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CBCT Evaluation of Temporomandibular joint spaces and Condylar morphology of different skeletal patterns among Filipino adult patients

Jean H. Tating
Manila Central University, EDSA, Caloocan CIty, Philippines

Abstract

Temporomandibular Joint Disorder (TMD) is one of the most controversial and popular topics in orthodontic literature. According to studies, the condylar position and morphology in relation to the glenoid fossa may cause this condition. The narrowing of joint spaces and alteration of condyle morphology in relation to different skeletal patterns lead to higher risk of developing TMD. The present study evaluated TMJ joint spaces, condylar position and condylar morphology and their correlation to different skeletal patterns among adult Filipinos using CBCT. The study involved 45 adult patients, 26 female and 19 male aged 18-55 years old. Pre-assessment on cephalometric radiograph of skeletal pattern based on Steiner`s ANB angle was used according to the degree of severity such as Class I (2.5), Class II ($2.5^o \geq$), and Class III ($2.5^o \leq$). They were divided into 3 groups. The CBCT PaX Reve3D dental CT took FOV sizes 15x15mm of TMJ images. Scanning protocol was 120kV, 36.9 mA, 0.4-mm voxel, with patients in a natural head position. Ezdent-I software was used to measure sagittal view of TMJ joint spaces. The overall result of the computation of error of measurement (EM) using Dahlberg was reliable at 0.017mm. Descriptive statistics showed the mean value of right AJS (2.43±0.91mm), right SJS (2.23±1.11mm), right PJS (2.53±1.09mm) and left AJS (2.64±1.06mm), left SJS (2.39±0.94mm), left PJS (2.71±1.19mm). Condyle morphology among all the skeletal patterns exhibited an overall 54.33% of a round shape, 37.78% flattened shape condyle, and 8.99% for irregular shape. Common to Class I and Class III was round shape, Class II flattened shape condyle. The non-concentric condylar position was commonly seen among Class I, II, and III skeletal patterns. Right condyle was posteriorly positioned with overall 51.11% and left condyle more anteriorly positioned with overall 53.33%. The study showed that there were significant differences in three-dimensional sagittal measurements of the right anterior, joint spaces. However, left anterior joint spaces, right and left superior and posterior joint spaces had no significant differences. There was no significant difference on right condylar morphology with p-value 0.0679, but the left condyle morphology with p-value 0.0197 was statistically significant. There was a significant difference between right and left condylar positions.

Keywords

Condylar Morphology, CBCT Evaluation, Skeletal Patterns, Temporomandibular Joint Disorder, Temporomandibular Joint Spaces

1. Introduction

In the early 90s, Temporomandibular Joint Disorder (TMD) was poorly understood by dentists and they were skeptical about its idea and philosophy. Nowadays, different fields of dentistry embrace TMJ practice. Practitioners are becoming more equipped with the knowledge about this condition.

The American Academy of Orofacial Pain broadly categorizes TMD as masticatory muscle disorder and articular disorder (Okeson, 2008). It is also known as craniomandibular disorder (CMD). It is related to the discomfort of the temporomandibular joint (TMJ) which is multifactorial with a degree of psychogenic influence varying throughout an individual's life with phases of symptoms affecting the quality of life. However, no particular factor is considered as having a more important role in its pathogenesis (Naeijeet et al., 2012).

Over the years, many have studied the condyle-fossa in relation to the sagittal skeletal pattern and its possible risk factor to be considered in the development of TMD (Dalili et al., 2012; Vitral et al., 2011). Several studies have been conducted to assess the narrowing of joint spaces, alteration of condyle morphology and non-concentric position of the condyle which could be a higher risk of developing TMD.

TMDs are heterogenous group of complex disorders affecting masticatory musculature and temporomandibular joint apparatus. It is characterized by triad of symptoms such as facial pain, limited mouth opening, and joint sounds. It is not a life threatening condition but to patients who cannot adapt to structural alterations, this may affect their everyday life activities leading to a more serious condition affecting their total well-being.

