Open Access Journal

Indian Journal of Medical Research and Pharmaceutical Sciences

October 2019;6(10) ISSN: ISSN: 2349-5340

DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

COMPARATIVE STUDY OF MANDIBULAR CONDYLAR SPATIAL RELATIONSHIP AND MORPHOLOGY IN SKELETAL CLASS II MALOCCLUSION PATIENTS WITH DIFFERENT VERTICAL SKELETAL PATTERN

Mohammed Al-Rajeh[1], Akram Al-Nasri[1] & Kang Na, PhD*[2]

[1]Master student in the Postgraduate Program of Orthodontic, Department of Orthodontics, College of Stomatology, Guangxi Medical University, Nanning, Guangxi, China

*[2]Associate professor, Department of Orthodontics, College and Hospital of Stomatology affiliated to Guangxi Medical University, No. 10 Shuangyong Road, Nanning, Guangxi, 530021, China

Keywords:
CBCT, Condylar position, Temporomandibular joint, Vertical craniofacial pattern.

Abstract

Objective: the study aims to compare the mandibular condyle-fossa spatial relationship and morphologies in asymptomatic skeletal class II patients with different vertical skeletal pattern.

Method and material: Cone-beam computed tomography (CBCT) images of 68 adult patients (136 TMJ) were recruited. Four groups of 17 CBCT images each were made according to their ANB and mandibular plane (SN-MP) angles: class II low SN-MP angle (CII-LA), class II normal SN-MP angle (CII-NA), class II high SN-MP angle (CII-HA) and class I normal SN-MP angle (CI-NA). Condyle-fossa spatial relationship and morphologies were compared among groups.

Results: Condylar position of skeletal class II patients in low, normal, and high angle groups were dominantly positioned concentrically, posteriorly and anteriorly respectively, while the condyles of (CI-NA) group tended to positioned concentrically and anteriorly. TMJ morphology appeared to be more affected by vertical skeletal pattern than sagittal one. Abnormal condylar morphology was typical in high angle group.

Conclusions: Both vertical and sagittal skeletal class II showed a significant correlation with the position of the condyle. Vertical skeletal morphology has more influence on TMJ morphology than sagittal skeletal type. This relationship should be regarded during orthodontic treatment to early predict and establishing proper treatment for the temporomandibular disorder

Introduction

The main components that form the temporomandibular joint (TMJ) are condylar process,glenoid fossa articular discs, and the articular eminence of temporal bone [1]. Due to developmental variability or condylar remodeling, the mandibular condyle varies significantly in different groups and individuals[2]. Recently, several studies have delivered on the condylar position in the glenoid fossa related tomany factors, Some of these studies have focused on sagittal skeletal patterns[3], facial asymmetry[4], vertical skeletal morphology[5], symptomatic TMD[6] or disc displacement[7]. Furthermore, many scholars have been evaluated the TMJ morphology concerning with gender type, [8] age[9], different craniofacial patterns[5, 10, 11] ,and different dental and occlusal factors[12-17]. The masticatory function differs considerably in people with different skeletal discrepancies, which reflected in the TMJ morphology and the position of the condyle consequently[18, 19]. These multifactorial influences on the TMJ represent a challenge to the orthodontist and justify the disparity of scholars' findings on studying the relation of sagittal or vertical skeletal pattern with TMJ characteristics. The interest of orthodontist in studying the condylar position and TMJ morphologies are not arbitrary, but it has foundations which represent its significant role in the establishment the stability of the occlusion after orthodontic treatment[3] besides, its essential features for Orthodontic diagnosis, treatment, and therapeutic responses[5, 20]. The clinical significance of condylar position and its association with temporomandibular disorder (TMD) have always been a matter of controversy[21]. However, to maintain functional balance, the value of the proper condylar position in glenoid fossa is well-illustrated where an

Indian Journal of Medical Research and Pharmaceutical Sciences
October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

alteration in condylar position leads to displacement of disc either anterior or posterior causing disc derangements which thereby leading to TMD[22]. The anterior limit of the glenoid fossa formed by the articular eminence on which the condylar process slides during mandibular movements and is convex in shape[23]. The articular eminence varies in peoples, and its development relies on functional stimulus from the condyle[23, 24]. Several authors have reported an increased risk of condyle-disc derangement in the steep articular eminence slope and deep depth of the glenoid fossa [25-27]. The majority of recent studies are moving towards using a cone-beam computed tomography (CBCT) as a modality of choice for evaluating osseous structures of TMJ. This approach increasingly adopted by TMJ investigators due to its capability in terms of accuracy that is showing the real anatomical size of TMJ component [28, 29], compared to old two-dimensional radiographs [30]. So, similar to the most recent studies which have embarked on using CBCT approach, our study utilized this imaging technique to assess the condyle-fossa relationship and morphologies. The present study conducted on skeletal class II patient taking into account the different vertical skeletal patterns side by side to clarifying the prevalence and compensation which could happen in a combination of different vertical skeletal pattern with sagittal skeletal class II malocclusion and then compare it to the normal vertical and sagittal skeletal craniofacial pattern group.

Materials and Methods

2.1. Subject Selection:
Diagnostic CBCT images of 68 adult Chinese patients (136 TMJ) who visited the Department of Orthodontics and Radiology of the College and Hospital of Stomatology Guangxi Medical University for orthodontic treatment and required CBCT as a part of diagnostic record-taking were recruited in this study. The subjects were 36 women and 32 men aged 18-30 years old (Table 1). The institutional ethics committee of faculty approved the research design of the present study. All subjects met the following requirements: All permanent dentition, all teeth present except the third molars, no functional mandibular deviations, no open bite or crossbite, no remarkable facial or occlusal asymmetry, absence of orthodontic treatment, lack of maxillary functional orthopedic and eventually no signs and symptoms of TMD.

