Three-Dimensional Morphology of Temporomandibular Joint in Patients with Class I, Class II and Class III Malocclusion: A CBCT Study

Shabih Fatima[1], Rajiv Ahluwalia[2], Parvinder Kaur[3], Tina Chugh[4]

[1]Private Practitioner, New Delhi - 110014 India

[2]Professor and Head, Department of Orthodontics, Santosh Deemed to be University, Ghaziabad – 201009, India.

[3]Professor, Department of Orthodontics, Santosh Deemed to be University, Ghaziabad – 201009, India.

[4]Reader, Department of Orthodontics, Santosh Deemed to be University, Ghaziabad – 201009, India.

DOI: 10.47750/pnr.2022.13.S06.094

Abstract

Background: Varying types of malocclusions may have an effect on the morphology and position of the condyle in the glenoid fossa.

Aim: This retrospective study aims to evaluate and compare the three-dimensional position and morphology of the condyle in the glenoid fossa in Angle's Class I, Class II division I, Class II division II and Class III malocclusions using cone-beam computed tomography panoramic reconstructions.

Material and Method: Pre-treatment CBCT scans of 40 subjects (17-30 years) with 10 subjects in each of the study groups as per Angle's malocclusion were obtained. The CBCT images of all subjects were evaluated and compared following parameters, i.e., differences in anterior joint space, posterior joint space, superior joint space, anteroposterior and mediolateral width of the condyle, condylar height, and the vertical distance of the geometric center of the condyle from the mid-sagittal plane.

Result: Statistical analysis revealed all parameters were statistically similar for all the malocclusion groups except the anterior and the superior joint space. The latter two parameters were significantly smaller in subjects with class III malocclusion compared to class I ($p < 0.05$).

Conclusion: The Anterior joint space and the Superior joint space were statistically significantly larger in the Class I malocclusion group when compared with the Class III malocclusion group. This implies that condyles were more superiorly and anteriorly placed in subjects with class III malocclusion. These differences could be considered during the diagnosis temporomandibular disorders and orthodontic treatment.

Keywords: Condylar morphology, glenoid fossa, joint space.

INTRODUCTION

The temporomandibular joint (TMJ) is a vital and complex joint of the human body.1 It comprises bony as well as soft tissue components which together work in synchrony to bring about mastication. The relationship between different types of occlusions and the anatomic morphology of the temporomandibular joint is still a matter of great curiosity. Some studies have shown a direct relationship between the different types of malocclusions and the anatomic morphology of the temporomandibular joint.2,3 Few studies, however, failed to establish any such correlation in their findings.4,5 These varying findings in the previously conducted studies might be due to the use of 2-D panoramic radiography, which may be difficult to interpret. The latest generation of CBCT allows us to visualize the sites of interest by providing the option to adjust the image orientation and rotation.6-9 The presence of a wide range of grey scale intensities in CBCT imaging based on the amount of radiation absorbed by different tissues allows us to distinguish soft tissue from hard tissue and thus gives us a better understanding of the temporomandibular joint. Also, CBCT is a three-dimensional imaging modality and thus enables visualization of the rendered image in all spatial planes.

There is limited literature on the quantitative standard for the optimal position of the mandibular condyle in the glenoid fossa and none in the Indian population. The purpose of this study was to evaluate the three-dimensional position of the condyle in the glenoid fossa in Class I, Class II division I, Class II division II and Class III malocclusions along with analyzing and comparing the relative position of the condylar head to the joint space.

Materials And Method

Study settings and Study Design: The present study was approved by the Institutional Review Board of Santosh Deemed to be a university. The present cross-sectional study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, Santosh Dental College and Hospitals, Ghaziabad.

Recruitment of study population: A total of 40 subjects, i.e., 10 subjects each in one of the four types of malocclusions, i.e., Class I, Class II Division 1, Class II Division 2, Class III were recruited as per pre-specified eligibility criteria from the outpatient department of Orthodontics and Dentofacial Orthopedics, Santosh Dental College and Hospitals, Ghaziabad.

