CBCT based Comparison of Condylar Postion in Hypodivergent and Hyperdivergent Facial Skeletal Pattern

Ajoy Kumar Shahi[1], Subhash Chandra[2], Anurag Rai[3], Amesh Golwara[2]

ABSTRACT

Introduction: Orthodontists have always believed in the appropriate positioning of mandibular condyle in relation to the glenoid fossa, when teeth are in maximum intercuspation. Orthodontic diagnosis and treatment planning are considered on skeletal pattern of the patient.
Objective To compare condylar position between hypodivergent and hyperdivergent skeletal patterns.
Material and Methods: Diagnostic cone-beam computed tomography images of two groups of 15 subjects, each representing the extremes in facial type, who visited our orthodontic clinic were reviewed. The subjects were divided into two equal groups according to the mandibular plane angle: hypodivergent, and hyperdivergent groups. The total amount of change between the 2 groups was examined using a statistical *t*-test
Results: The hypodivergent and hyperdivergent groups showed a statistically significant differences in superior joint spaces.
Conclusion: Condylar position vary according to vertical facial morphology. The findings of this study demonstrated significantly lesser Superior joint space for hyperdivergent group as compared to hypodivergent group Therefore, condylar position and joint spaces should considered during assessment of orthodontic cases, the risk of misdiagnosis is high, being significantly higher in patients with the hyper divergent facial pattern

Keywords: Cone beam computed tomography, Hypodivergent face type, hyperdivergent face type, Condylar position.

INTRODUCTION

The ideal position of the condyle in the glenoid fossa during maximum intercuspation is one of the goal of the temporomandibular joint (TMJ) oriented orthodontic treatment planning.[1,2] Although, the occlusion of the patient can be observed directly in the mouth, condylar position in the fossa is unapproachable to the naked eye.[3]
There are several factors that could affect the TMJ morphology and condyle position, such as age, sex, facial growth pattern, pathological/functional alterations, decreased or increased muscular activity, occlusal force, and dental occlusion changes.[4-7]
The condylar position in the glenoid fossa can be determined by the dimension of the joint space. The joint space is a term radiographically used for description of the radiolucent zone seen between condylar and temporal parts.[8]
The use of conventional radiographs to asses TMJ has inherent limitations such as structural superimpositions in two-dimensional imaging, particularly in the region of the petrous temporal bone, the mastoid process, and the articular eminence, which indeed limits an accurate view of the TMJ.[9] The complex structure of the TMJ makes radiographic examination difficult, and accurate diagnosis requires several types of radiographic images.
Conventional radiologic imaging techniques such as panoramic radiography, TMJ radiography, both open- and closed-mouth transcranial projections, linear tomography, cannot show anatomical relationships exactly, as a result, modern imaging modalities such as MRI and CT are now being used more frequently for radiographic TMJ examination.[9]
Magnetic Resonance Imaging (MRI) is considered as one of the most useful tools that show disc displacement. Unfortunately MRI gives a little information of the bone TMJ structures.[10,11] Computed tomography (CT) provides three-dimensional images of the bony components of TMJ but radiation dose is very high. Cone beam computed tomography (CBCT) allows higher resolution three dimensional imaging of TMJ structures with lower radiation doses than conventional spiral CT. [11,12]
CBCT has several advantages such as lower radiation dose and rapid scan time and reduced image artifact compared to conventional spiral computed tomography. Multiplanar reformatting of the image can be done using CBCT. CBCT technique allows the measurement of the position of condyle in the glenoid fossa with high accuracy. It gives high quality istotropic images of the bony components in all planes[11,12]
Studies focusing on the relation between facial configuration and TMD indicate an association of hyperdivergency with TMD.[13,14] Several studies have been done to establish relationship between facial morphology and condylar position.[15-19] In addition, Condylar displacement of significant magnitude occurs frequently in the asymptomatic population and represents an attempt to compensate for disproportions.
Gidarakou found there was an increase in the mandibular plane angle (Go Gn to SN) and an increase in the gonial

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angle of the mandible (Ar-Go-Me) to be associated with increased TMJ internal derangement.[16] Girardot reported a more significant Condylar displacement in hyperdivergent facial morphologies, whereas Burke et al. found diminished upper articular joint spaces in the same facial type.[15,19]

