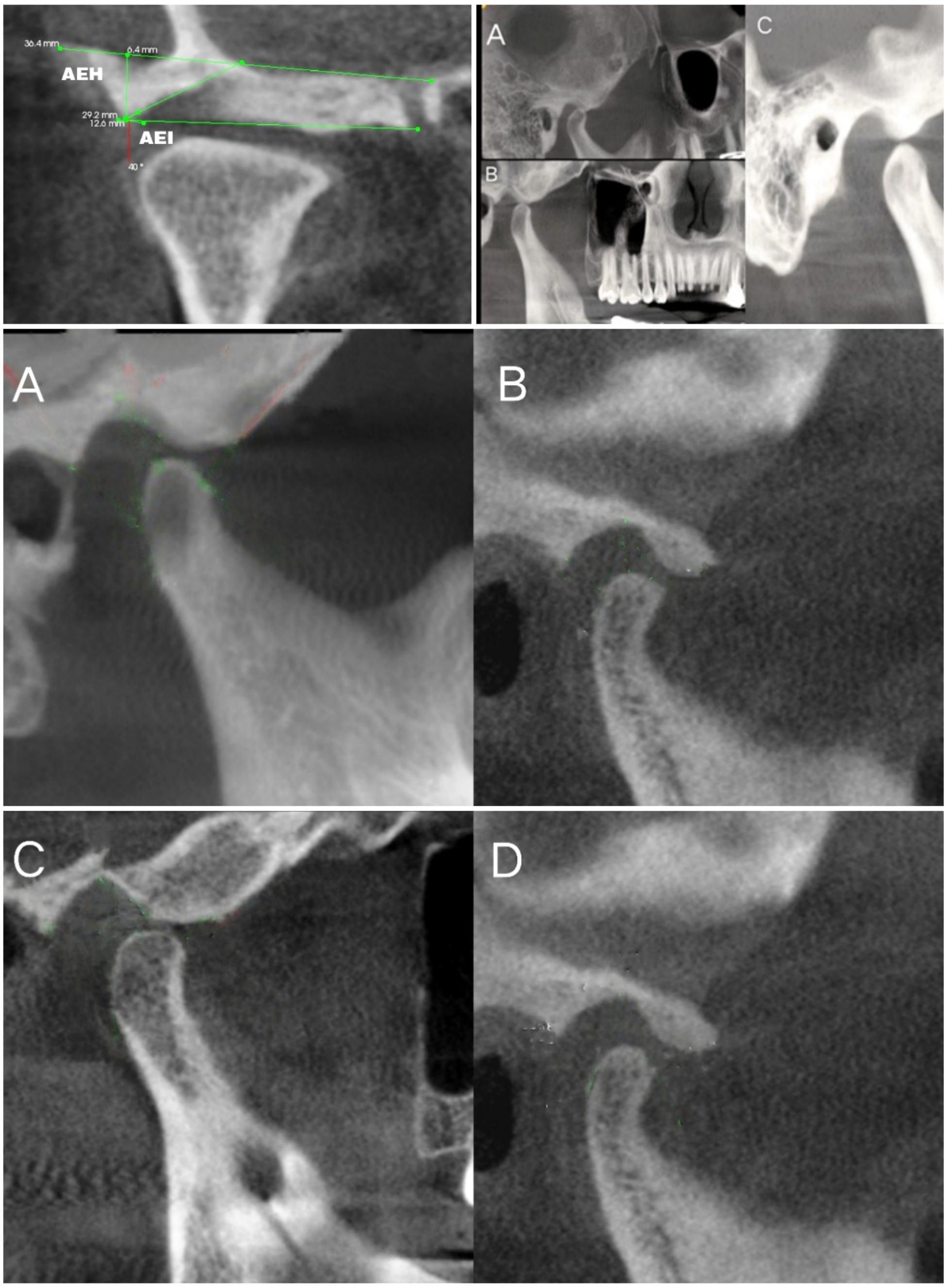

Fig. (2). Assessment of articular eminence height and inclination in the sagittal view of CBCT, as well as view of condylar changes in the coronal plane, classified as 1. (**A**). Osteophyte (**B**). Erosion (**C**). Normal and different glenoid fossa shapes, which are further classified as (**A**). Triangular; (**B**). flattened; (**C**). oval; (**D**). round.