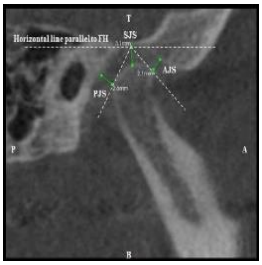
Inclusion criteria were:

- 17-30 years of age
- Presence of a full complement of permanent teeth (except 3rd molars).

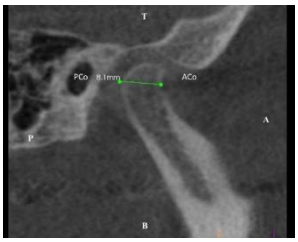
Exclusion criteria were

- Subjects with a history of facial trauma
- Presence of any temporomandibular disorders,
- Presence of cross-bite
- Any functional mandibular deviation
- Presence of facial asymmetry.

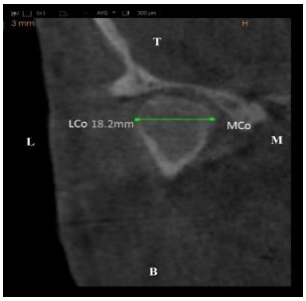
Evaluation parameters: The CBCT images of subjects were constructed and analyzed using Kodak 9500 CBCT - Cone Beam CT (Carestream) machine and Dental imaging software. The comparative parameters [Table 1] were measurements on the sagittal plane, i.e., anterior joint space (AJS), posterior joint space (PJS), and superior joint space (SJS), and linear measurements on the axial image, i.e., the greatest anteroposterior diameter of the mandibular condyle (ACo-PCo), the greatest mediolateral diameter of the mandibular condyle, (MCo-LCo); and the condylar height the vertical distance from the geometric centers of the condyles to the midsagittal plane [Figures 1, 2, 3].



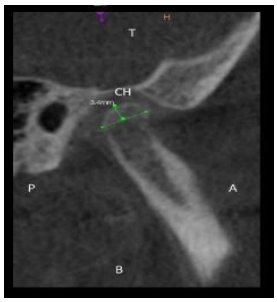
"**Figure 1 A:** AJS (anterior joint space), PJS (posterior joint space) SJP (superior joint space)"



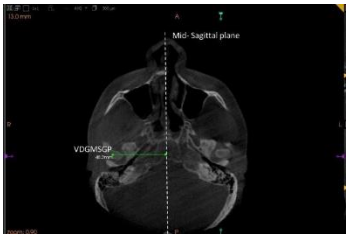
"**Figure 1 B.** Aco-Pco (anteroposterior diameter of the mandibular condyle)"



"**Figure 2 A:** Mco-Lco (mediolateral diameter of the mandibular condyle)"



"**Figure 2 B:** Condylar height (CH)"



"**Figure 3 A:** Distance of geometric center of condyle to the mid-sagittal plane"

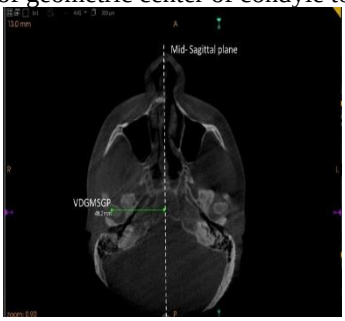


Figure 3 B: Distance of geometric center of condyle to the mid-sagittal plane

Record keeping and statistical analysis: Individual patient data were entered into pre-printed case record proformas and then entered into a Microsoft Excel sheet (Microsoft office, Redmond, Washington). From there data were transported to SPSS software version 22 (ISB, Armonk, New York).

Statistical Analysis: All statistical analyses of the data were performed using SPSS software. For bilateral parameters, the average of left and right-side measurements was calculated and average values were employed for further analysis. Descriptive statistics were expressed as Mean ± SD. Differences in AJS, PJS, SJS, anteroposterior width of the condyle, mediolateral width of the condyle, condylar height, and the vertical distance of the geometric center of the condyle from the midsagittal plane were compared between groups by Student's t-test and by one-way ANOVA. A value of $P < 0.05$ was established as the threshold of statistical significance.