According to the cephalometric images, the subjects were divided into four balanced groups based on their sagittal and vertical skeletal morphology. Subjects with skeletal class II malocclusion(ANB: >4°) were classified according to the SN-MP angle to three groups each containing 17 subjects : low angle < 26° (CII-LA), normal angle 26°–36° (CII-NA), and high angle > 36° (CII-HA) groups, Besides 17 subjects of normal sagittal skeletal class I (ANB: 1-4°) and normal vertical craniofacial morphology (CI-NA) group. Given that the skeletal class II patients were involved according to the ANB angle, both class II division 1 and 2 were included. So, the impact of this difference was not considered in the present study. Condyle-fossa spatial relationship and morphologies were compared among groups.

Table 1.Distribution of subjects among groups

Variable		Groups				
		CII-LA	CII-NA	CII-HA	CI-NA	Total
Patient (n)		17	17	17	17	68
Age		24.76 ± 2.75	24.47 ± 3.64	24.29 ± 3.51	21.94 ± 3.31	
MP-SN ANGLE		22.04 ± 3.54	31.79 ± 2.3	40.08 ± 3.76	31.17 ± 2.81	
ANB ANGLE		5.47 ± 1.44	6.16 ± 1.19	6.85 ± 1.48	2.87 ± 0.85	
SEX	**Male**	10	9	7	6	32
	Female	7	8	10	11	36

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

Values are presented as number only, or mean±standard deviation
CII-LA, class II low MP-SN angle group; CII-NA, class II normal MP-SN angle group; CII-HA, class II high MP-SN angle group; CI-NA, class I normal angle group.
MP-SN, the angle formed by Sella-Nasion plane and mandibular plane; ANB, A point-Nasion-B point angle to measure the relative position of the maxilla to the mandible.

Imaging Procedures:
CBCT scans were acquired with i-CAT 17-19 CBCT machine (i-CAT 17-19) manufactured by Imaging Sciences Intl Inc. The CBCT images were acquired with patients in centric occlusion, and their heads were positioned so that the midsagittal plane was perpendicular to the floor. The scanning conditions were 120 kVp, 5 mA, and 26.9 seconds with FOV of 16 × 13 Software used in i-CAT 17-19 CBCT machine was i-CATvision.

Measurements made in Sagittal Plane:
136 TMJs (right and left) were assessed separately. In the axial view, the condylar process had the extended mediolateral width was used as a reference guide. On this axial view, the sagittal slice of 3.5 mm in thickness starting approximately from the center of axial condyle view extended medially were reconstructed, where the sagittal slices displaying a plain view of the condyle and mandibular fossa, the cephalogram were examined. (Figure 1) On the sagittal section, the following linear measurements were performed using i-CATvision CBCT software, and the angular measurements were performed using ImageJ (v. 1.51j8 bundled with Java v. 1.8.0_112 National Institutes of Health) (Table 2, Figure 1).

Table 2.Definition of the variables.

	Measurement	Definition
1	**Anterior joint space (AJS)**	It indicates the shortest distance between the posterior wall of the articular eminence and the most anterior point of the condylar head
2	**Superior joint space (SJS)**	It indicates the distance between the most superior point of the mandibular fossa and the most superior point of the condylar head
3	**Posterior joint space (PJS)**	It indicates the shortest distance between the posterior wall of the mandibular fossa and the most posterior point of the condylar head
4	**Depth of mandibular fossa (DMF)**	The distance between the most superior point of the mandibular fossa and the plane formed by the most inferior points of the articular eminence and the postglenoid process
5	**Articular eminence slop angle (AEA)**	The angle formed by the most superior point of the mandibular fossa, the most inferior point of the articular eminence, and the most inferior point of the glenoid process

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

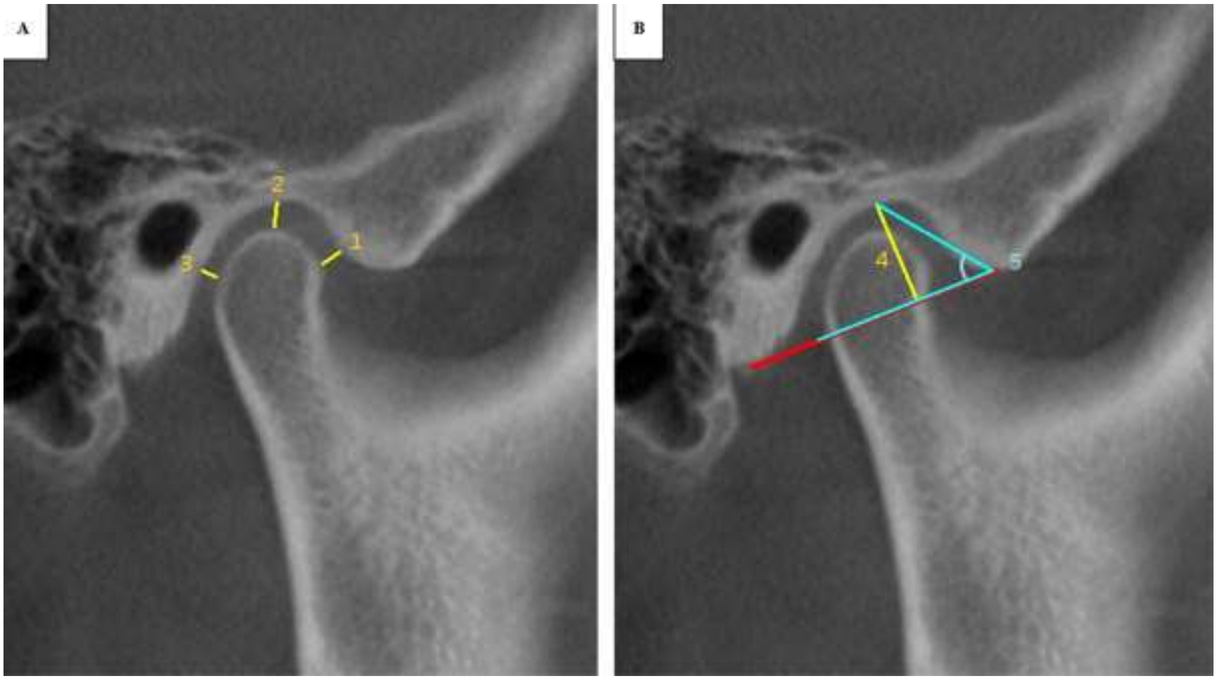

Figure 1.Sagittal measurements. (A) 1, Anterior joint space; 2, superior joint space; 3, posterior joint space measured by i-CATvision CBCT software; (B) 4, depth of the mandibular fossa; 5, angulation of the posterior wall of articular tubercle measured by ImageJ software