2.1.1. Height of Articular Eminence

The articular eminence height was assessed by measuring the perpendicular distance between the lowest point of the articular eminence and the highest point of the fossa (Fig. **2**).

2.1.2. Condylar Changes

The condylar bone changes were classified as normal, erosion, and osteophyte formation. They were visualised and predicted in the coronal plane (Fig. **2**).

2.1.3. Shape of Condyle and Glenoid Fossa

The condylar shapes of TMJ were assessed as triangular, oval, flattened, and round for the condyles in a coronal plane of a CBCT slice, and triangular, trapezoidal, oval, and round shapes for assessing the shape of the glenoid fossa in the saggital plane. The central coronal slice was taken to determine the condylar shape, and the central saggital plane was assessed for the glenoid fossa shape (Figs. **2** and **3**).

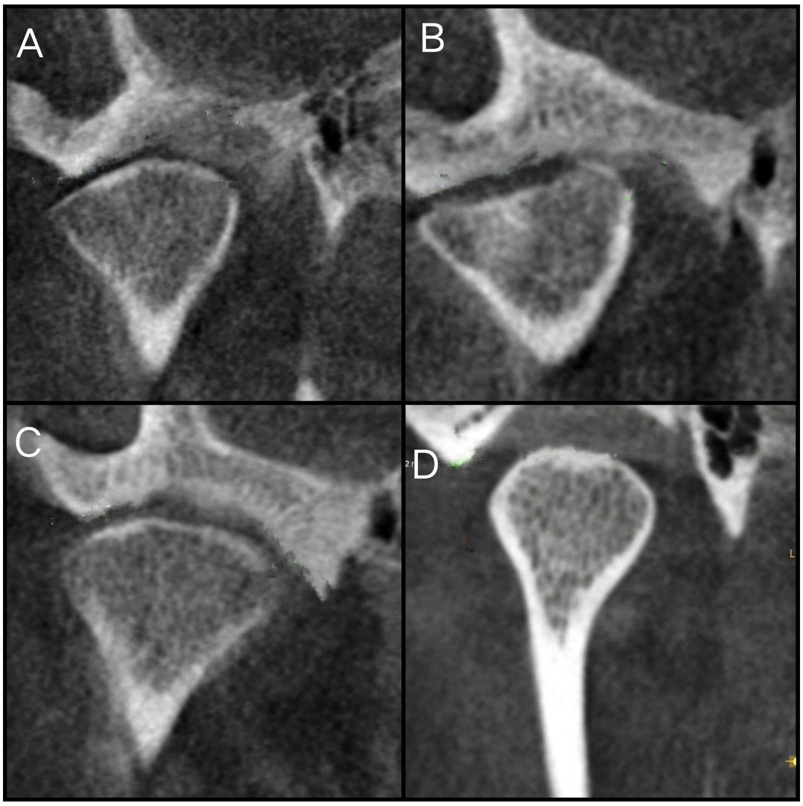

Fig. (3). Various shapes of the condyle in the coronal view of CBCT. (**A**). Round (**B**). Trapezoidal (**C**). Triangular (**D**). Oval.

2.2. Statistical Analysis

All the statistical analysis was done using MS Excel 2007 and SPSS version 221. Quantitative variables were expressed as frequencies and percentages. The quantitative variables were expressed as means and standard deviations. The chi-square test was used for examining the qualitative data. For the comparison of two means, a student-independent sample “t” test was used. NOVA was used for more than two group comparisons. P< 0.05 was considered statistically significant in all statistical analyses (Supplementary tables).

3. RESULTS

Assessment of the front, back, top, middle, and side joint spaces, as well as the height and angle of the articular eminence, in both groups: When the morphological parameters AJS, PJS, SJS, MJS, LJS, articular eminence height, and inclination were compared between the TMJ and control groups, each showed a highly significant difference with a P value of 0.000**. The observations can be appreciated in Table **1**, (Figs. **1** and **2**).

3.1. Assessment of Condyle and Glenoid Fossa Shapes and Condylar Changes in TMJ and Control Groups

The condylar and glenoid fossa shapes were assessed in the TMJ and control groups, where significant differences could be noted. The triangular shape was most noticeable in the TMJ group, while the oval shape was most noticeable in the control group. P = 0.000** was a very high P value. Similarly, the glenoid fossa shape was oval in both groups, where the p-value was highly significant (p > 0.005). Likewise, erosive changes could be noticed in the mandibular condyle. The findings have been illustrated in Table **2** and Figs. (**2** and **3**).