Individuals between 20 and 40 age group are affected and its prevalence increases with age. For females, puberty and hormonal changes play an important role in the onset of TMD (Ostensjo, 2017). About 3.6 to 7% of the population has severe TMD symptoms that cause patients to seek treatment (Wright, 2014).

According to Rodrigues, et al. (2009), one of the symptoms associated with TMD is TMJ joint sound which is an indication that TMJ apparatus is undergoing initial sign of derangement brought about by changes of TMJ morphology through condyle remodelling and diminishes in the TMJ joint spaces. Ostensjo, et al. (2017) stated that clicking or crepitation sounds from TMJ may occur as well as reduced mobility of the joint.

Nowadays, the number of patients with TMD is increasing substantially in the field of dentistry and is clinically observed in orthodontics which leads to a growing demand for TMJ patients seeking possible treatments.

Radiographic imaging is an integral part of overall assessment (Barghan, et al., 2010). In conjunction with patients' medical and dental history, clinical evaluation of skeletal and dental interrelationship is a necessity due to its non-dental origin. Cone beam computed tomography (CBCT) is an excellent diagnostic tool to assess the morphology, integrity, and structural alterations of the osseous components of the TMJ.

Mohamed Bazina (2018) reported that there has been a dramatic increase in the use of cone-beam computed tomography (CBCT) in dentistry which provides more information than 2-dimensional (2D) images, and in certain cases, 3-dimensional (3D) images provide a more accurate and efficient diagnosis and treatment plan. Recent guidelines recommend CBCT as a modality of choice for the evaluation of TMJ osseous components and its application in orthodontics focused on the diagnosis and treatment planning of the craniofacial complex and mandibular condyle morphology.

In chronic TMD, a collaborative interdisciplinary treatment is mostly appropriate method of choice. However, the American Association for Dental Research (AADR) strongly recommends that unless there are specific and justifiable indications, TMD treatment initially should be based on the use of conservative, reversible and evidence-based therapeutic modalities (Greene, 2010). Minimally invasive and invasive procedures should be considered (Wieckiewicz, et al., 2015).

The Clinical Diagnostic Criteria for Temporomandibular Joint Disorders (CDC/TMD) provide a standard and operationalized manner to examine the temporomandibular joint and its associated structures (Durham, 2015). Accordingly, the most important symptoms of TMD are clicking, crepitation, and reduction or closed lock of mouth opening movements. Because of the complexity of TMD, a thorough diagnosis alongside with the clinical evaluation, diagnostic tools, and imaging of the TMJ is necessary (Schiffman et al., 2014).

There is a wide choice of imaging tools of the osseous portion of temporomandibular joint (TMJ). These include Transcranial Radiograph, Panoramic and (CT) Computed Tomography. Jones et al. (2016) reported that osseous changes can occur in 14% to 44% of patients with TMD symptoms.

Another imaging that could be helpful in this chronic condition is the Magnetic Resonance Imaging (MRI) which can be used to verify articular disc position. It is described as the gold standard for soft tissue assessment although it suffers certain limitations on its use to patients with claustrophobia, pacemakers, and metallic prosthesis.

In the Philippines, the traditional use of transcranial radiograph to evaluate TMJ joint spaces and condylar morphology is still commonly practiced due to its cost effectiveness. However, according to Ikeda et al. (2018), the conventional 2-dimentional imaging leads to magnification error and distortion. The overlapping of anatomic structures during exposure cannot guarantee concrete details in the assessment of the condylar position and morphology.

The main purpose of this study was to evaluate TMJ joint spaces, condylar position, condylar morphology and its correlation to the different skeletal patterns among adult Filipino using CBCT. The study used CBCT over transcranial radiograph, since its emergence has expanded its clinical application in the field of dentistry particularly for TMJ imaging, which can provide high dimensional accuracy to assess TMJ osseous structures and can quantitatively measure joint spaces and evaluate the concentricity of the condyle which could be significant in orthodontic treatment planning among Filipino orthodontists.

II. Methods

The study used the descriptive correlational design to evaluate TMJ joint spaces and condylar morphology of the different skeletal patterns of adult Filipino patients. It examined CBCT images of 45 Filipino adult patients between 18 and 48 years of age purposively selected from private patients of different dentists, students of a selected university, family members, and friends with a total of 90 TMJ diagnostic CBCT scans.