Results

The measurements were comparable for all measured parameters [Table 2] except for a significant difference for AJS ($p = 0.048$) and SJS ($p = 0.045$) between Group A (Class I malocclusion) and Group D (Class III malocclusion).

Table 1. Evaluation parameters of Temporomandibular Joint

S. No.	Evaluation parameter	Description
Measurements assessed on the sagittal plane		
1	Anterior joint space (AJS)	Shortest distance between the most anterior point of the condyle and the posterior wall of the articular tubercle [Figure 1]
2	Posterior joint space (PJS)	Shortest distance between the most posterior point of the condyle and the posterior wall of the mandibular fossa [Figure 1]
3	Superior joint space (SJS)	Shortest distance between the most superior point of the condyle and deepest point of the mandibular fossa [Figure 1]
Linear measurements were obtained from the axial image		
4	ACo -PCo	The greatest anteroposterior diameter of the mandibular condyle [Figure 1]
5	MCo-LCo	The greatest mediolateral diameter of the mandibular condyle [Figure 2]
6	CH	The condylar height [Figure 2]
7	VD form GCC to Mid sagittal plane (MSP)	The vertical distance (VD) from the geometric centers of the condyles (GCC) to the midsagittal plane [Figure 3]

ACo – Most anterior point on the mandibular condyle

PCo – Most posterior point on the mandibular condyle

MCo – Most medial point on the mandibular condyle

LCo – Most lateral point on the mandibular condyle

Table 2. Shows the means of individual components of all the Groups

Serial No.	Components	Group A Mean Value	Group B Mean Value	Group C Mean Value	Group D Mean Value
1	AJS	2.43±0.257*	2.43±0.601	2.45±0.133	1.63±0.330*
2	SJS	2.66±0.504*	2.64±0.162	2.61±0.132	1.86±0.2118*

3	PJS	2.34±0.259	2.15±0.153	2.24±0.088	2.60±0.153
4	ACo – PCO	8.78±0.437	8.02±0.356	8.52±0.079	8.53±0.698
5	MCO – LCO	18.18±0.758	18.46±0.762	18.16±0.125	18.01±0.874
6	CH	3.47±0.292	3.13±0.287	2.84±0.054	3.22±0.261
7	VD form GCC to MSP	48.90±1.070	51.639±1.901	52.76±0.162	49.78±1.909

*Significant differences (p = 0.048, p = 0.045 for AJS and SJS, respectively)

Discussion

It has been a challenge for orthodontists to understand the relationship between TMJ morphology and spatial positioning of the condyle in a glenoid fossa in class I, class II and class III groups. Also, the relationship between occlusion and TMJ is debatable owing to controversial findings of previously conducted studies. Few of the previously conducted studies have shown that the shape of condyle and fossa are different in different types of malocclusion.10-12 However, few studies failed to report any significant association between condylar morphology and spatial positioning in different types of malocclusions.13-15The uneasy visualization of the TMJ (due to its complex anatomy and the superimposition of adjacent structures) could possibly be a factor responsible for the discrepancies in the results of different studies. The paradigm shift came with the improvement in 3D imaging technology at the hands of the Cone Beam Computed Tomography (CBCT) scan which gave insights to dentists and provided the required information to unravel the questions that surrounded the TMJ.16-19

In the present study, the condyle-fossa relationship was assessed by measurement of the anterior, superior, and posterior joint spaces. Additionally, the condylar height, the antero-posterior length, the medio-lateral width and the vertical distance of the geometric center of the condyle from the mid-sagittal plane were also assessed. Knowledge of these parameters is important as the variations in these parameters are evidence for whether the condyle has undergone morphological transformation after birth or not. Also, changes in these distances can give rise to various pathologies, i.e, condylar hyperplasia or resorption. Further as per findings of Katsavrias,10condylar morphology is different in class II and class III and the treatment can further alter it. This fact is to be borne in mind while planning the orthodontic treatment as the treatment can further decrease the joint space.

