3D CBCT Evaluation of Condyle Position in Skeletal Class I & Class III Growing Subjects

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ABSTRACT

Introduction: Evaluation of temporo-mandibular joint (TMJ) anatomy and function is an essential part of orthodontic diagnosis and treatment planning. It has been hypothesized that dental and skeletal malocclusions alter the functional loading of TMJ which can affect joint morphology.

Objective: Three dimensional (3D) evaluation of condylar position using CBCT in skeletal Class I and Class III growing subjects.

Materials & Method: CBCT images of ten growing skeletal Class I & ten Class III patients in the age range of 7-14 years were analyzed. 3D condylar position were evaluated representing antero-posterior, vertical, laterolateral position of condyle, axial condylar angle and coronal condylar angles which were measured in axial, coronal and sagittal sections using Dolphin Imaging software. Antero-posterior and vertical difference of right and left condyle were measured in axial and coronal sections respectively.

Result: Paired t-Test revealed no significant difference between right and left sides of condyle in skeletal Class I as well as Class III subjects. Independent t-test and Mann-Whitney U test showed no significant difference between position of condyle in Class I and Class III subjects.

Conclusion: 3D CBCT analysis shows no significant difference in condylar position of skeletal Class I and Class III subjects.

Keywords: CBCT, condyle position, skeletal growth pattern

INTRODUCTION

For majority of patients undergoing orthodontic therapy, esthetics is the primary concern however the long term success of orthodontic therapy can only be ascertained by ensuring optimal functional efficiency of the masticatory apparatus. The relationship between malocclusion pattern and temporo-mandibular joint (TMJ) problems are not clear and so is the relationship between orthodontic treatment and TMJ disorders.[1] Most of the previous studies[2-4] suggest that the incidence of TMJ disorders between subjects who have received orthodontic therapy and those who have not were similar but orthodontist should always be aware of the fact that nearly all orthodontic therapy alters patients' existing occlusion and may predispose the patient to TMJ disorders. Hence knowledge of normal anatomy and its variations are essential for orthodontist. The effect of function on form is well documented in orthodontic literature. The form of temporo-mandibular joint can be affected by various anatomical and pathological factors. Facial anatomical factors like growth pattern, dental and skeletal malocclusion can affect the morphology of TMJ by altering the loading pattern of the joint.[5,6] TMJ morphology of Class I and Class III subjects has been compared in few studies but the findings of these studies are not uniform.[5,7-9] Some studies have reported no significant difference between the condylar position in Class I and Class III subjects,[7,8] while others have reported the difference.[5,9] These discrepancies might be due to differences in measuring technique and parameters used to assess the condylar position. Various two dimensional radiographic views like panoramic radiograph, TMJ radiograph, cephalograms have been used to asses condylar position but the overlapping of surrounding structures over the TMJ limit the accuracy of these methods.[5] 3D imaging procedures like conventional CT had also been used,[10,11] but the risk of high radiation exposure has limited the use of this method. CBCT has emerged as a useful imaging technique owing to significantly low radiation exposure as compared to conventional CT and high quality of 3D images;[12] however very few studies, till date have used CBCT data to evaluate condylar position
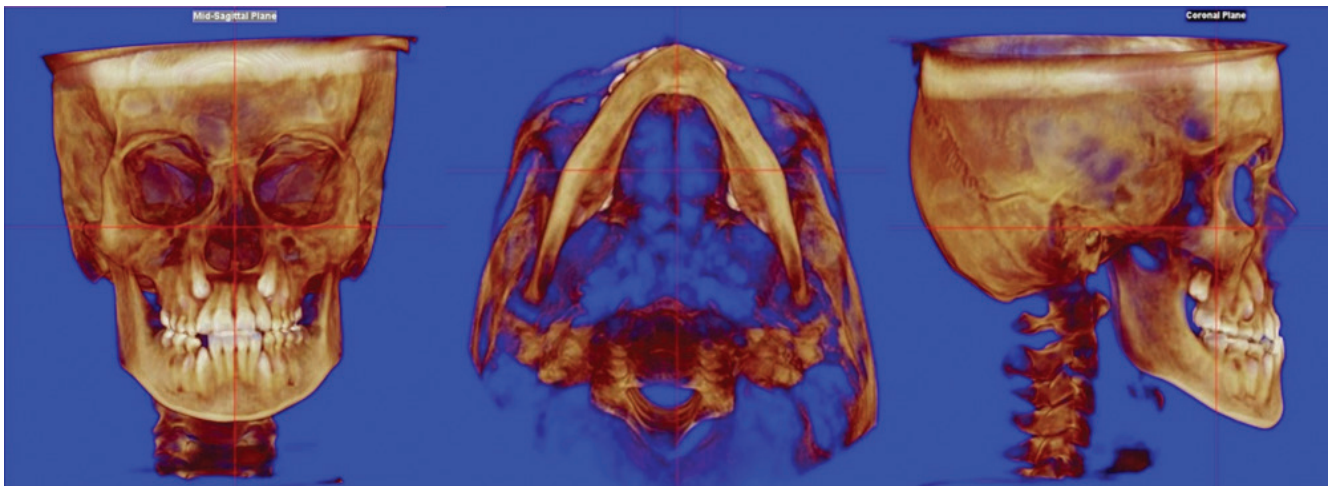
Figure 1: CBCT Image orientation

