King Saud University

Saudi Dental Journal

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ORIGINAL ARTICLE

Relationship between horizontal condylar angle and radiographically detectable morphological changes of the condyle in asymptomatic and symptomatic patients with TMD

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Abstract *Background:* The relationship between horizontal condylar angle (HCA) measurements and radiographically detectable morphological changes of the condyle in patients with temporomandibular disorder (TMD) is an area of controversy in dentistry.

Aim: This study sought to determine the effect of the HCA on radiographically morphological changes in the condyles of asymptomatic and symptomatic patients with TMD.

Material & methods: Cone beam computed tomography (CBCT) scans were used of patients with 146 temporomandibular joints (TMJ) with and without symptoms of TMD. The reconstructed axial plane was adjusted to depict the condyle in maximum width. The HCA was established and measured as the angle formed between the condylar long axis intersecting with the coronal plane. Each condyle long axial was determined independently from the other joint by two oral and maxillofacial radiologists. The average of the readings from the two examiners was used for statistical analysis.

Results: Based on the clinical symptoms, the mean of the HCA in the symptomatic joint was 27.69°, which was slightly greater than the angle measured in asymptomatic patients of 25.6°; however, this was not a statistical difference. No significant differences existed in the mean of the HCA between the joint with and without radiographic arthritic findings in both groups. In both groups, none of the arthritic findings manifested in the affected joint that had influenced the HCA.

Conclusion: The HCA was increased in the symptomatic group but had no direct influence on joint's morphological changes in the asymptomatic and symptomatic patients.

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

1. Introduction

Temporomandibular disorder (TMD) is a broad orthopedic term that encompasses numerous pathological conditions that can affect the hard or soft tissue components of the

temporomandibular joint (TMJ). Among these is degenerative osteoarthritis (DO) (de Leeuw, 2013). TMJ osteoarthritis affects the joint's hard and soft tissue components, causing malformation of joint tissues. The affected part deforms to overcome disease progression and prevent further destruction. Consequently, remodeling of the joint occurs, resulting in altered morphology. Upon radiographic interpretation, cortical erosion, sclerosis, or osteophyte formation of any part of the joint can be apparent as radiographic manifestation (Dworkin and LeResche, 1992; Ahmad et al., 2009; Schiffman et al., 2014). TMJ osteoarthritis can affect wide range of age groups (Tanaka et al., 2008; Wang et al., 2015). Some patients may experience signs and symptoms, while others may not. The severity of symptoms varies among individuals with or without evidence of manifestations on radiographic examination.

Numerous researchers have documented TMD signs and symptoms among the younger group of people, none of these studies conducted any radiographic examinations to support their findings (Al-Khotani et al., 2016; Zwiri and Al-Omiri, 2016; Aldhalai et al., 2017).

Symptomatic patients with TMJ osteoarthritis may exhibit radiographic signs of morphological changes while others, for unknown reasons may not exhibit any evidence of these morphological changes. However, asymptomatic individuals exhibit morphological changes based on the radiographic assessment as reported by Al-Ekrish et al. (2015). Wide range of horizontal condylar angle (HCA) from 15° to 33° have been reported in asymptomatic individuals (White and Pharoah, 2014; Westesson et al., 1991; Sülün et al., 2001). Few studies have been conducted to study the effect of the HCA on the morphology of the condyle on symptomatic and asymptomatic patients with TMD. Based on the contradictory findings reported by many researchers, it is not clear if the HCA could have a direct effect on the arthritic changes in patients with signs and symptoms of TMD. Therefore, this study conducted to determine the effect of the HCA on the morphological changes of the condyle in asymptomatic and symptomatic patients with TMD.

2. Material and methods

Approval from the Institutional Review Board at the College of Dentistry, king Saud University (registration number NF 2228) was obtained. The selection process of patients was described in a previous publication by Al-Ekrish et al. (2015). A cone beam computed tomography (CBCT) device was used (Iluma, Imtek Imaging, 3 M Company, USA) with a large field of view; the detector was a flat panel 19 × 24 cm in size. The exposure parameters were 3.8mA, 120 kV and a 40 s exposure time with voxel size 0.29 mm. The processed data set was saved on the workstation of the CBCT device.