Stringent and worms studied the relationship between skeletal pattern and internal derangement. They found greater incidence of internal derangement in hyperdivergent skeletal pattern.[20]

A vertical facial pattern is a factor considered in the condylar-glenoid fossa relation because
patients with a long vertical facial pattern exhibit greater divergence of the palatal and mandibular plane influencing condylar rotation, which can be displaced with respect to a group of medium vertical pattern control.[21]

Despite reasonable evidence of Dolichofacial configurations being more prone to articular instability, data related to the subject is scarce and conflicting. For the above reasons, it has been hypothesized that vertical skeletal pattern is a factor influencing condylar position.

However, this information has not been reported yet with data obtained through CBCT imaging. Therefore, the aim of this study was to compare the CBCT-based spatial analysis of the mandibular condylar position as related to hypodivergent and hyperdivergent facial skeletal pattern.

MATERIALS AND METHODS

All the CBCT images were obtained from previously available diagnostic data from patients currently under orthodontic treatment. These CBCT images were not specifically taken for this study but were already taken through the request of the treating professional for many reasons except TMJ disorder. Informed consents were obtained from each subject before obtaining the records to use their volumetric data of CBCT images for study.

CBCT images of patients (between 14 years and 26 years old) with full permanent dentition at maximum occlusal intercuspation and with dolichofacial (hyperdivergent) and Brachyfacial (hypodivergent) skeletal pattern were obtained for study.

The research protocol was reviewed and approved by Ethical committee of the Institute. Condylar position was studied in two groups of 15 subjects each representing the extremes in facial type. The subjects were patients who reported to our practice. Based on the study criteria, we included individuals, who were between 14 to 26 years of age and facial skeleton characteristics as measured cephalometrically. Age was a criterion for selection since the intention was to study young adult subjects having completed growth or close to completion of growth. Facial skeleton type was determined by using the Jarabak rotation index and mandibular plane angle. Subjects were considered to be hyperdivergent if the posterior- anterior face height ratio (sella – gonion/ nasion-menton) was 59% or less and mean mandibular plane angle was 34 degrees or more. Subjects were considered to be hypodivergent if the posterior- anterior face height ratio (sella – gonion/ nasion- menton) was 65% or more and mean mandibular plane angle was 19 degrees or less.

Patients were excluded if they had missing permanent teeth except third molars, grossly carious teeth, restorative treatment, mobile teeth due to advanced periodontitis, crossbite or open bite, functional mandibular deviation due to occlusal interference, previous orthodontic treatment, history, clinical signs and symptoms of TMDs as determined by patients clinical history and clinical examination, previous TMD treatment, evident dental or facial asymmetry, congenital skeletal deformity such as cleft lip and palate, and history of trauma or surgery to the temporomandibular joints. In addition patients were excluded if they had deviation on opening and closure, mouth opening less than 40 mm, Class III malocclusion and Class II div2 malocclusion. It was felt these factors could significantly affect condylar length and / or the occlusion, which could in turn distort data gathered for the study.

The records utilized included clinical history to evaluate TMJ dysfunction, clinical examination, Lateral cephalometric radiograph in centric occlusion,

Cephalometric measurements made were Mandibular plane angle (GoGn – SN),Anterior facial height, Posterior facial height, PFH x 100/AFH (Jarabak's ratio).

Cone-beam computed tomography images were taken with the subject in an upright standing position, placing with no chin rest. Head position was adjusted using mid-sagittal positioning laser beam for a central positioning. Temple supports were tightened. No bite blocks were used, and the scan was taken in maximum intercuspal position.

Temporomandibular joints were scanned with Sirona Orthophos XG 3D cone-beam 3D CT System (Sirona, Germany) with a volume size of FOV 8 cm × 8cm. CBCT Protocol was:

a) FOV: 8cmsX 8cms.
b) Maximum slices: 511
c) Slice thickness: 0.16 mm
d) Peak voltage: 85kVp
e) Tube current: 5mA
f) Scan time: 14.2s
g) Radiation dose: 64µSv

Axial, coronal, sagittal, cross-sectional and 3D images in bone window are generated. The acquired data was reconstructed into MPR image and panoramic projection. Measurements were done at slice thickness of 160 microns (0.16 mm). The acquired volume was reconstructed into three-dimensional images with volume rendering software – CS 3D Imaging Software 3.1.9 (Carestream Health Inc.).