The subjects were divided into 3 groups according to the skeletal pattern, 15 adult patients each per group. In Class I, the subjects were 11 females and 4 males who were 18 to 24 years old. In Class II, there were 7 females and 8 males who were 25 to 34 years old. In Class III, there were 8 females and 7 males who were 35 years old and above.

Pre-assessment of dental classification was done according to the occlusal relationship and skeletal pattern based on Steiner`s ANB angle, based on the degree of severity such as Class I (2.5), Class II ($2.5^{o} \geq$) and Class III ($2.5^{o} \leq$). Cephalometric landmarks digitized; (S) sella, (N) nasion (A point), (B point). Linear measurement was done using pencil and protractor from CBCT scans of the patients using the sella-nasion, to A-point for the SNA value, and sella-nasion to B-point for SNB. ANB value was the difference of SNA and SNB values. In this study, Class I subjects with ANB ranged from (0 -2), Class II with ANB ranged from (3 - 8) and Class III ANB ranged from ($^{-}1$ - $^{-}11$).

A screening process of the patients was done according to the selection criteria. The selected 45 respondents were fully informed of both the objectives of the study and all the clinical procedures of the study. As an agreement, an informed consent form was signed and the procedures were initiated by answering the questionnaires of TMD evaluation form prepared by the researcher. This was followed by clinical assessment.

The respondents underwent occlusal examination and palpation of muscle of mastication intraorally and extra orally. The TMJ area in front of the ears was palpated where patients were instructed to open and close the jaw to examine for joint noises. Patients' photos, profile, and occlusion were taken before CBCT scanning at Dental System Center using calibrated PaX Reve3D dental CT.

Cephalometric radiographs were taken for the evaluation of skeletal classification for linear measurement SNA, SNB, and ANB; a protractor and a pencil were used. The identification of all the necessary landmarks for joint spaces and condyle morphology was done by a single operator, the researcher herself. The measurement was done twice with a one-week interval in between to check for the accuracy of the landmarks and measurements based on the method of Rodriguez-Cardenas et al. (2014). The reliability test used was the Dahlberg Formula. The data from the Ezdent-i software were encoded using statistical analysis software package (SPSS) IBM 2018 from a coding manual. The structured data entry were statistically analyzed using descriptive statistics such as frequency, mean, and percentage.

Data analysis measured TMJ joint spaces: anterior joint space (AJS) or the shortest distance between the most anterior point of the condyle and the posterior wall of the articular tubercle, superior joint space (SJS) or the shortest distance between the most superior point of the condyle and the most superior point of the mandibular fossa, and posterior joint space (PJS) or the shortest distance between the most superior point of the condyle and the most superior point of the mandibular fossa.

Other methods to locate exactly the landmark used in this study were similar to those used by Rawlani, et al. (2018). Statistical analysis of condyle position of the different skeletal pattern was calculated by dividing the anterior joint space (A) and by dividing the posterior joint space (P) based on Reis Fraga et al. (2013). Sagittal condylar morphology used in this study was based on Park et al. (2015).

The main instrument for the evaluation of the TMJ joint spaces condylar morphology was performed by properly calibrated PaX Reve3D dental CT which took FOV sizes 15x15mm. This allowed the researcher to obtain the entire dental status and TMJ structure of the patient in a single exposure. The scanning protocol was 120kV, 36.9 mA, 0.4-mm voxel, with patients in a natural head position.

The head orientation images were standardized and observed from a front view. The horizontal plane was aligned with the orbits and was repositioned according to the Frankfort horizontal plane. The 3D dental imaging system recorded the condyle morphology and qualitatively measured TMJ joint spaces with accuracy. The joint spaces in the anterior, superior and posterior were correlated between right and left condyle for each subject and to the different skeletal patterns.

Research instruments that were also necessary to achieve the purpose of the study were cephalometric radiograph, cephalometric protractor, tracing paper, cephalometric X-ray viewer, and questionnaire for TMD assessment.