Comparing each joint space, the height and tilt of the articular eminence, and the shape of the mandibular condyle in the TMJ and control groups: The association of morphological parameters,such as AJS, PJS, SJS, MJS, LJS, articular eminence height, and inclination were compared with condylar shapes, although no significant difference could be noted between the two groups with a p>0.05. The details are given in Table **3a**.

Comparing each joint space, the height and tilt of the articular eminence, and the shape of the glenoid fossa in the TMJ group and the control group: The present table depicts the association of glenoid fossa shapes with the morphological parameters of TMJ; however, no significant difference was noted between the two groups except for articular eminence inclination, and the P value was p 0.05. All the observations can be seen in Table **3b**.

Comparing all joint spaces, the height and angle of the articular eminence, and the changes in the condyles in the TMJ and the control group: Considering whether there was any association of condylar changes with the joint spaces, we found no significant difference except for the superior joint space (SJS) in the TMJ group, and the p value was (p<0.01). The findings can be seen in Table **3c**.

Based on the Eichner classification, the majority of individuals had Eichner class A in the TMJ group. In the current study, those with an age range of 38–47 had more TMJ problems (Fig. **4A**, **B**).

Table 1. Distributions of the condylar shape, fossa shapes, and condylar changes in the temporomandibular joint disorder and control group.

Morphological Variations	Shapes	Total(n)	TMJ (%)	P-value
Condylar shapes	Flattened	5	5(12.5)	**0.000****
	Oval	30	4(10)	
	Round	21	11(27.5)	
	Triangular	24	20(50)	
Glenoid Fossa shapes	Oval	35	12(30)	**0.002****
	Round	22	9(22.5)	
	Trapezoid	11	10(25)	
	Triangular	12	9(22.5)	
Condylar changes	Erosion	12	12(30)	-
	Normal	22	22(55)	
	Osteophyte	6	6(15)	

Table 2. Mean and standard deviations of the Morphological parameters between TMJ and control group.

Morphological Parameters	Group	N	Mean	Std. Deviation	t-value	P-value
AJS	TMJ	40	4.938	2.1479	5.963	**0.000****
	Controls	40	2.830	.6186		
PJS	TMJ	40	7.525	2.1213	7.120	**0.000****
	Controls	40	5.063	.5338		
SJS	TMJ	40	6.088	2.3743	8.041	**0.000****
	Controls	40	3.015	.4504		
MJS	TMJ	40	2.558	1.0444	9.623	**0.000****
	Controls	40	4.245	.3734		
LJS	TMJ	40	4.635	1.6557	6.584	**0.000****
	Controls	40	2.880	.3180		
AEH	TMJ	40	6.495	1.3804	8.487	**0.000****
	Controls	40	8.605	.7528		
AEI	TMJ	40	32.20	7.353	7.304	**0.000****
	Controls	40	22.83	3.441		

Table 3a. Comparison of Morphological parameters according to the condylar shapes in TMJ and controls.

-	TMJ					Controls			
Morphological Parameters	**Condylar Shape**	**N**	**Mean**	**Std. Deviation**	**P-value**	**N**	**Mean**	**Std. Deviation**	**P-value**
AJS	Triangular	20	5.075	2.0463	0.323	4	2.500	.7789	0.376
	Round	11	5.136	2.5244		10	3.010	.4606	
	Oval	4	5.725	1.7251		26	2.812	.6458	
	Flattened	5	3.320	1.6843		-	-	-	-
PJS	Triangular	20	7.775	2.1880	0.779	4	5.100	.7528	0.987
	Round	11	7.109	2.0032		10	5.070	.5334	
	Oval	4	6.950	2.0404		26	5.054	.5232	
	Flattened	5	7.900	2.5855		-	-	-	-
SJS	Triangular	20	6.005	2.3467	0.924	4	2.900	.2944	0.618
	Round	11	5.845	2.6051		10	3.130	.4739	
	Oval	4	6.600	1.8403		26	2.988	.4659	
	Flattened	5	6.540	2.9305		-	-	-	-
MJS	Triangular	20	2.620	1.2033	0.806	4	4.500	.5944	0.109
	Round	11	2.691	1.0473		10	4.370	.4191	
	Oval	4	2.325	.2062		26	4.158	.2955	
	Flattened	5	2.200	.8367		-	-	-	-

(Table 3a) contd.....