CBCT images were interpreted and assessed by two oral and maxillofacial radiologists with more than seven years of experience interpreting CBCT images. Uluma software for reformatting processing tools was used (Iluma- Vision 3-D (Version 1.0.2.5). The selected patients were recruited from the Department of oral and maxillofacial radiology who referred for CBCT examination. None of the CBCT scan of asymptomatic group were done originally for this study, the

CBCT were done for various reasons; assessment of impacted third molar, impacted canine, implant site assessment or other reasons required CBCT. The total sample reviewed were 408 joints. Two hundred sixty-two (262) joints were excluded because they were not suitable for angular measurement. For this study only 146 joints from both groups were available for angular measurement. The majority of the selected sample had both right and left joints available for measurement. Fifty-three joints belonged to the symptomatic group, and 93 joints belonged to the asymptomatic group, who did not show any signs and symptoms of TMD based on review of their dental files. CBCT scans with high diagnostic qualities used for Interpretation and analysis. Both examiners were blinded with regards to the clinical and radiographic changes and the category of each groups.

For interpretation and angle measurement, scans were in a closed-mouth position. The reconstructed axial plane was parallel to the cranial base. The sagittal plane was parallel to the nasal septum (in both coronal and axial views). The axial section was determined individually for the right and left TMJs at the level corresponding to the largest dimension of the condyle mediolaterally. The angle formed between the condyle's horizontal long axis and the coronal plane, as demonstrated by Fig. 1, was measured. For each individual the HCA of the right and left joints were individually determined by both examiners, the average of HCA obtained by the two examiners was consider for statistical analysis.

For testing the reliability between examiners, interclass correlation between the two examiners was fair; therefore, the average readings from the two examiners were used for statistical analysis.
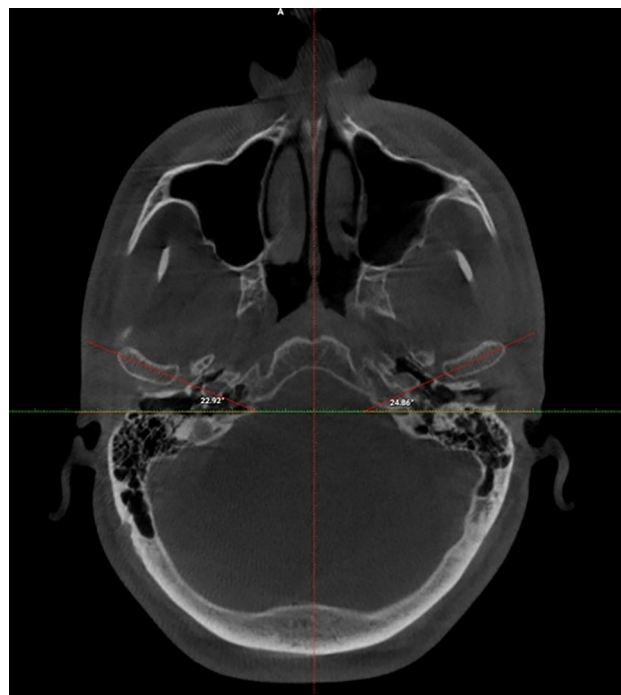

Fig. 1 Reconstructed Axial plane demonstrates the maximum mediolateral length of the mandibular condyle with HCA of the condyle's. The coronal plane perpendicular to the midsagittal plane. The angle formed between the horizontal condylar long axis and the coronal plane.

Data was collected and analyzed using SPSS ((Statistics V 22.0) Package for the Social Sciences, IBM Software Group, USA). Mean and standard deviations were calculated. An independent *t*-test was used to determine the statistical significance of the differences between the two groups was used. A P-value of < 0.05 was considered statistically significant.

3. Results

A total of 146 joints of both groups were included. These joints belonged to 70 males (47%) and 76 females (52.1%) with a mean age of 33.82 ± 13.57-year-old. In the asymptomatic group, the average age was 33.68 years old, while in the symptomatic group, the mean age was 34.01-year-old.

The average HCA in the symptomatic group was 27.69°, which is more than the HCA of asymptomatic group's angle 25.67°. Using an independent *t*-test, no statistically significant difference existed between the two groups with p < 0.05. Table 1 demonstrate the HCA depicted in male and female of both groups. The difference was insignificant between them for asymptomatic as well as the symptomatic group with a P-value of 0.189 and 0.375 respectively.

Based on radiographic findings, Table 2 showed that, for the asymptomatic group, 18 joints showed no arthritic changes and 69 joints showed radiographic arthritic changes. In this group, the mean of the HCA for the joints without arthritic changes was 26.42° whereas the mean of affected joints with arthritic changes was 25.46°, no significant difference between the joints with arthritic and without arthritic changes existed.

For the symptomatic group, we were able to identify 43 joints with various arthritic changes and nine joints without any arthritic changes. The means of the HCA for the affected joint and unaffected joints was 27.2° and 30.71°, respectively. Using an independent *t*-test, no statistically significant difference existed in either group for joints with degenerative arthritis or without arthritic changes.