MATERIALS AND METHOD

The study was conducted at a university orthodontic department. Cone beam computed tomography (CBCT) image were retrieved from department archives of the patients in the age range of 7-14 years. The DICOM (Digital Imaging and Communications in Medicine) images were evaluated with Dolphin imaging software Version 11.7 (Dolphin Imaging & Management Solutions, Chatsworth, California). These images were rendered into volumetric images and reconstructed sagittal, axial, coronal slices and the 3D models were obtained. The 3D images were oriented such that the mid-sagittal plane passed through the skeletal midline, the axial plane showed the FH plane (right porion to right orbitale), and the coronal plane passed through the furcation of the right maxillary first molar (Figure 1). After orienting the images, lateral cephalograms were obtained from the CBCT images using ray-sum feature of the software. Subjects were classified on the basis of ANB angle. Ten Class I subjects (seven male, three female) and ten Class III subjects (five male, five female) were selected (Table 1). The inclusion criteria were: ANB< 0° for Class III and 0-4° for Class I, no other craniofacial anomalies, no symptoms or history of TMJ disorders, no history of previous orthodontic treatment, and average growth pattern (FMA: 17°–28°). Evaluation of condylar position was based on the methodology described by Melgaco *et al*[13] and modifications suggested by Balachandran *et al*.[14] All measurements were done by principal investigator.

Table 1: Demographic features of study sample

	Number	Mean Age	Mean ANB
Class I	10(7M/3F)	10.8±1.61	1.4±0.9 0
Class III	10(5M/5F)	10.8±1.4	-2.3±1.210

The landmarks used were as follows (Figure 2):

1. Centre of condyle (CC): Intersection of lines representing largest anteroposterior and mediolateral widths of condyle, identified in axial slice.

2. External acoustic meatus (EAM): The most external point in the posterior wall of external acoustic meatus, identified in axial slice.

3. Laterosuperior condylar landmarks (LSC): The point at the intersection of tangent to the most superior and lateral part of condyle, identified in coronal slice.

After landmark identification, digitization was done on the software to measure following parameters:
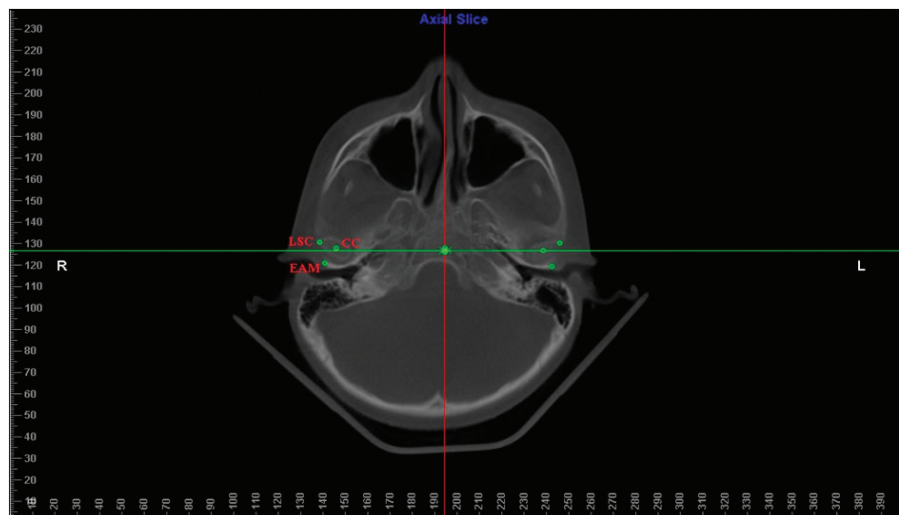