-	TMJ					Controls			
Morphological Parameters	**Condylar Shape**	**N**	**Mean**	**Std. Deviation**	**P-value**	**N**	**Mean**	**Std. Deviation**	**P-value**
LJS	Triangular	20	4.695	1.3740	0.974	4	2.700	.3559	0.451
	Round	11	4.700	1.1454		10	2.940	.2066	
	Oval	4	4.550	2.9275		26	2.885	.3472	
	Flattened	5	4.320	2.8093		-	-	-	-
AEH	Triangular	20	6.600	1.4272	0.841	4	8.925	.7890	0.653
	Round	11	6.473	1.5730		10	8.510	.9085	
	Oval	4	6.675	1.4454		26	8.592	.7014	
	Flattened	5	5.980	.8556		-	-	-	-
AEI	Triangular	20	32.25	6.980	0.212	-	4	22.50	0.769
	Round	11	30.00	8.729		-	10	22.20	
	Oval	4	30.50	6.807		-	26	23.12	
	Flattened	5	38.20	3.033		-	-	-	-

Table 3b. Comparison of the morphological parameters according to the Glenoid fossa shapes and condylar changes in TMJ and controls.

-	TMJ					Controls			
Morphological Parameters	**Glenoid Fossa Shapes**	**N**	**Mean**	**Std. Deviation**	**P-value**	**N**	**Mean**	**Std. Deviation**	**P-value**
AJS	Triangular	9	3.822	2.2264	0.295	3	2.9	0.7211	0.547
	Trapezoid	10	5.470	2.1919		1	3.500	-	
	Round	9	5.544	2.5851		13	2.938	.5810	
	Oval	12	4.875	1.5428		23	2.730	.6392	
PJS	Triangular	9	7.000	2.2995	0.589	3	4.733	.1155	0.281
	Trapezoid	10	7.740	1.8928		1	5.800	-	
	Round	9	7.044	2.7203		13	5.177	.4206	
	Oval	12	8.100	1.7257		23	5.009	.5977	
SJS	Triangular	9	5.544	2.4403	0.502	3	3.133	.5508	0.263
	Trapezoid	10	6.660	2.4222		1	3.700	-	
	Round	9	5.344	3.1592		13	2.869	.4309	
	Oval	12	6.575	1.5322		23	3.052	.4399	
MJS	Triangular	9	2.967	1.5248	0.519	3	4.000	.3606	0.197
	Trapezoid	10	2.490	1.0322		1	3.700	-	
	Round	9	2.222	.7190		13	4.200	.2646	
	Oval	12	2.558	.8339		23	4.326	.4092	
LJS	Triangular	9	4.778	1.2911	0.623	3	2.800	.4000	0.725
	Trapezoid	10	5.050	1.8265		1	3.200	-	
	Round	9	4.044	2.2667		13	2.908	.2691	
	Oval	12	4.625	1.2578		23	2.861	.3448	
AEH	Triangular	9	6.744	.9112	0.551	3	8.033	.7506	0.151
	Trapezoid	10	6.400	1.3157		1	10.000	-	
	Round	9	5.967	1.2298		13	8.669	.8350	
	Oval	12	6.783	1.8050		23	8.583	.6610	
AEI	Triangular	9	38.00	4.555	0.045	3	22.33	6.658	0.481
	Trapezoid	10	29.60	8.086		1	28.00	-	
	Round	9	30.00	8.352		13	22.38	2.063	
	Oval	12	31.67	5.867		23	22.91	3.642	

Table 3c. Comparison of the morphological parameters according to condylar changes in TMJ and controls.