The information on TMJ joint spaces were measured, processed, and analyzed using a computer software. The condylar position was manually computed based on the formula given by Reis Fraga et al. (2013). In determining condylar morphology, a clear view of TMJ CBCT scan was categorically evaluated.

III. Results and Discussion

1. Patients' Profile

As shown in Table 1.1, 34 or 75.56% of the patients regardless of skeletal pattern were 18-27 years old; 7 or 15.56% were 28-37 years old; 4 or 8.89% were 38-48 years old. As to sex, there were 19 (42.22%) male and 26 (57.78%) female patients.

Table No. 1.1: Distribution of the Subjects' Profile According to Age

*Age category	Skeletal pattern			Total
	Class I Frequency (percent)	Class II Frequency (percent)	Class III Frequency (percent)	
18-27	10 (66.67%)	11 (73.33%)	13 (86.67%)	34 (75.56%)
28-37	4 (26.67%)	1 (6.67%)	2 (13.33%)	7 (15.56%)
38-48	1 (6.67%)	3 (20.00%)	0	4 (8.89%)

Table 1.2: Distribution of the Subjects' Profile According to Sex

SEX	CLASS 1		CLASS 2		CLASS 3		OVERALL	
	F	%	f	%	f	%	f	%
Male	4	26.67	8	53.33	7	46.67	19	42.22
Female	11	73.33	7	46.67	8	53.33	26	57.78
TOTAL	15	100.0	15	100.0	15	100.0	45	100.0

Table 1.3 shows that 26 or 57.78% of the patients had temporomandibular joint symptoms, while 19 or 42.22% did not have these symptoms regardless of skeletal pattern. The results revealed that 10 patients with Class I, and 9 with Class II skeletal patterns had TMD symptoms. The results were similar to Leite's (2009) study where it was found that most patients with Class I and II skeletal patterns had TMD symptoms. Further, out of 26 female respondents, 15 or almost 58% experienced TMD symptoms while 13 out of 19 or 68% male respondents had TMD symptoms.

Table 1.3: Distribution of the Subjects' Profile According to Presence of TMD Symptoms

TMD Symptoms	CLASS 1		CLASS 2		CLASS 3		OVERALL	
	f	%	f	%	f	%	f	%
With	10	66.67	9	60.00	7	46.67	26	57.78
Without	5	33.33	6	40.00	8	53.33	19	42.22
TOTAL	15	100.0	15	100.0	15	100.0	45	100.0

Table 1.3.1: Distribution of Female with TMD Symptoms

Patient ID	SEX	TMD	Patient ID	SEX	TMD	Patient ID	SEX	TMD
C-I-1	F		C-II-1	M		C-III-1	F	+
C-I-2	F	+	C-II-2	M	+	C-III-2	M	
C-I-3	F	+	C-II-3	F	+	C-III-3	F	
C-I-4	F	+	C-II-4	M		C-III-4	F	+
C-I-5	M	+	C-II-5	F		C-III-5	F	+
C-I-6	M		C-II-6	M	+	C-III-6	F	
C-I-7	F	+	C-II-7	M		C-III-7	M	+
C-I-8	F		C-II-8	F		C-III-8	F	+
C-I-9	F		C-II-9	F	+	C-III-9	M	
C-I-10	F	+	C-II-10	F		C-III-10	F	
C-I-11	F	+	C-II-11	M	+	C-III-11	F	
C-I-12	M	+	C-II-12	F	+	C-III-12	M	+
C-I-13	M	+	C-II-13	F	+	C-III-13	M	
C-I-14	F		C-II-14	M	+	C-III-14	M	+
C-I-15	F	+	C-II-15	M	+	C-III-15	M	

*+ = patient with TMD

2. TMJ Joint Spaces in Relation to the Different Skeletal Patterns

Table 2 shows that among patients with Class 1, the mean average of right anterior joint space (AJS) was 2.35 mm, right superior joint space (SJS) was 2.19 mm, and right posterior joint space (PJS) was 2.31 mm. The mean average on the left anterior joint space (AJS), left superior joint space (SJS), and left posterior joint space (PJS) was 3.07 mm, 2.33 mm, and 2.45 mm, respectively.