The data analysis revealed that subjects in Group D (Class III) had the smallest AJS and the difference was significant compared to subjects with group A (Class I). This might be due to the imbalanced, strained position of the condyle in subjects with reverse overjet. It also implies that condyles are more anteriorly and superiorly placed in joint space in subjects with class III malocclusion. Similarly, SJS was also significantly smaller in subjects with class III malocclusion compared to subjects with class I malocclusion. A similar trend has been reported in studies done by Song et al,19Vitral et al4 and Zhang et al.20Previous studies by Ricketts21,22 and Katsavrias et al10 have reported that in subjects with Class III malocclusion, the condyles were superiorly placed and the SJS was decreased. These findings are in line with the results of the present study.

However, the previous studies have reported varying findings in subjects with class II malocclusion. aIn studies done by Chaeet al23 and Arieta-Miranda et al24 SJS was smaller in class II compared to class I while in the present studies no significant difference was reported. Arieta-Miranda et al24 and Pardes et al25 reported that subjects with short facial profiles had larger SJS and those with vertical facial types had smaller SJS. Further Arieta-Miranda et al24 and Katsavrias et al10 reported smaller AJS in subjects with class II malocclusion compared to those with class I malocclusion. It is to be noted here that the subjects in the present study had horizontal growth patterns and this can be the reason for the varying findings.

Also, Arieta-Miranda et al24 and Katsavrias10 reported that condyle is positioned more anteriorly in class II (both groups) compared to class I as in these studies statistically smaller AJS was reported in class II compared to class I. This can be because of the compensatory alteration in condyle because of the posterior position of the mandible. However, no difference in this parameter was reported in class I and class II in the present study.

Interestingly, although the comparison and analysis of various parameters of the condyle via Cone Beam Computed Tomography (CBCT) in different Angle's malocclusion proved to be different in each group; only two parameters tested to be statistically significant. A larger sample in future studies would prove helpful in determining and finding statistically significant differences between the groups in all the measured condylar parameters.

It is noteworthy that values of parameters employed for condylar positioning in glenoid fossa, i.e, AJS, SJS and PJS were similar to values reported by Ricketts21,22 and Arieta-Miranda et al.24 Ricketts21,22 used laminographic technique to study condylar morphology and Arieta-Miranda et al24 used CBCT. As suggested by Ricketts21,22, the measurement of PJS has been taken as then shortest distance between the most posterior point of the condyle and the posterior wall of the mandibular fossa. Therefore the statistical value obtained in our study is not numerically in agreement with other studies as the reference for measurement that has been taken is different. The measurements in the present study are also reliable as CBCT was used and it is known to be an accurate technique.

A larger sample size and a multicenter study is suggested in future to gather more data in each Angle's malocclusion group to better understand the mean values of different condylar parameters. Additionally, it is recommended that future studies should include subjects with both horizontal and vertical growth pattern in class II.

Conclusions

Significantly smaller AJS and SJS were reported in subjects with class III malocclusion compared to subjects with class I malocclusion.