This study could not confirm the influence of arthritic changes on the HCAs of either group because the asymptomatic group also showed arthritic changes as well. Tables 3 and 4, show no significant difference between either group affected by erosion, or osteophyte.

Few cases of generalized sclerosis and subcortical cysts were identified in both groups; therefore, no further statistical analysis was carried out.

4. Discussion

Temporomandibular Disorder (TMD) is a major public health problem that can disturb the health of affected individuals. TMD has a multifactorial etiology associated with several risk elements that play a major role in the initiation, spread, and exacerbation of TMD symptoms (McNeill, 1997). The sample included in this study was selected based on TMD symptoms and not based on the diagnosis of the condition.

The most frequent type of osteoarthritic radiographic manifestations detected in patients with TMD are erosion, osteophytes, flattening, sclerosis, and subcortical cysts (Ahmad et al., 2009). In this study, all of these arthritic changes were

Table 1 Descriptive statistics of HCA values obtained for the asymptomatic and symptomatic groups based on clinical diagnoses.

Groups	Number of joint	Mean of HCA	Standard deviation	# of joint in female (HCA)	# of joint in Male (HCA)	P -value
Asymptomatic	93	25.67	6.50	39(26.71)	54(24.91)	0.189
Symptomatic	53	27.69	7.19	37(28.27)	16(26.34)	0.375
P -value		0.085				

Table 2 Descriptive statistics of HCA values obtained for asymptomatic and symptomatic groups based on radiographic arthritic changes.

Groups	Radiographic findings	N	Mean	Std. Deviation	P-value
Asymptomatic	without arthritic changes	24	27.15	6.46	0.198
	with arthritic changes	63	25.10	6.61	
Symptomatic	Without arthritic changes	18	30.08	7.45	0.098
	with arthritic changes	34	26.60	6.88	

Table 3 Descriptive statistics of HCA values obtained for asymptomatic and symptomatic groups based on the radiographic changes of erosion.

Groups	Erosion	Number of joint	Mean	Standard Deviation	P-value
Asymptomatic	No	24	27.15	6.46	0.198
	Yes	63	25.10	6.61	
Symptomatic	No	18	30.08	7.45	0.098
	Yes	34	26.60	6.88	

Table 4 Descriptive statistics of HCA values obtained for asymptomatic and symptomatic groups with osteophyte formation.

Groups	Osteophyte	Number of joint	Mean	Standard Deviation	P-value
Asymptomatic	No	42	25.84	6.16	0.812
	Yes	45	25.50	7.05	
Symptomatic	No	22	27.62	6.05	0.874
	Yes	30	27.94	8.04	

investigated except for flattening because it might be considered as an aging process in elderly. Therefore, in this study, the manifestation was not considered to be DO if the condyle was affected by flattening alone. Only changes in the condyle's morphology were considered in this study because the condyle is the most part affected by arthritic changes other than the temporal component.

CBCT is the preferred imaging modality for imaging of the TMJs with osteoarthritic changes because it has several advantages compared with Multidetectors CT, as reported by many investigators (Tsiklakis et al., 2004; Larheim et al., 2015) with high diagnostic accuracy for detecting the condyle's osteoarthritic changes (Honda et al., 2006; Patel et al., 2014).

The TMJ is an extremely challenging research topic, as it has been extensively investigated by various dental specialties because unsuccessful dental treatments can influence the TMJ. It is a complex structure that represents articulation between bony, soft tissue structures with the help of teeth that provide support for the stability of the condyles within the joint. These structures should be working together in harmony as one unit. However, disturbance of any components can lead to the development of a broad spectrum of clinical symptoms with various severity between individuals. Patients respond differently due to this dysfunction. Explaining why some symptomatic individuals may or may not reveal radiographic manifestation of arthritic changes. For unknown reasons, some individuals may develop arthritic changes despite being asymptomatic of TMD signs and symptoms, and the degenerative arthritic changes will be discovered incidentally when the TMJ area is examined for another purpose, as reported in the previous publication (Al-Ekrish et al., 2015).

Sato et al. (1997) have used Submentovertical View (SMV), lateral and frontal TMJ tomography to study the effect of HCA on the presence of radiographic changes in patients with osteoarthritis compared to asymptomatic patients. Their results did not confirm that condyles with higher HCA presented with abnormal radiographic changes than in those with a normal joint. This was the same result obtained in this study despite different imaging modalities used.