Table 2: TMJ Joint Spaces in Relation to the Different Skeletal Patterns

	Class	RIGHT TMJ			LEFT TMJ		
		AJS	SJS	PJS	AJS	SJS	PJS
Average CBCT measure	Class 1	2.35	2.19	2.31	3.07	2.33	2.45
	Class 2	2.62	2.63	2.88	2.69	2.79	3.18
	Class 3	2.31	1.89	2.43	2.18	2.07	2.53

Those with Class 2 had a mean average 2.62 mm on the right anterior joint space (AJS), 2.63 mm on the right superior joint space (SJS), and 2.88 mm on the right posterior joint space (PJS). The mean average on the left anterior joint space (AJS), left superior joint space (SJS), and left posterior joint space (PJS) was 2.69 mm, 2.79 mm, and 3.18 mm, respectively.

For those with Class 3, the mean average of right anterior joint space (AJS) was 2.31 mm, right superior joint space (SJS) was 1.89 mm, and right posterior joint space (PJS) was 2.43 mm. The mean average on the left anterior joint space (AJS), left superior joint space (SJS), and left posterior joint space (PJS) was 2.18 mm, 2.07 mm, and 2.53 mm, respectively.

Martins, et al. (2015) conducted a systematic review and meta-analysis on the sagittal joint spaces measurements of the temporomandibular joint. Seventeen of the reviewed studies were included in the meta-analysis which concluded that the mean sagittal joint space values for AJS, SJS, and PJS were 1.86 mm, 2.36 mm, and 2.22 mm, respectively.

The results showed that the right anterior joint space of Class I and III was nearly the same; Class II had the greatest space among the three patterns. The right superior joint space of Class III had the most reduced space as compared to Class I and II which implies that it was more superior than in Class I and II. The right posterior joint space of Class II was wider. This verified the findings of Martins et al. (2015) that posterior joint space is larger than the anterior joint space. Comparing the anterior joint space to the posterior joint space among skeletal classifications revealed that AJS was slightly narrower than the PJS. This was the same with the results of the study of Martins et al. (2015).

3. Condyle Positions of the Different Skeletal Patterns

Table 3a shows the statistical analysis of condyle position of the different skeletal patterns calculated by dividing the anterior joint space (AJS) by the posterior joint space (PJS) based on Reis Fraga et al. (2013). A/P ratio of 1.0 indicated a concentric condyle, A/P ratio of greater than 1.0 represented a posterior condylar position, and A/P ratio of less than 1.0 represented an anteriorly displaced condyle. The further the value from 1.0, the greater the decentralization of the condyle in the mandibular fossa or non-concentric condyle position.

Table 3a shows that the highest prevalence of right condyle position regardless of skeletal classification were posteriorly-positioned (51.11%) followed by anteriorly-positioned (46.67%). In Class I, no centric positioned was found, around 60% were posteriorly-positioned and 40% were anteriorly-positioned. Class II revealed more anteriorly positioned (53.33%) and only 6.67% were centric positioned. Class III were posteriorly positioned condyle at 53.33%.

Table 3a: Distribution of the Subjects' Right Condyle Position

Right Condyle Position	CLASS 1		CLASS 2		CLASS 3		OVERALL	
	f	%	f	%	f	%	f	%
Centric	0	0.0	1	6.67	0	0.0	1	2.22
Posterior	9	60.00	6	40.00	8	53.33	23	51.11
Anterior	6	40.00	8	53.33	7	46.67	21	46.67
TOTAL	15	100.0	15	100.0	15	100.0	45	100.0

Table 3b shows that the highest prevalence of left condyle position regardless of skeletal classification were anteriorly-positioned (53.33%) followed by posteriorly-positioned (42.22%). In Class I left condyle, only one was in centric-positioned (6.67%); most were posteriorly positioned. Class II almost equaled in the number of patients who were posteriorly and anteriorly positioned. Majority of patient with Class III were anteriorly positioned (66.67%). The overall left condyle position was anteriorly positioned (53.33%).