REFERENCES

1. Shaffer SM, Brismée JM, Sizer PS, Courtney CA. Temporomandibular disorders. Part 1: anatomy and examination/diagnosis. J Man Manip Ther. 2014;22(1):2-12.
2. 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;128:337e46.
3. Mongini F. Remodelling of the mandibular condyle in the adult and its relationship to the condition of the dental arches. Acta Anat (Basel).1972;82:437e53.
4. Vitral RW, Telles CS, Fraga MR, Oliveira RSM, Tanaka OM. Computed tomography evaluation of temporomandibular joint alterations in patients with Class II Division 1 subdivision malocclusions: condyle-fossa relationship. Am J Orthod Dentofacial Orthop 2004;126:48e52.
5. VitralRW, TellesCS. Computed tomography evaluation of temporomandibular joint alterations in Class II Division 1 subdivision patients: condylar symmetry. Am J Orthod Dentofacial Orthop 2002;121:369e75.
6. Schlueter B, Kim KB, Oliver D, Sortiropoulos G. Cone beam computed tomography 3D reconstruction of the mandibular condyle. Angle Orthodontist. 2008;78(5):880–8.
7. Farman AG, Scarfe WC. The basics of maxillofacial cone beam computed tomography. Seminars in Orthodontics. 2009;15:2–13.
8. Ludlow JB, Laster WS, See M, Bailey LJ, Hershey HG. Accuracy of measurements of mandibular anatomy in cone beam computed tomography images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;103(4):534–42.
9. Hussain AM, Packota G, Major PW, Flores-Mir C. Role of different imaging modalities in assessment of temporomandibular joint erosions and osteophytes: a systematic review. Dentomaxillofac Radiol. 2008;37(2):63–71.
10. 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;128(3):337–46.
11. Rodrigues AF, Fraga MR, Vitral RWF. Computed tomography evaluation of the temporomandibular joint in Class I malocclusion patients: condylar symmetry and condyle–fossa relationship. Am J Orthod Dentofacial Orthop. 2009;136(2):192–8.
12. Rodrigues AF, Fraga MR, Vitral RWF. Computed tomography evaluation of the temporomandibular joint in Class II Division 1 and Class III malocclusion patients: condylar symmetry and condyle–fossa relationship. Am J Orthod Dentofacial Orthop. 2009;136(2):199–206.
13. Pullinger AG, Solberg WK, Hollender L, Petersson A. Relationshipof mandibular condylar position to dental occlusion factors in an asymptomatic population. Am J OrthodDentofacialOrthop.1987;91(3):200–6.
14. Incesu L, Taşkaya-Yılmaz N, Öğütcen-Toller M, Uzun E. Relationship of condylar position to disc position and morphology. Eur J Radiol. 2004;51(3):269–73.
15. Matsumoto MA, Bolognese AM. Bone morphology of the Temporomandibular joint and its relation to dental occlusion. Braz Dent J. 1995;6(2):115–22.
16. Schlueter B, Kim KB, Oliver D, Sortiropoulos G. Cone beam computed tomography 3D reconstruction of the mandibular condyle. Angle Orthodontist. 2008;78(5):880–8.
17. Farman AG, Scarfe WC. The basics of maxillofacial cone beam computed tomography. Seminars in Orthodontics.2009;15:2–13.
18. Ludlow JB, Laster WS, See M, Bailey LJ, Hershey HG. Accuracy of measurements of mandibular anatomy in cone beam computed tomography images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007; 103(4):534–42.
19. Song, Jungyul& Cheng, Mingjia&Qian, Yufen& Chu, Fengting. Cone-beam CT evaluation of temporomandibular joint in permanent dentition according to Angle's classification. Oral Radiology. 2019;36. 10.1007/s11282-019-00403-3
20. Zhang Y, Xu X, and Liu Z Comparison of Morphologic Parameters of Temporomandibular Joint for Asymptomatic Subjects Using the Two Dimensional

and Three Dimensional Measuring Methods Hindawi Journal of Healthcare Engineering. 2017; 8
21. Ricketts RM. Variations of the temporomandibular joint as revealed by cephalometriclaminagraphy. Am J Orthodont. 1950; 36:877–97.
22. Ricketts RM. Various conditions of the temporomandibular joint as revealed by cephalometriclaminagraphy. Angle Orthod. 1950; 22(2):98–115.
23. Chae JM, Park JH, Tai K, Mizutani K, Uzuka S, Miyashita W, Seo HY. Evaluation of condyle-fossa relationships in adolescents with various skeletal patterns using cone-beam computed tomography. Angle Orthod 2020; 90 (2):224–32.
24. 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. 201;18:14:36.
25. Paredes NA, Silva M, Arieta JM, Arriola LE. Variación de posición condylar segúnpatrón vertical. Ortodontia,SPO.2012;45(5):555–6.