-	TMJ				
Morphological Parameters	**Condylar Changes**	**N**	**Mean**	**Std. Deviation**	**P-value**
AJS	Osteophyte	6	6.350	3.0468	0.118
	Normal	22	4.391	1.1775	
	Erosion	12	5.233	2.7766	
PJS	Osteophyte	6	7.033	1.8272	0.204
	Normal	22	8.064	2.1901	
	Erosion	12	6.783	1.9917	
SJS	Osteophyte	6	5.067	3.2420	0.002**
	Normal	22	7.195	1.8373	
	Erosion	12	4.567	1.7941	
MJS	Osteophyte	6	2.167	.8959	0.318
	Normal	22	2.473	1.0402	
	Erosion	12	2.908	1.0975	
LJS	Osteophyte	6	5.067	1.2404	0.058
	Normal	22	5.032	1.7638	
	Erosion	12	3.692	1.3014	
AEH	Osteophyte	6	5.850	1.1274	0.357
	Normal	22	6.741	1.4644	
	Erosion	12	6.367	1.3110	
AEI	Osteophyte	6	31.67	7.448	0.384
	Normal	22	31.00	7.771	
	Erosion	12	34.67	6.443	

The pie diagram represents the number of individuals having TMJ problems based on gender, where 65% of females and 35% of males were diagnosed (Fig. **4C**). In the TMJ group, both males and females had triangular-shaped condyles, whereas the oval shape of the glenoid fossa was observed in females and oval, round shapes in males. Likewise, no condylar changes could be observed in either gender (Fig. **4D**). Based on the Eichner classification, those belonging to Class A had a triangular shape of the condyle and an oval shape of the glenoid fossa, and the majority of cases belonging to Eichner Class A had no condylar changes (Fig. **4E**). Graph **2** shows the number of TMJ cases based on condylar and glenoid fossa shapes and morphological changes that correlate with age groups.

The morphological variations were observed in different age groups, where the triangular shape of the condyle and all types of fossa shapes could be seen, but no condylar changes were observed in the age group between 38 and 47 (Fig. **5**).

4. DISCUSSION

CBCT imaging is a potent tool that provides multiplanar images of the condyle and surrounding structures. It is constructed in such a way that the morphology, dynamics, and position of the TMJ can be visualised by projecting the real structures in the coronal, sagittal, lateral, and axial positions [15]. 2D and 3D designs have been employed previously to determine the TMJ morphology of symptomatic and asymptomatic patients. Various parameters have been assessed by researchers to diagnose TMJ disorders. Parameters, such as articular eminence height (AEH) and inclination (AEI) have been included in evaluating TMJ diseases, especially for evaluating the disc displacements of TMJ [5]. The articular eminence is placed in front of the glenoid fossa, and its posterior surface slope bears the functional load, whereas the inclination plays a key role in condylar movements and the degree of rotation of the joint disc during mastication, and it varies among individuals [4]. The eminence changes depending on chewing and masticatory forces, which are usually concerned with functional loading [16]. The development of AEI is usually complete by the age of 20 years, and in older age, the osteoarthritic changes are visible and affect the TMJ morphology [17]. Conventional methods like panoramic radiographs, interocclusal and protrusive records, and lateral cephalometry were used to evaluate the AEI in TMJ. However, advanced techniques, such as CBCT with a large FOV are now preferred over conventional imaging [18].

The articular eminence inclination in TMJ groups was (32.20± 7.353) and (22.83 ± 3.441) in the control group.

Our results were in accordance with the findings of Julin Ma *et al*. [19] and Sulun *et al*. [20], where articular eminence inclination was greater in the TMJ group. Contrary to this, the AEI was increased in controls in a study done by Choudhary *et al*. [14] and Sumbullu *et al*. [16]. The steeper AI in TMJ and the fact that the articular disc has to rotate forward on the condylar disc relation during mandibular movements are the reasons attributed to our study. The steeper inclination of articular eminence peaks at 20–30 years, though it is considered normal. Emotional stress influences the endurance of muscles and the masticatory system [21].