This study was used two methods to describe the position of the condyle in the glenoid fossa, the first method was determined by linear measuring the anterior, superior and posterior joint spaces expressed in millimeters. The second method was expressed the condyle-fossa anteroposterior relation depended on calculating the ratio between anterior and posterior joint spaces utilizing the following formula offered by Pullinger and Hollender[31] :

$$\text{Linear ratio } = \frac{(\text{Posterior Space } - \text{Anterior Space})}{(\text{Posterior Space } + \text{ Anterior Space})} \times 100$$

A ratio more than +12% refer to an anterior-positioned condyle whilst a ratio less than -12% suggest a posterior-positioned condyle. The linear ratio between +12% and -12% was considered a concentric condylar position.

In order to identify glenoid fossa morphology, the mandibular fossa depth, and articular eminence angulation were measured. Figure 1

Measurements made in the Axial Plane:
On the axial section, the morphology of the condyle in axial view was evaluated by measuring the greatest mediolateral width, greatest anteroposterior width, and condylar head angle using i-CATvision CBCT software, and ImageJ tool (Table 3, Figure 2).

The morphology of the condyle in the sagittal view was classified as a normal, flattened, osteophyte, and erosion. Figure 3

Indian Journal of Medical Research and Pharmaceutical Sciences
October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

Table 3.Definition of the variables

Measurement		Definition
1	**The Antero-posterior width of the condylar process (APW)**	It indicates the anteroposterior diameter of the condylar process
2	**Mediolateral width of the condylar process (MLW)**	It indicates the mediolateral diameter of condylar process
3	**Condylar head angle (CHA)**	It indicates the angle between the mediolateral plane of thecondylar process and the midsagittal plane

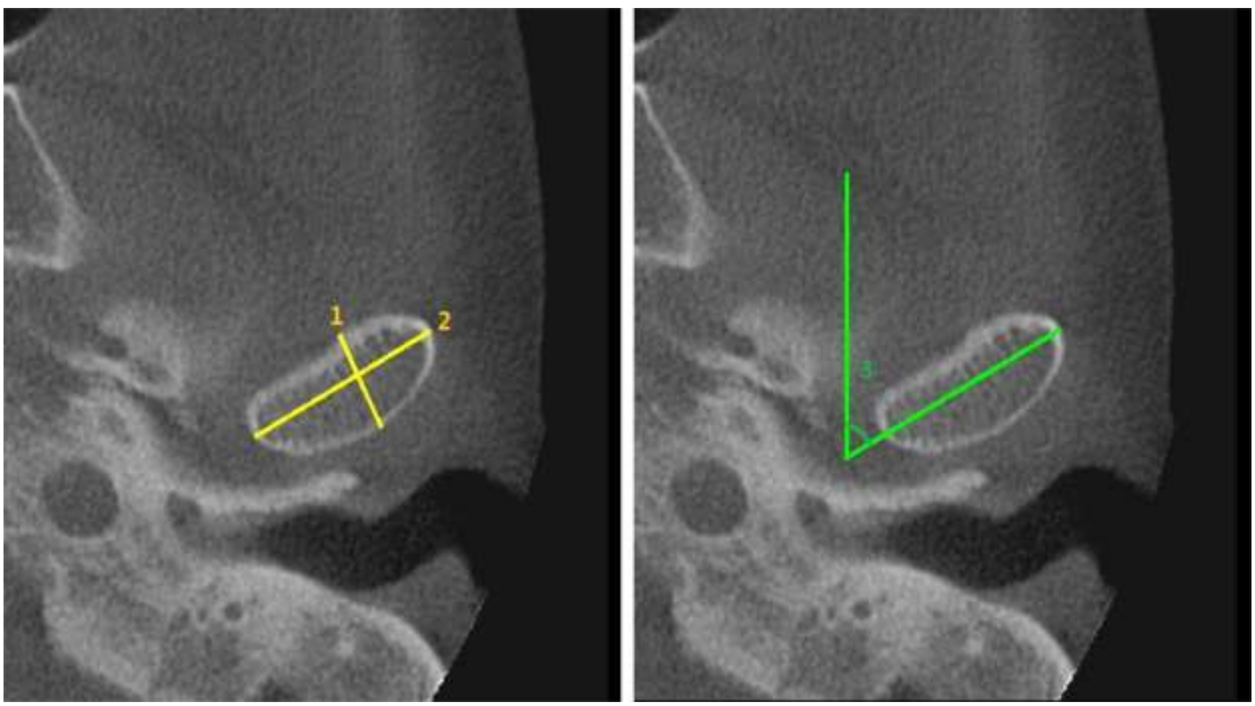

Figure 2.Axial measurements:1, Anteroposterior width of the condylar process 2, Mediolateral width of the condylar process using i-CATvision CBCT software 3, Condylar head angle using ImageJ software.