Table 3b: Distribution of the Subjects' Left Condyle Position

Left Condyle Position	CLASS 1		CLASS 2		CLASS 3		OVERALL	
	f	%	f	%	f	%	f	%
Centric	1	6.67	0	0.0	1	6.67	2	4.44
Posterior	8	53.33	7	46.67	4	26.67	19	42.22
Anterior	6	40.00	8	53.33	10	66.67	24	53.33
TOTAL	15	100.0	15	100.0	15	100.0	45	100.0

The present study affirmed the observation of Cohlmia et al. (1996) that left condyle was positioned more anteriorly than the right condyle. Similar findings were shown in the study of Ganesh et al. (2017) among all three types of malocclusion. They reported that Class III left condyle was placed more anteriorly than the left condyle. The present study also revealed that Class II patients' left condyle did not find a concentric position and only 1 on the right condyle. This was similar to the earlier findings of Pullinger et al. (1987).

Ganesh et al. (2017) evaluated TMJ joint images of 45 patients and assessed on axial view the concentricity of condyle to the glenoid fossa. A non-concentric position for Class I and concentric position for Class II and III groups were revealed. Moreover, left condyle was placed more anteriorly than the right condyle which is similar to the result of this study.

4. Right and Left Condylar Morphology of the Different Skeletal Patterns Using CBCT

Table 4.1 shows that round and flattened morphologies had the highest prevalence in Class I right condylar morphology. The flattened condylar shape had the highest prevalence in Class II, while the round shape had the highest prevalence in Class III. Overall, the round condylar morphology had the highest proportion among the different skeletal patterns with 54.33%; only few were irregular in shape with 8.89%.

Table 4.1: Distribution of the Subjects' Right Condylar Morphology

Right Condylar Morphology	CLASS 1		CLASS 2		CLASS 3		OVERALL	
	f	%	f	%	f	%	f	%
Round	7	46.67	5	33.33	12	80.00	24	54.33
Flattened	7	46.67	8	53.33	2	13.34	17	37.78
Irregular	1	6.66	2	13.34	1	6.66	4	8.89
TOTAL	15	100.0	15	100.0	15	100.0	45	100.0

Table 4.2 shows that round condyle shape had the highest prevalence in Class I left condylar morphology at 60.00%. The flattened condylar shape had the highest prevalence in Class II at 66.67%, while the round shape had the highest prevalence in Class III at 60.00% similar with Class I skeletal pattern. Overall, round condylar morphology had the highest proportion seen in Class II among the different skeletal patterns at 48.88%; only few were irregular in shape with 4.4%.

Table 4.2: Distribution of the Subjects' Left Condylar Morphology

Left Condylar Morphology	CLASS 1		CLASS 2		CLASS 3		OVERALL	
	F	%	f	%	f	%	f	%
Round	9	60.00	4	8.89	9	60.00	22	48.89
Flattened	5	33.33	10	66.67	6	40.00	21	46.67
Irregular	1	6.66	1	6.66	0	0.0	2	4.44
TOTAL	15	100.0	15	100.0	15	100.0	45	100.0

According to Alhammadi et al. (2016), the morphology and condyle-glenoid fossa relationship in sagittal discrepancies could be compromised due to the tension or compression of forces of the surrounding tissues exerted on the TMJ. Karsavrias and Halazonetis (2015) argued that both condyle and mandibular fossa differ in shape among patients with various type of malocclusion. Park et al. (2015) reported that condylar position and morphology varied according to vertical skeletal patterns. Their study was based on the results of three dimensional cone-beam computed tomography comparing condylar position and morphology according to vertical patterns.

5. Temporomandibular Joint Spaces, Condyle Position, and Condylar Morphology of the Different Skeletal Patterns

There is a significant difference in the right anterior joint spaces. However, there was no sufficient evidence to say that there was a difference in the right superior and posterior joint spaces. Left anterior, superior, and posterior joint spaces across skeletal patterns had no significant differences. The results also showed that there was a significant difference between right and left condylar position. Class I had the least number of centric position.