The following measurements were assessed according to a study conducted by Ikeda and Kawamura[11] (Figure 1)

a. Anterior joint space (AS): Expressed by the shortest distance between the most anterior point of the condyle and the posterior wall of the articular tubercle

b. Superior joint space (SS): Measured from the shortest distance between the most superior point of the condyle and the most superior point of the mandibular fossa

c. Posterior joint space (PS): Represented by the shortest distance between the most posterior point of the condyle and

the posterior wall of the condylar fossa.
Linear measurements of optimal joint space between the condyle and fossa were made on the sagittal section of the orthogonal slicing in the software module (Figure-2).
Data gathered from the measurements were tabulated and organized to compare the Anterior, Superior and posterior joint spaces between the hyperdivergent and hypodivergent groups

RESULT

The images of the TMJ of the 30 subjects were taken using limited CBCT to evaluate the optimal condylar position. Anterior joint space, Superior joint space and Posterior joint space were measured, and the values were subjected to statistical analysis. A statistical report was created from linear measurements of joint space to compare both groups. A student's t- test was performed for comparison of joint space in hypodivergent (Group I) and hyperdivergent (Group II) skeletal pattern.
Mean AS, SS, and PS of right and left side TMJ 's of hypdivergent (Group I) and hyperdivergent (Group II) skeletal pattern were calculated and presented in Table 1. Paired *t*-test were used for each measurement to evaluate the average differences between the right and left side of group and between Group I and Group II. Statistical analysis with the *t*-test indicated no significant differences in right and left AS and PS values between the hypodivergent and and hyperdivergent groups. Statistically significant differences in right and left Superior joint space were found between the hypodivergent and hyperdivergent groups.

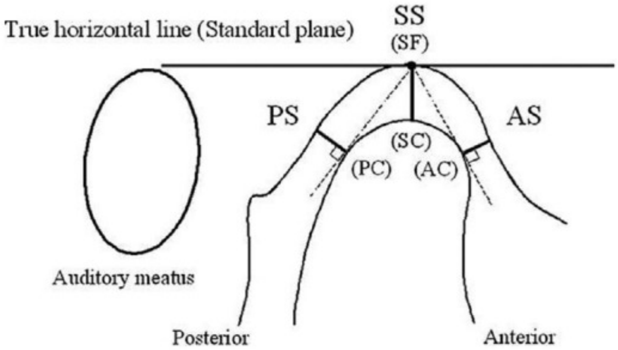

Figure-1: Measurements of Anterior, Superior and Posterior joint space

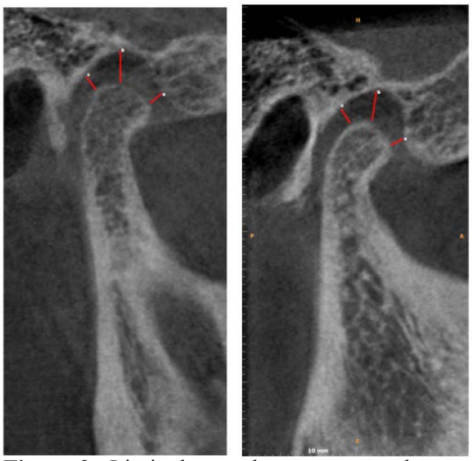

Figure-2: Limited cone beam computed tomography images of temporomandibular joint a. Anterior joint space (AS), b Superior joint space (SS), C Posterior joint space

		Group 1	Group2	SIG
AS	R	1.72 ± 0.3	1.64 ±0.4	
	L	1.78 ±0.5	1.70 ±0.5	
PS	R	2.24 ±0.4	2.14 ±0.5	
	L	2.32 ±0.3	2.26 ±0.4	
SS	R	3.14 ±0.5	2.42 ±0.6	*
	L	3.18 ±0.6	2.38 ±0.7	*