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

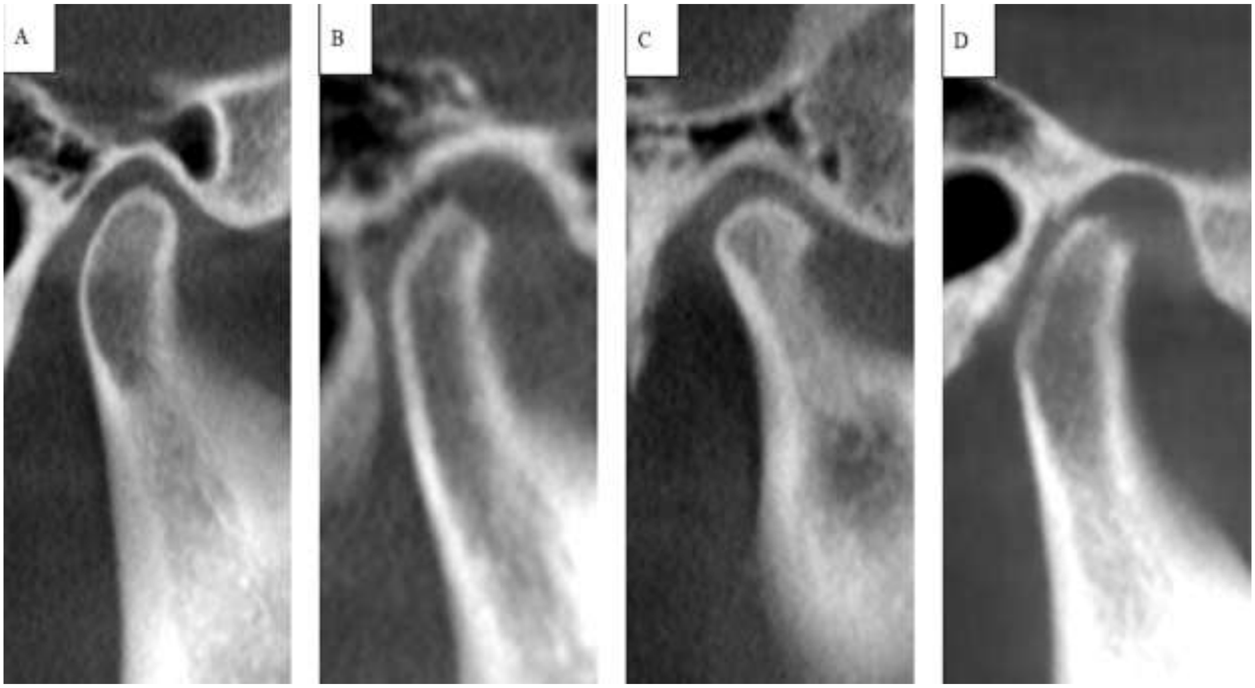

Figure 3. A: Normal B: Flattened C: Osteophyte D: Erosion

Statistical analysis

Data were analyzed using SPSS version 19 (SPSS Inc. software, Chicago, Illinois, USA) measurements were repeated on 32 randomly selected subjects (8 each group). The same examiner has repeated the measurements after a 2-week interval to confirm intra-observer reliability. The reliability of the measurements was assessed by the intraclass correlation coefficient. Since no statistically significant differences were found between right and left temporomandibular joint measurements, the data from the two joints were pooled together. The chi-square test was used to assess the correlation between the anteroposterior condylar position with vertical and sagittal growth pattern. The distribution of quantitative variables (AJS, SJS, PJS, DMF, AEA, APW, MLW and CHA) were examined for normality using the Shapiro-Wilk test before analysis. The data were distributed normally. So, TMJ parameters were compared between groups using One-way ANOVA (analysis of variance), and to compare mean values among the groups; the post-hoc Tukey test was applied. The present study judged a p-value less than 0.05 as significant.

Results

The consistency of the Intra-observer measurements was almost perfect ($r> 0.90$, $p < 0.001$ for all).

On the linear measurements of the condylar position, no significant differences in the PJS between groups. However, only AJS was significantly greater in CII-NA than all other groups. So, measuring the ratio between the anterior and posterior joint spaces according to Pullinger was used to specify anteroposterior condyle position in the glenoid fossa. Distribution ofpatients based on the condylar position of each group according to Pullinger equationis displayed in Table 4. There was a statistically significant differenceamong the four groups for the condylar position using the chi-square test (P-value< 0.001). The condyles were positioned posteriorly inCII-NA subjects comparedto all other groups. In the CII-HA, the condyles were situated anteriorly compared to CII-NA and CII-LA. No significant differences in condylar position between CI-NA and CII-LA (P-value= 0.220) or CII-HA (P-value= 0.064).

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

Table 4.Distribution of the condylar position in each classified group.

Groups	CONDYLE POSITION			Total
	anterior	concentric	posterior	
CI-NA	15 (44.1%)	17 (50.0%)	2 (5.9%)	34 (100.0%)
CII-LA	10 (29.4%)	18 (52.9%)	6 (17.6%)	34 (100.0%)
CII-NA	4 (11.8%)	10 (29.4%)	20 (58.8%)	34 (100.0%)
CII-HA	18 (52.9%)	9 (26.5%)	7 (20.6%)	34 (100.0%)
Total	47 (34.6%)	54 (39.7%)	35(25.7%)	136 (100.0%)

Values are presented as number or percentage (%).
CII-LA, class II low MP-SN angle group; CII-NA, class II normal MP-SN angle group; CII-HA, class II high MP-SN angle group; CI-NA, class I normal angle group.

According to the different vertical craniofacial pattern in Class II subjects; Significant differences in depth of mandibular fossa, condyle head angle, mediolateral condyle width, and superior joint space were found between the Class II low angle and the high angle groups. The Class II high and normal angle groups exhibited a significant difference only in anterior joint space. In Class II normal angle and low angle groups, anterior joint space, depth of mandibular fossa and mediolateral condyle width were significantly different (Tables 5 and 6).

In comparing each group of the different vertical skeletal pattern of class II patients to normal sagittal and vertical skeletal subjects; superior joint space, depth of mandibular fossa and mediolateral condyle width were significantly different between CI-NA and CII-LA group. The CI-NA and CII-NA groups exhibited a significant difference in anterior joint space and anteroposterior condyle width. In the CI-NA and CII-HA groups, the condyle head angle and anteroposterior condyle width were significantly different (Tables 5 and 6).