The left condylar morphology had less of irregular shape condyle in skeletal Class III than Class I and II. There was no sufficient evidence to say that there was a difference in the right condylar morphology. However, there was a significant difference in the left condylar morphology.

The cross-sectional study done by Dalili, et al. (2012) on TMJ joint spaces using CBCT among 40 patients without any history of TMD and in Class I skeletal pattern showed that there were no differences between the values of joint spaces.

Park, et al. (2015) studied CBCT images of 60 adult patients and compared condylar position and morphology among the different skeletal patterns. They concluded that condylar position varied according to vertical facial morphology. The relationship between condylar position and morphology should be considered in predicting and establishing a proper treatment plan for TMD during orthodontic treatment. In another study, Merigue et al. (2016) found that the morphology of TMJ joint varied and that functional load was one of the factors that influenced its shape.

Table 5.1: Descriptive Statistics of AJS, SJS, and PJS

	Mean	**Stdev.**
Right AJS	**2.4333**	**0.9192**
Right SJS	**2.2356**	**1.1156**
Right PJS	**2.5378**	**1.0916**
Left AJS	**2.6467**	**1.0616**
Left SJS	**2.3956**	**0.9465**
Left PJS	**2.7178**	**1.1925**

Table 5.2: Difference in the Right Temporomandibular Joint Spaces of the Different Skeletal Patterns among Adult Filipino Patients

Parameter	Computed F-test Value	p- Value	Decision	Interpretation
Right AJS	0.46	0.0314	$H_{o::}$ Rejected	Significant
Right SJS	1.16	0.3235	$H_{o::}$ Accepted	Non-Significant
Right PJS	1.72	0.1913	$H_{o::}$ Accepted	Non-Significant

*alpha level at 10% level of significance

Table 5.3 Difference in the Left Temporomandibular Joint Spaces, of the Different Skeletal Pattern Among Adult Filipino Patients

Parameter	Computed F-test Value	p-Value	Decision	Interpretation
Left AJS	2.57	0.0882	$H_{o:}$ Accepted	Non-Significant
Left SJS	2.32	0.1106	$H_{o:}$ Accepted	Non-Significant
Left PJS	1.77	0.1834	$H_{o:}$ Accepted	Non-Significant

*alpha level at 10% level of significance

Table 5.4: Difference in the Temporomandibur Condyle Position of the Different Skeletal Patterns among Adult Filipino Patients

	F comp.	p-value	Decision/Interpretation
Right condyle position	40.36	0.0003	$H_{o:}$ Rejected Significant
Left condyle position	15.34	0.0004	$H_{o:}$ Rejected Significant

*alpha level at 1% level of significance

Table 5.5: Difference in the Temporomandibular Condylar Morphology of the Different Skeletal Patterns among Adult Filipino Patients

	F comp.	p-value	Decision/Interpretation
Right condyle morphology	4.35	0.0679	$H_{o:}$ Accept Non-Significant
Left condyle morphology	8.11	0.0197	$H_{o:}$ Rejected Significant

*alpha level at 5% level of significance

IV. Conclusion and Recommendations

The results of the study revealed that there were significant differences in three-dimensional sagittal measurements of the right anterior joint spaces. However, left anterior joint spaces, right and left superior, and posterior joint spaces had no significant differences.

There were significant differences in the right and left TMJ condylar position among the group of different skeletal patterns, but there was no significant difference in the right TMJ condylar morphology. The results also showed that there were significant differences in the left TMJ condylar morphology among the group of different skeletal patterns.

Filipino dental practitioners may use a systematic protocol for the clinical application of the CBCT diagnostic tool in their temporomandibular joint (TMJ)-oriented orthodontic treatment. Future researchers may conduct further studies on TMJ joint spaces, condylar position, and condylar morphology and correlate them to TMD symptoms. They may use a larger sample size and purposively select skeletal patterns above acceptable values with equal distribution of respondents' age and sex.

CBCT is a diagnostic tool which provides considerable information to evaluate condylar position and morphology that might be contributory to the initial stage of internal derangement. Hence, future researchers may improve the technique in using CBCT to eliminate possible errors in the measurement and to make it more practical and friendly to the user.

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