Table-1: Values are presented as mean ± standard deviation. Group 1 Hypodivergent, Group 2 is hyperdivergent, R –Right, L- Left. * $p < 0.05$

DISCUSSION

Knowledge on the spatial variations of normal condyle-glenoid fossa relationship
could allow the clinician to potentially identify the beginning of a degenerative joint disease or indicate problems already established, as well as better treatment planning where obtaining values closer to normal is indicated.[21,21] Therefore, the accurate determination of these values in conjunction with clinical observations could be of great importance for diagnosis and treatment planning in different skeletal relationships.
Proper diagnosis plays an important role in the successful treatment of temporomandibular dysfunction that includes internal derangement, osteo-arthrosis, and myofacial syndromes. Dolwick defined internal derangement of TMJ as the abnormal relationship of the articular disc to the condyle, fossa and articular eminence with disc usually displaced in anteromedial direction.[23,24]
Temporomandibular joint is a unique joint. Moreover, TMJ is a rather difficult area for radiological investigation because there is no possibility for accurate evaluation of this position in conventional radiographs. Thus, more advanced techniques are needed to show anatomical relationships accurately.[25]
Ikeda and Kawamura[11] also stated that the accurate measurement of condylar position can be done using CBCT and MRI. Soumalainen *et al*.[26] showed that the error of the linear measurement by using CBCT technique is less than multislice CT. Kobayashi *et al*.[27] found that the measurement error was significantly less with CBCT technique than the spiral CT. Moreover, CBCT allows accurate morphologic assessment of the bony structures of TMJ.[11]
The significantly smaller superior joint space in the hyperdivergent group indicates that the hyperdivergent skeletal pattern is associated with more superiorly positioned condyles. Similarly, Burke et al. found reduced superior joint space and posteriorly inclined condyles in preadolescent patients with skeletal Class II malocclusion and hyperdivergent tendency. They believe that this tendency reflects reduced condylar

tissue, predicts decreased condylar growth potential, and eventually results in increased anterior facial height during growth and development of the nasomaxillary and dentoalveolar complex.[15] They didn't find any correlation between facial morphology and antero posterior position of condyle in glenoid fossa. The absence of a significant difference in anterior and posterior joint spaces indicate a lack of correlation between vertical facial morphology and anteroposterior condylar position

Katsavrias *et al*.[28] reported that the class III group had closer vertical relationship between the condyle and the roof of the fossa, indicating that SS is smaller. His samples were mainly comprised of hyperdivergent pattern. In the present study also, we found that SS was smaller in hypodivergent skeletal pattern.

Gateno *et al*.[29] used linear measurements of both horizontal and vertical distances by using the geometric centers of the condylar head and the glenoid fossa and also anteroposterior joint space ratio for evaluation of the condylar position space ratio. They found that in the patient with anterior disc displacement posterior joint space and superior joint space was significantly less than normal group.

Ikeda and Kawamura[11] assessed the optimal position of the mandibular condyle in 24 joints of 22 symptom-free subjects (10 male, 12 female; mean age, 18 years) who had no disc displacement and verified it by MRI. He reported that optimal condylar position was 1.3 mm (SD ± 0.3 mm) for AS, 2.5 (SD ± 0.6 mm) for SS, and 2.1 (SD ± 0.3 mm) for PS.

Major *et al*.,[30] and Christiansen *et al*.[31] found an association between disc displacement and changes in joint space. Discrepancy between the optimal and the altered joint spaces might indirectly indicate disc displacement. Thus in all synovial joints, the articulating surfaces of the opposing bones should be held in firm contact by the associated ligaments and musculature and closely fitted between the opposing articular surfaces throughout the range of jaw movement. If this close relationship between the eminence and the condyle is lost due to disc displacement, there will be changes in joint space.

CONCLUSION

It was hypothesized that hyperdivergent group would exhibit more superiorly positioned condyles than the hypodivergent group. The findings of this study demonstrated significantly lesser Superior joint space for hyperdivergent group as compared to hypodivergent group.

Therefore, if condylar position and joint spaces is not considered during assessment of orthodontic cases, the risk of misdiagnosis is high, being significantly higher in patients with the hyper divergent facial pattern.

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