Table 5.Comparisons measured parameters of TMJ on sagittal and axial view between class II with different vertical skeletal pattern and normal proportion group

Variable	CII-LA	CII-NA	CII-HA	CI-NA	Sig
AJS (mm)	2.04 ± 0.53	2.59 ± 0.74	1.94 ± 0.52	1.72 ± 0.45	0.000*
SJS (mm)	3.28 ± 0.60	3.91 ± 0.72	2.72 ± 0.93	2.74 ± 0.78	0.002*
PJS (mm)	2.19 ± 0.58	1.88 ± 0.70	2.17 ± 0.80	2.01 ± 0.61	0.192
DMF (mm)	12.03 ± 0.82	11.36 ± 0.84	10.86 ± 0.90	11.14 ± 1.39	0.000*
AEA (◦)	56.91 ± 5.00	57.22 ± 6.53	58.72 ± 5.04	56.27 ± 6.64	0.364
APW (mm)	7.63 ± 0.91	7.33 ± 1.23	7.16 ± 1.17	8.11 ± 1.16	0.004*

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

MLW (mm)	20.33 ± 1.74	18.84 ± 1.64	17.83 ± 2.67	18.57 ± 2.67	0.000*
CHA (◦)	71.51 ± 6.08	68.59 ± 6.82	65.8 ± 8.76	71.66 ± 7.71	0.003*

CII-LA, class II low MP-SN angle group; CII-NA, class II normal MP-SN angle group; CII-HA, class II high MP-SN angle group; CI-NA, class I normal angle group; NS, not significant. *p < 0.05, analyzed by one-way ANOVA and level of significance (Sig) among groups.

Table 6.Mean difference and level of significance tested with post-hoc test

Variable	Comparison Class II among different skeletal pattern						Comparison of all groups to normal proportion group					
	CII-LA and CII-NA	P-VALUE	CII-NA and CII-HA	P-VALUE	CII-LA and CII-HA	P-VALUE	CI-NA and CII-LA	P-VALUE	CI-NA and CII-NA	P-VALUE	CI-NA and CII-HA	P-VALUE
AJS (mm)	-0.55	0.001*	0.64	0.000*	0.09	NS	-0.31	NS	-0.86	0.000*	-0.22	NS
SJS (mm)	0.09	NS	0.47	NS	0.56	0.016*	-0.55	0.020*	-0.45	NS	0.02	NS
PJS (mm)	0.31	NS	-0.29	NS	0.02	NS	-0.18	NS	0.13	NS	-0.16	NS
DMF (mm)	0.67	0.036*	0.50	NS	1.17	0.000*	-0.89	0.002*	-0.22	NS	0.28	NS
AEA (◦)	-0.31	NS	-1.50	NS	-1.81	NS	-0.64	NS	-0.95	NS	-2.45	NS
APW (mm)	0.30	NS	0.17	NS	0.47	NS	0.48	NS	0.78	0.025*	0.95	0.004*
MLW (mm)	1.49	0.034*	1.01	NS	2.50	0.000*	-1.75	0.008*	-0.27	NS	0.74	NS
CHA (◦)	2.91	NS	2.79	NS	5.71	0.010*	0.16	NS	3.07	NS	5.86	0.008*

CII-LA, class II low MP-SN angle group; CII-NA, class II normal MP-SN angle group; CII-HA, class II high MP-SN angle group; CI-NA, class I normal angle group; AJS, anterior joint space; SJS, superior; PJS, posterior; DMF, depth of mandibular fossa; AEA (◦), articular eminence angle; APW, anteroposterior width of the condyle; MLW, Mediolateral width of the condyle; CHA (◦), condylar head angle; NS, not significant. *p < 0.05. NS, not significant.

Distributions of the condyles according to their morphology among the groups are shown in Table 7. The groups showed differences in normally shaped condyles (Table 7, Figure 3). the frequency of condylar osteoarthritis changes in the CI-NA, CII-LA, CII-NAand CII-HA groups was respectively 11.7%,47.1%, 38.2%, and 61%

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

Table 7. Distribution of condylar shape in each group

Groups	CONDYLAR SHAPE				Total
	normal	flattened	osteophyte	erosion	
CI-NA	30 (88.2%)	2 (5.9%)	1 (2.9%)	1 (2.9%)	34
CII-LA	18 (52.9%)	10 (29.4%)	4 (11.8%)	2 (5.9%)	34
CII-NA	21 (61.8%)	12 (35.3%)	1 (2.9%)	0 (0%)	34
CII-HA	13 (38.2%)	12 (35.3%)	8 (23.5%)	1 (2.9%)	34
Total	82 (60.3%)	36 (26.5%)	14 (10.3%)	4 (2.9%)	136

Values are presented as number or percentage (%).
CII-LA, class II low MP-SN angle group; CII-NA, class II normal MP-SN angle group; CII-HA, class II high MP-SN angle group; CI-NA, class I normal angle group.

Discussion

In orthodontic treatment, the TMJ considered as an influential factor, and the functional balance without stable TMJ can't be obtained [22]. The structure of the TMJ makes visualization of the TMJ difficult. The CBCT considered as a favorite choice to evaluating spatial and bony components of the TMJ as it provides a realistic anatomical size [3], and higher spatial resolution [32, 33], which allowed us to analyze the TMJ's morphology and spatial relationship precisely [34]. So, the CBCT diagnostic method was adopted in the present study.

Different studies have been carried out on the relation between sagittal craniofacial pattern and condylar position[3, 11, 35-37]. However, only two published studies have carried out on the relationship between condylar position and vertical craniofacial pattern using CBCT [5, 19], notably still not carried out on different vertical facial type of skeletal class II patients. This study clearly showed variations in condyle position in the glenoid fossa based on both sagittal malocclusions and vertical craniofacial patterns. On the sagittal skeletal pattern and its relation to the anteroposterior condylar position, we found that the CII-NA group was associated with posteriorly positioned, while the CI-NA group tends to concentrically and anteriorly position, noting that the two groups have the same normal vertical facial pattern.