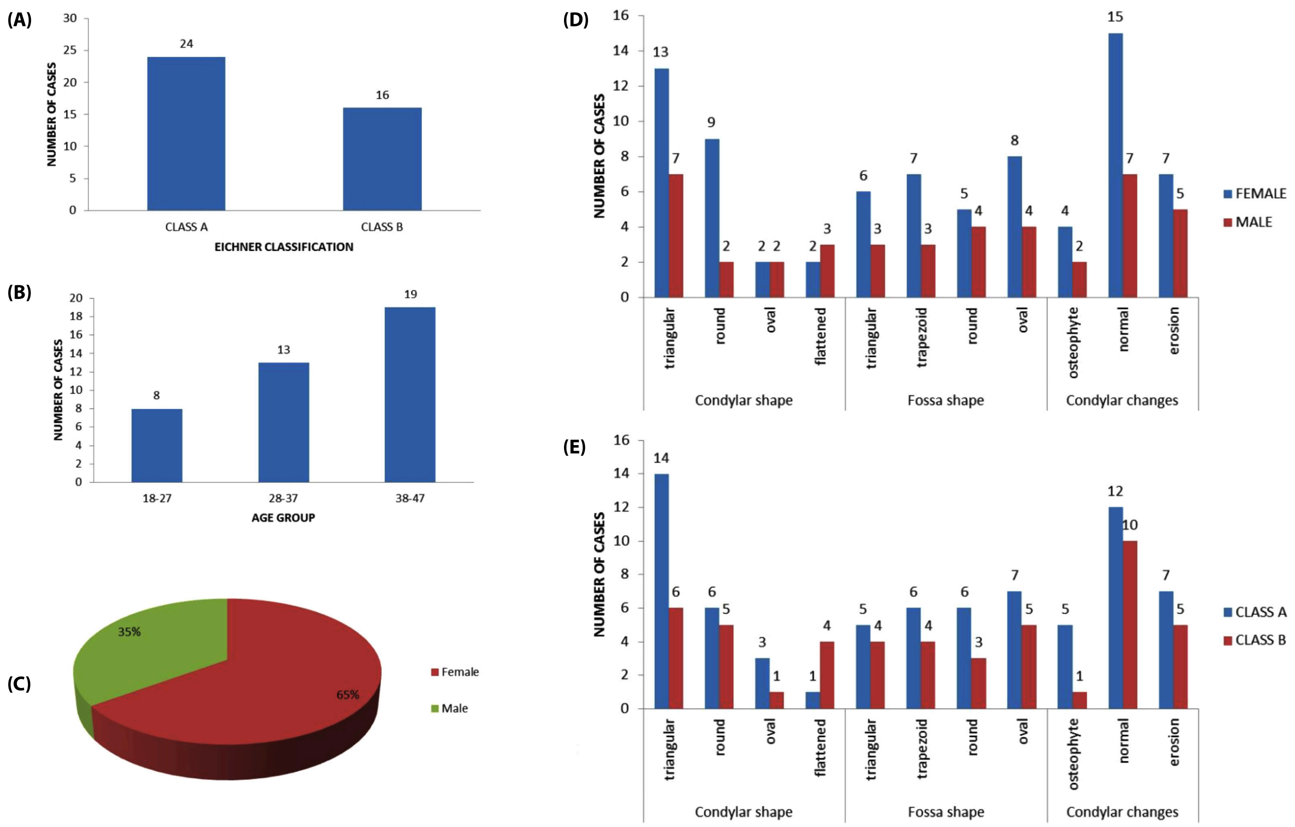

Fig. (4). (**A**). Distribution of a number of subjects according to Eichner classification. (**B**). The number of cases divided according to various age groups (**C**). The pie diagram represents the number of individuals having TMJ problems based on gender. (**D**): Graph representing the number of cases of TMJ correlating condyles, glenoid fossa shapes, and morphological changes with gender distribution. (**E:**) Graph representing the distribution of cases of TMJ correlating condyle, glenoid fossa shapes, and morphological changes with Eichner classification.