Lee et al. (2017) have studied the HCA in unilateral condyles affected by moderate or severe osteoarthritis and compared them with the unaffected joints, they found the HCA was greater in affected joints compared with unaffected joints of the same individual with a significant difference. Their result was consistent with this study's results as the HCA in TMD patient's was greater than asymptomatic patients, but this difference was insignificant. The difference between this study and their study was that they compared the joints with moderate and severe arthritic changes with unaffected joints of the same individuals. However, in this research, the severity of the osteoarthritic changes not determined. Patients showing any radiographic manifestations of

arthritic changes with various severity were included. Also The comparison between the two groups was based on the reported TMD symptoms.

Eisenburger et al. (1999) used CT to measure the intercondylar angle in symptomatic patients and a control group. By measuring the intercondylar angle at the intersection of the condyles' longitudinal axes, they found no significant difference between the studied groups, which is the same result obtained in this study. Their method is not comparable to this study's design; therefore, no further comparison is made.

Al-Rawi et al. (2017) have used CBCT to measure the angle formed between the long axis of the condyle with a midsagittal plane in symptomatic and asymptomatic individuals; they found that the mean HCA of the symptomatic TMJ was (15.63°) which was smaller than control group (21.19°), which contradicts the result obtained in this study. This could be due to the different methods used to measure the HCA between the two studies.

It was difficult to compare precisely our results with other studies due to different criteria of sample selection and the design of study.

The HCA of asymptomatic patients was presented differently in different populations. Westesson et al. (1991) have found that the average HCA in the normal joint was 21.1°. Sülün et al. (2001) using MRI, found that the average HCA in Turkish population was 25.68°. Using CBCT, Lee et al. (2017) have reported that the HCA in the control group was 23.83°. The HCA of control individuals reported by Al-Rawi et al. (2017) was 21.19°. In the present study, the average of the HCA in asymptomatic individuals was 25.64°, which falls within the reported average of previous studies.

In this study, most joints (76%) were affected by arthritic changes; this could explain why we did not find any significant difference between asymptomatic and symptomatic groups because both groups had arthritic changes.

The debate between researchers is continuous. Some support the idea that an increased HCA is associated with anterior disk displacement and arthritic changes, while others are not in favor of these findings. In the current study, a group of symptomatic patients was affected by osteoarthritis or diagnosed with anterior disk displace. This could explain why our finding lies within the range of reported HCA of previous results for TMD patients.

This variation among researchers could be attributed to use of different imaging modalities. As well as selection and reformatting of the axial plane used for angle measurements, and reference lines may also vary because selecting the point to determine the most lateral and medial pole to determine the maximum width of the condyle is subjective and could be influenced by the experience of the radiologist.

Lee et al. (2017) have measured the HCA three separate times. The mean of the three measurements for each joint was then calculated and used for all the analyses. However, in the current study, two oral and maxillofacial radiologists independently measured the HCA of the entire sample. Moreover, to avoid inter-examiner variability, the average reading of both oral radiologists was used for statistical analysis.

It is difficult to state if the arthritic changes depicted in symptomatic and asymptomatic individuals are due to increased HCA alone. Many factors should be considered. For instance, the patients' age, hyperactivity of the muscle of mastication, or if the patients clench their teeth, which is not investigated previously or by this study.

The inclination of the HCA of the condyle within the joint is crucial in the case of condylar replacement, which is a treatment option for a diseased joint. Condylar replacement is one of the major treatment strategies implemented due to benign or malignant tumors of the mandibular condyle. Surgeons need to restore function by replacing the resected condyle with a prosthetic condyle or 3D fabrication of the condyle. The surgeon needs to consider normal orientation and inclination of the condyle within the joint to establish harmony between the patients' stomatognathic system. The HCA is varied among populations, and it is suggested to determine the appropriate inclination based of a local population rather than the results reported by various racial groups.

The limitation of this study is that the severity of the arthritic changes was not determined; the heterogonous group included diagnosed as having TMD included as symptomatic patients. It is preferable to know the TMD diagnosis. It will be more precise if the diagnosis is known.

5. Conclusion

HCA was increased in the symptomatic group but had no direct influence on the joint's morphological changes in symptomatic and asymptomatic patients. The effect of HCA in the development of TMJ arthritic changes which affect the condyle's morphology, is debatable.

Data availability

The data set is available upon reasonable request

Funding

Ethical Statement

This study was conducted after obtaining approval from the Institutional Review Board at the College of Dentistry, King Saud University (Registration number NF 2228).

CRediT authorship contribution statement

Wafa Alfaleh: Conceptualization, Data curation, Formal analysis, Investigation, Supervision, Project administration, Writing - original draft.

Declaration of Competing Interest

The author of this manuscript has no conflict of interest to declare.

Acknowledgment

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