Some studies have failed to describe the correlation between the anteroposterior condylar position and vertical facial morphology[5, 38]. However, Maryam Paknahad[19] in their research on condylar position among different vertical skeletal pattern for the class I subjects, they found the condyles were further anteriorly-positioned in patients with high angle vertical pattern than average and low angle vertical pattern, which agreed with our findings. In the article mentioned above, the author has indicated that variation in the results could be due to one of these reasons; the type of sagittal malocclusion not considered, investment old radiograph technique or the disparity of age ranges in the studies which failed to describe this relation. However, the present study clarified that the class II sagittal pattern does not eliminate the effect of high facial pattern tendency in anteriorly positioning. On the other hand, the relationship between the sagittal craniofacial patterns with condylar position seems to be eroded in the presence of vertical skeletal pattern influence. As an instance, In Arieta-Miranda et al. study[35] on spatial analysis of condyle position related to the sagittal skeletal relationship by CBCT, they divided groups according to their ANB and vertical facial pattern to three groups: class I normal facial pattern, class II and III with the long facial pattern. They

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

showed the condyles were significantly more anteriorly positioned in class II and III than class I, referring that to different sagittal skeletal patterns, even though they mentioned the possibility of anteriorly positioned could be due to the vertical facial pattern of class II and III groups. However, the findings of the current study proved that the anteriorly positioned tendency at least in the class II group corresponded to the long facial pattern. So, this study not only compares the TMJ characteristic between different vertical skeletal patterns but also shed light on the interrelation might present in the condyle-fossa relations and TMJ measured parameters between the vertical craniofacial and sagittal skeletal morphologies. Hence, studying the TMJ and condyle-fossa relations according to the type of malocclusions must consider the vertical skeletal morphology to avoid misinterpreting. In addition to previously mentioned confounding factors, the diversity of ethnicity in the study, un-balanced gender distribution in studied groups and measuring method employed to define the condylar position may be one of the reasons for the disparity of the findings. Thus, the present study has evaluated only Chinese people with well-balanced gender distribution in groups, and utilizing two methods to define the position of the condyle in the glenoid fossa. The factor of age have been reported to have a certain impact on condyle-fossa morphology, condylar position [21], and articular eminence morphology due to remodeling and degenerative changes in the structural components of the joint[39, 40]. Accordingly, only young adult patients have been recruited in this study. Furthermore, any patient subjected to orthodontic treatment or any therapeutic procedure that can affect the occlusion integrity, and might affect the condylar position consequently were excluded from the study.

The presence of significant differences in the position of the condyle between vertical groups in class II patients might reveal the inequality in the amount pressures exerted on the joints between these groups, whereas the low, normal, and high angle groups were dominantly positioned concentrically, posteriorly and anteriorly, respectively. The CII-HA groupwas significantly smaller superior joint space compared to CII-LA group. This relationship might give rise to the presence of the adaptation responses to the masticatory forces in a high facial pattern which reflected on the position of the condyle by displacing it superiorly. Accordingly, this may confirm that the musculoskeletal system acts differently in different skeletal discrepancies which could support a view which describe this alteration in condylar position as a normal physiological responding at the expense of presence of TMJ dysfunction.

No significant difference in superior joint space between CI-NA and CII-NA may indicate that no relationship between sagittal skeletal class II malocclusion with the vertical plane. However, the superior joint space in CI-NA group was only significantly smaller respect to the CII-LA group which exhibit that the CII-LA associated with lower positioned condyle, these findings would seem to call for the presence of a synergistic influence of class II malocclusion and low vertical patterns in more inferiorly positioning of the condyle. Following these data, the fact of the direct influence on the mandibular position by the effect of the condylar position as some author suggested [41, 42] has become unlikely. Furthermore, some authors [43] support the concept that the condylar position has been subjected to the different biomechanical environment created by various skeletal and sagittal patterns, which get along with our findings

High angle craniofacial morphology was correlated with smaller anteroposterior and mediolateral condyle widths as well as smaller condylar head angle. Whereas CII-HA head condyle angle was significantly narrower than in CII-LA and CI-NA groups, and the anteroposterior width of the condyles in CI-NA was only significantly greater than CII-HA group. While the CII-LA was associated with a larger condyle whereas, the mediolateral condyle width in CII-LA was significantly greater compared to CII-NA, CII-HA, and CI NA. Moreover, the depth of mandibular fossa in CII-LA was significantly higher compared to all other groups. No significant differences were found in the articular eminence angle between groups.

As previously mentioned, the study only included patients with no evidence or history of TMD, but the degenerative joint conditions which were not accompanied by symptoms might be there, as the subject selection was depending on the lack of TMD symptoms. In this regard, the study aimed to evaluate the incidence of osteoarthritis changes in each group given that the subcortical cysts, osteophytes, surface erosion, or generalized sclerosis are a radiographic characteristic in this condition [44], but any symptoms as limited mouth opening, pain or clicking were not accompanied within this study. Abnormal condylar morphology was typical in the high and low angle groups. In particular, high angle facial morphology. (Table 7).

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

As the present study was recruited the skeletal class II patients according to the ANB angle, both class II division 1 and 2 were included. So, the impact of the difference between the two divisions was not considered. However, the HandeGorucu-Coskuner study[45] was the only study concerned with the difference between the two divisions of class II preadolescence patients in characteristics of the temporomandibular joint, whereas the mandibular fossa depth and anterior joint space were the only statistically significant differences between the Class II division 1 and division 2.. Therefore, it would be more logical to analyze the two divisions separately in future studies.

Conclusions

Both of skeletal class II malocclusion type and vertical craniofacial pattern showed a significant correlation with the position of the condyle. Presence of interrelation in some combination of the vertical and sagittal skeletal pattern which affect both position and morphologies of the condyle can be regarded for predicting and building a proper treatment plan for TMD during orthodontic treatment.