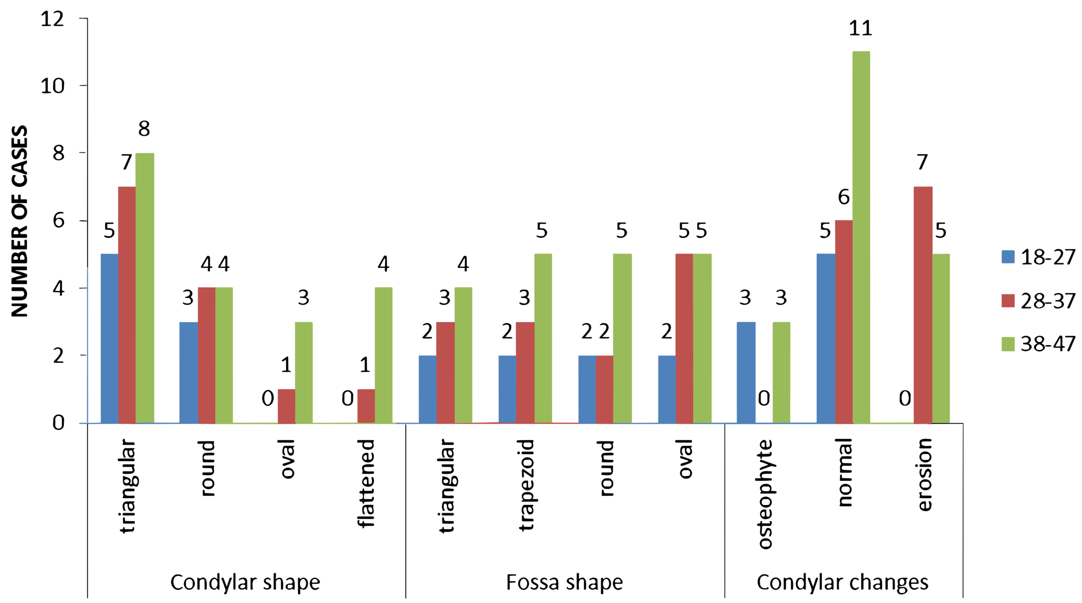

Fig. (5). Evaluation of shapes of the condyle, glenoid fossa, and bony changes pertaining to various age groups.

Moreover, due to a steeper AI, there is an increased anterior position in relation to the condyle, leading to anterior disc displacement [22]. No bilateral differences could be observed in our study with regards to inclination and height of articular eminence. Also, we could not appreciate any difference with reference to age or gender. The next parameter was determining the joint spaces. The joint space has been described as a radiolucent zone placed between the condylar and temporal parts. It helps in determining the optimal condylar position. The etiological factors for disc displacements and degenerative joint diseases could be determined by measuring the joint spaces, such as AJS, LJS, SJS, PJS, and MJS. In the current study, all the joint spaces were determined on the coronal CBCT slide. A significant increase in the medial joint space could be found in the control group. Although there were increased dimensions of AJS, PJS, SJS, and LJS in the TMJ group, correlating with the present findings in a study conducted by AI Rawi *et al*. [8], Kawamura and Ikeda *et al*. [23], there were decreased dimensions of AJS in the TMJ group, and the results were contrary to our findings. Moreover, in a study done by Dalili *et al*. [24], SJS was increased in people with normal TMJ. However, their findings were opposite to our research findings, and the same statement is in accordance with Ikeda *et al*. In another study done by Imanimoghaddam *et al*. [25], they evaluated different joint spaces in patients with TMJ disorders, where AJS was more prevalent in the TMJ group, which is in accordance with the findings of our present study. Usually, males have larger measurements of joint spaces than females, especially posterior, anterior, and superior, due to the thickness of soft tissues in the TMJ compartment or variations in the size of the temporal fossa and mandibular condyle owing to sexual dimorphism [7, 26].

Furthermore, the measurement of joint spaces decreases with increased age due to bony changes and degenerative changes of the mandibular condyle. Major *et al*. found an association between the differences in dimensions in the joint spaces and disc displacements [27]. Also, we compared all the parameters on both sides (right and left) of TMJ, where we could not observe any difference with regards to joint spaces except for AJS, which was increased in the control group. There was not much-supporting literature, according to our findings. Moreover, we could not find any difference in the measurement of joint spaces with regards to age and gender, probably due to the small sample size, so our findings could not be correlated with statements given by other researchers. The next point of discussion was determining the shapes of the condyle and glenoid fossa. The etiological factors may be due to parafunctional habits, genetic factors, mechanical loading, or an imbalanced occlusion. The pattern of forces would definitely hamper the TMJ morphology [25]. Due to stronger forces, the fossa becomes deeper, and the AEI is steeper. The triangular shape of the condyle was observed in the TMJ group (50%), round (27.5%), oval (10%), and flattened (12.5%) in the current study. However, an oval shape was more observed in the control group (65%). Our findings are in agreement with the study conducted by Choudhary *et al*. [14].