Acknowledgments

I would like to express my deepest gratitude to all the staff of the orthodontics Department for their help during my project work. My appreciation and deepest gratitude to. Dr. Basheer Hamed Hamood Al-Shameri for his help and guidance during the statistical analysis and writing phase.

References

1. Oliveira MVLD, Andrade MEA, Batista WO, Campos PSF, Andrade MEA, Batista WO, et al. Skin Doses On the Lens for Temporomandibular Joint Exam in Cone Beam Computed Tomography. Braz.arch.biol.technol 2015;58(6):886-90.
2. Al-Rawi NH, Uthman AT, Sodeify SM. Spatial Analysis of Mandibular Condyles in Patients with Temporomandibular Disorders and Normal Controls Using Cone Beam Computed Tomography. Eur J Dent 2017 2017-01-01;11(1):99-105.
3. Kaur A, Natt AS, Mehra SK, Maheshwari K, Singh G, Kaur A. Improved Visualization and Assessment of Condylar Position in the Glenoid Fossa for Different Occlusions: A Cbct Study. J Contemp Dent Pract 2016 2016-08-01;17(8):679-86.
4. Oh MH, Kang SJ, Cho JH. Comparison of the Three-Dimensional Structures of Mandibular Condyles Between Adults with and without Facial Asymmetry: A Retrospective Study. KOREAN J ORTHOD 2018 2018-03-01;48(2):73-80.
5. Park IY, Kim JH, Park YH. Three-Dimensional Cone-Beam Computed Tomography Based Comparison of Condylar Position and Morphology According to the Vertical Skeletal Pattern. KOREAN J ORTHOD 2015 2015-03-01;45(2):66-73.
6. Imanimoghaddam M, Madani AS, Mahdavi P, Bagherpour A, Darijani M, Ebrahimnejad H. Evaluation of Condylar Positions in Patients with Temporomandibular Disorders: A Cone-Beam Computed Tomographic Study. Imaging Sci Dent 2016 2016-06-01;46(2):127-31.
7. Turp JC, Schlenker A, Schroder J, Essig M, Schmitter M. Disk Displacement, Eccentric Condylar Position, Osteoarthrosis - Misnomers for Variations of Normality? Results and Interpretations From an Mri Study in Two Age Cohorts. BMC ORAL HEALTH 2016 2016-11-17;16(1):124.
8. Willems NM, Mulder L, Langenbach GE, Grünheid T, Zentner A, van Eijden TM. Age-Related Changes in Microarchitecture and Mineralization of Cancellous Bone in the Porcine Mandibular Condyle. J STRUCT BIOL 2007;158(3):421-7.
9. Hiroaki Ishibashi D, YasuharuTakenoshita D, Kuniko Ishibashi D, Masuichiro Oka M. Age-Related Changes in the Human Mandibular Condyle : A Morphologic, Radiologic, and Histologic Study ☆. Journal of Oral & Maxillofacial Surgery 1995;53(9):1023-4.
10. Burke G, Major P, Glover K, Prasad N. Correlations Between Condylar Characteristics and Facial Morphology in Class Ii Preadolescent Patients. American Journal of Orthodontics & Dentofacial Orthopedics 1998;114(3):328-36.
11. Matteo S, Michele DA, Daria R, Felice F, Antonella P, Simona T. Condylar Volume and Condylar Area in Class I, Class Ii and Class Iii Young Adult Subjects. HEAD FACE MED 2012;8(1):34.

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

12. Granados JI. The Influence of the Loss of Teeth and Attrition On the Articular Eminence. J PROSTHET DENT 1979 1979-07-01;42(1):78-85.
13. Wish-Baratz S, Hershkovitz I, Arensburg B, Latimer B, Jellema LM. Size and Location of the Human Temporomandibular Joint. AM J PHYS ANTHROPOL 1996;101(3):387-400.
14. Gianelly AA, Ruben MP, Risinger R. Effect of Experimentally Altered Occlusal Vertical Dimension On Temporomandibular Articulation. J PROSTHET DENT 1970;24(6):629-35.
15. Kurusu A, Horiuchi M, Soma K. Relationship Between Occlusal Force and Mandibular Condyle Morphology. Evaluated by Limited Cone-Beam Computed Tomography. ANGLE ORTHOD 2009;79(6):1063.
16. Hinton RJ. Changes in Articular Eminence Morphology with Dental Function. AM J PHYS ANTHROPOL 1981;54(4):439-55.
17. Seward FS. Tooth Attrition and the Temporomandibular Joint. ANGLE ORTHOD 1976;46(2):162-70.
18. O'Ryan F, Epker BN. Temporomandibular Joint Function and Morphology: Observations On the Spectra of Normalcy. Oral Surg Oral Med Oral Pathol 1984 1984-09-01;58(3):272-9.
19. Paknahad M, Shahidi S. Association Between Condylar Position and Vertical Skeletal Craniofacial Morphology: A Cone Beam Computed Tomography Study. Int Orthod 2017 2017-12-01;15(4):740-51.
20. Wu CK, Hsu JT, Shen YW, Chen JH, Shen WC, Fuh LJ. Assessments of Inclinations of the Mandibular Fossa by Computed Tomography in an Asian Population. CLIN ORAL INVEST 2012;16(2):443-50.
21. Liu Q, Wei X, Guan J, Wang R, Zou D, Yu L. Assessment of Condylar Morphology and Position Using Msct in an Asian Population. Clin Oral Investig 2018 2018-09-01;22(7):2653-61.
22. Ganugapanta VR, Ponnada SR, Gaddam KP, Perumalla K, Khan I, Mohammed NA. Computed Tomographic Evaluation of Condylar Symmetry and Condyle-Fossa Relationship of the Temporomandibular Joint in Subjects with Normal Occlusion and Malocclusion: A Comparative Study. J Clin Diagn Res 2017 2017-02-01;11(2):C29-33.
23. Ilguy D, Ilguy M, Fisekcioglu E, Dolekoglu S, Ersan N. Articular Eminence Inclination, Height, and Condyle Morphology On Cone Beam Computed Tomography. ScientificWorldJournal 2014 2014-01-20;2014:761714.
24. Katsavrias EG. Changes in Articular Eminence Inclination During the Craniofacial Growth Period. ANGLE ORTHOD 2002 2002-06-01;72(3):258-64.
25. Piancino MG MD DP, Tepedino M DDS P, Cavarra F DDS M, Bramanti E DDS P, Lagana G DDS MP, Chimenti C MD DM, et al. Condylar Long Axis and Articular Eminence in Mri in Patients with Temporomandibular Disorders. CRANIO 2018 2018-10-17:1-9.
26. Paknahad M, Shahidi S, Akhlaghian M, Abolvardi M. Is Mandibular Fossa Morphology and Articular Eminence Inclination Associated with Temporomandibular Dysfunction? J Dent (Shiraz) 2016 2016-06-01;17(2):134-41.
27. Panmekiate S, Petersson A, Akerman S. Angulation and Prominence of the Posterior Slope of the Eminence of the Temporomandibular Joint in Relation to Disc Position. DentomaxillofacRadiol 1991 1991-11-01;20(4):205-8.
28. Hilgers ML, Scarfe WCScheetz JP, Farman AG. Accuracy of Linear Temporomandibular Joint Measurements with Cone Beam Computed Tomography and Digital Cephalometric Radiography. American Journal of Orthodontics & Dentofacial Orthopedics 2005;128(6):803-11.
29. Ludlow JB, Laster WS, See M, Bailey LJ, Hershey HG. Accuracy of Measurements of Mandibular Anatomy in Cone Beam Computed Tomography Images. Oral Surgery Oral Medicine Oral Pathology Oral Radiology & Endodontology 2007;103(4):534-42.
30. Schlueter B, Kim KB, Oliver D, Sortiropoulos G. Cone Beam Computed Tomography 3D Reconstruction of the Mandibular Condyle. ANGLE ORTHOD 2008;78(78):880-8.
31. Pullinger AG, Hollender L, Solberg WK, Petersson A. A Tomographic Study of Mandibular Condyle Position in an Asymptomatic Population. J PROSTHET DENT 1985 1985-05-01;53(5):706-13.

October 2019;6(10) ISSN: ISSN: 2349-5340
DOI: 10.5281/zenodo.3502167 Impact Factor: 4.054

32. Nakajima A, Sameshima GT, Arai Y, Homme Y, Shimizu N, Dougherty HS. Two- And Three-Dimensional Orthodontic Imaging Using Limited Cone Beam-Computed Tomography. ANGLE ORTHOD 2005 2005-11-01;75(6):895-903.
33. Kobayashi K, Shimoda S, Nakagawa Y, Yamamoto A. Accuracy in Measurement of Distance Using Limited Cone-Beam Computerized Tomography. Int J Oral Maxillofac Implants 2004 2004-03-01;19(2):228-31.
34. Dalili Z, Khaki N, Kia SJ, Salamat F. Assessing Joint Space and Condylar Position in the People with Normal Function of Temporomandibular Joint with Cone-Beam Computed Tomography. Dent Res J (Isfahan) 2012 2012-09-01;9(5):607-12.
35. Arieta-Miranda JM, Silva-Valencia M, Flores-Mir C, Paredes-Sampen NA, Arriola-Guillen LE. Spatial Analysis of Condyle Position According to Sagittal Skeletal Relationship, Assessed by Cone Beam Computed Tomography. PROG ORTHOD 2013 2013-10-18;14:36.
36. Katsavrias EG, Halazonetis DJ. Condyle and Fossa Shape in Class Ii and Class Iii Skeletal Patterns: A Morphometric Tomographic Study. Am J Orthod Dentofacial Orthop 2005 2005-09-01;128(3):337-46.
37. Krisjane Z, Urtane I, Krumina G, Zepa K. Three-Dimensional Evaluation of Tmj Parameters in Class Ii and Class Iii Patients. Stomatologija 2009 2009-01-20;11(1):32-6.
38. Burke G, Major P, Glover K, Prasad N. Correlations Between Condylar Characteristics and Facial Morphology in Class Ii Preadolescent Patients. Am J Orthod Dentofacial Orthop 1998 1998-09-01;114(3):328-36.
39. Sulun T, Cemgil T, Duc JM, Rammelsberg P, Jager L, Gernet W. Morphology of the Mandibular Fossa and Inclination of the Articular Eminence in Patients with Internal Derangement and in Symptom-Free Volunteers. Oral Surg Oral Med Oral Pathol Oral RadiolEndod 2001 2001-07-01;92(1):98-107.
40. Kurita H, Ohtsuka A, Kobayashi H, Kurashina K. Flattening of the Articular Eminence Correlates with Progressive Internal Derangement of the Temporomandibular Joint. DentomaxillofacRadiol 2000 2000-09-01;29(5):277-9.
41. Mongini F. [Changes in the Temporo-Mandibular Joint in Partial Edentulism]. Minerva Stomatol 1968 1968-10-01;17(10):850-8.
42. Wedel A, Carlsson GE, Sagne S. Temporomandibular Joint Morphology in a Medieval Skull Material. SWED DENT J 1978 1978-01-19;2(6):177-87.
43. Tanne K, Tanaka E, Sakuda M. Stress Distributions in the Tmj During Clenching in Patients with Vertical Discrepancies of the Craniofacial Complex. J Orofac Pain 1995 1995-03-01;9(2):153-60.
44. Nah KS. Condylar Bony Changes in Patients with Temporomandibular Disorders: A Cbct Study. Imaging Sci Dent 2012 2012-12-01;42(4):249-53.
45. Coskuner HG, Ciger S. Computed Tomography Assessment of Temporomandibular Joint Position andDimensions in Patients with Class Ii Division 1 and Division 2 Malocclusions. Journal of Clinical & Experimental Dentistry 2017;9(3):e417-23.