We observed a triangular shape of the condyle in females and a round shape in males. The convex shape of the condyle has been observed more in females due to less mechanical stress from occlusion and reduced muscle mass [28]. However, we could not observe any difference with regards to gender. In addition, we found a triangular shape of the condyle in people aged 38 to 47. There was no difference on either side, and both the left and right side condyles were triangular in shape. Those with Eichner class A also had triangular-shaped condyles. Mathew *et al*. [29] stated that there was no relationship between age and radiographic changes pertaining to condylar shapes. However, in the study done by Singh *et al*., the round shape of the condyle was observed in Eichner class A. The available literature search reveals no relationship between the status of dentition and variations in the shape of the condyle. The oval-shaped condyle was observed in a study done by Katsarvvias *et al*.

Similarly, round-shaped condyles were observed in a study done by Singh *et al*. and Oliverias Santos *et al*. [30]. The next parameter was determining the shape of the glenoid fossa, where we observed an oval shape in both groups. The same was observed in the 28-37, 38-47, and both gender age groups. Those with Eichner class A dentition status had an oval-shaped glenoid fossa. Our findings are consistent with those of Choudary *et al*. [14]. However, in another study

done by Caglayan *et al*. [11]. There was a significant difference between the shapes of the condyle and glenoid fossa in both the control group and the TMJ group. In our study, we could also see the shape difference between the triangular-shaped condyle and the oval-shaped glenoid fossa. The differences in shape are due to differences in the growth pattern of these structures, as the condyle and glenoid fossa interact in ways that are unique to each individual [31]. Similarly, we observed no bony changes in the condyle; no osteophyte formation could be seen. Although we could see erosive changes in age groups 28–37 when compared to other age groups. The erosive changes occur due to decreased density, resulting in the loss of the articular cortex. The formation of osteoporosis is usually caused by loading occlusal forces, and it is more common in older people. The cause of degenerative changes is that, because of the continuous remodelling of joint structures, there is a phase of repair and a destructive process in the cartilage and bone, due to which there is stress on the TMJ [3].

Furthermore, flattening and erosion of the condyle appear to be the result of avascular necrosis caused by mechanical overload to the joints [32]. Degenerative changes, such as osteophytes, subcortical sclerosis, surface erosion, and articular surface flattening, can be assessed through CBCT as it provides valuable diagnostic information [33]. To finalize, in the current study, the triangular shape of the condyle was significantly observed in the TMJ group and the oval shape in the control group; also, the oval-shaped glenoid fossa was significantly noticed in both the TMJ and the control groups; similarly, the erosive changes of the TMJ were more apparently seen in the current study. Also, among all the joint spaces, only MJS was increased in the control group. Furthermore, there was no significant difference or association between the joint spaces and condylar and glenoid fossa shapes of TMJ. However, the association of joint spaces and articular eminence height was evident, even though it has been proven there is no association with the presence or absence of TMDs. The association between condylar changes and SJS was also found in the current study, although whether this factor would help in diagnosing TMD'S is still unclear. Further research correlating and evaluating each TMJ parameter would aid in the diagnosis of TMDs associated with age, gender, and dentition status. Although the literature shows similar studies, our study is one of its kind where the age and gender are included. Our study is not an exception to certain limitations, such as sample size. Further studies with larger sample sizes may help in reducing interpretation errors and for generalization.

CONCLUSION

The current study elucidated the relationship between the assessment of TMJ morphology and the diagnosis of temporomandibular diseases. We could notice the erosion of the condyle in patients diagnosed with TMDs, and the triangular shape of the condyle was seen in the TMJ group, although the oval glenoid fossa shape was seen in both groups. There was also an increase in medial joint space among controls, and all the other joint spaces were increased in the TMJ group. Further, there was also increased articular eminence height and inclination in the TMJ group. Furthermore, in our study, there was an association between condylar fossa shape and articular eminence inclination, as well as an association between condylar changes and superior joint space. Certainly, the results of our study depicted that, due to the complex anatomy of the TMJ, the assessment of these parameters and their association with TMDs is still dubious and not enough to prove the presence of temporomandibular joint disorders. Besides, we could see highly significant differences pertaining to all the chosen parameters between the control and TMJ groups.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The institutional ethical committee of DRS Sudha and Nageswararao Siddhartha Institute of Dental Sciences gave the approval, having approval number ID: OC/IEC/10784.

HUMAN AND ANIMAL RIGHTS

All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants of this study.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analyzed during the present study are available from the corresponding author [C.L].

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

SUPPLEMENTARY MATERIALS

Supplementary material is available on the publisher's website along with the published article.

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