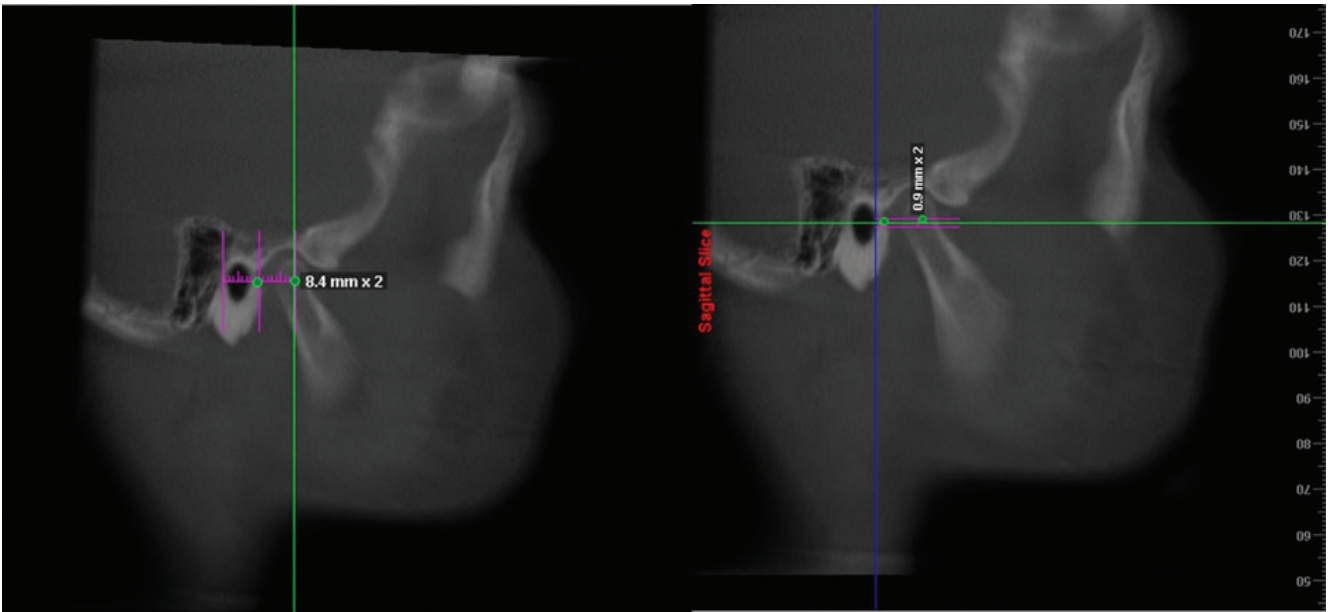**Figure 2: Axial slice showing landmarks**

Figure 3: Sagittal section measurements

1. Sagittal section measurements (Figure 3):

    a. Anterioposterior position of condyle (APC): Horizontal distance between the external acoustic meatus and centre of condyle

    b. Vertical Position of condyle (VPC): Vertical distance between EAM and centre of condyle.

2. Axial section measurement (Figure 4):

    a. Axial condylar angle (ACA): Angle formed between the line connecting centre of condyle and laterosuperior point of condyle and midsagittal plane (MSP)

    b. Laterolateral position of condyle (LLPC): Distance between centre of condyle and MSP

    c. Antero-posterior difference of condyle (APDC): Distance between orthogonal projection of left and right condylar center on MSP as measured.

3. Coronal section measurements (Figure 5):

    a. Coronal condylar angle (CCA): Angle formed between the MSP and line connecting LSC and centre of condyle

    b. Vertical difference of condyles (VDC): Vertical distance between the orthogonal projection of left and right center of condyle on the MSP.

Each measurement was done separately on right and left sides. Measurements were repeated twice after one week interval in ten cases and intra-class correlation coefficient (ICC) was used to determine the reliability of measurement. The statistical analysis was done using SPSS software version 17. Kolmogorov-Smirnov test was used to determine the normalcy of data distribution. For parameters with normal distribution, paired t-test was applied for comparison between left and right sides of the subjects while independent t-test was used to compare between Class I and Class III subjects. Mann-Whitney U test was used to compare between Class I and III for parameters which were not normally distributed. The level of significance was set at $p<0.05$.
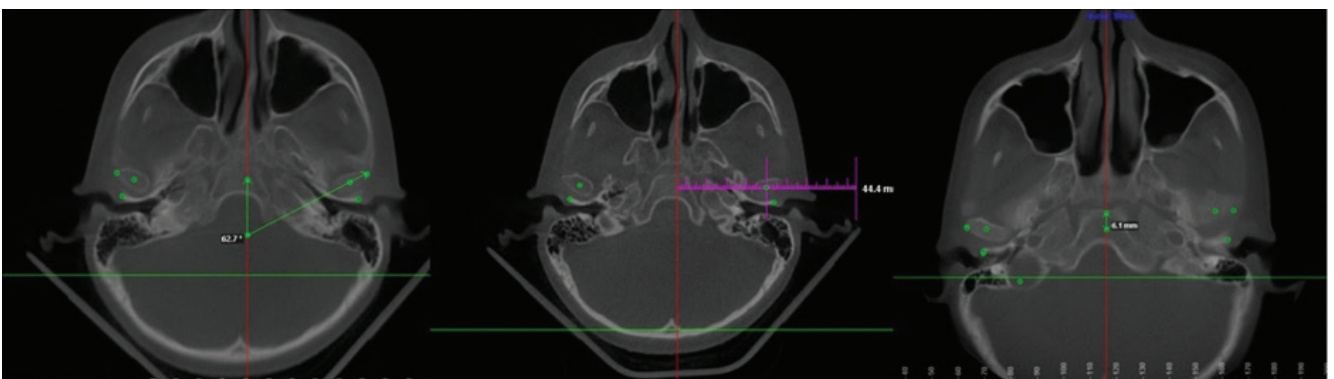

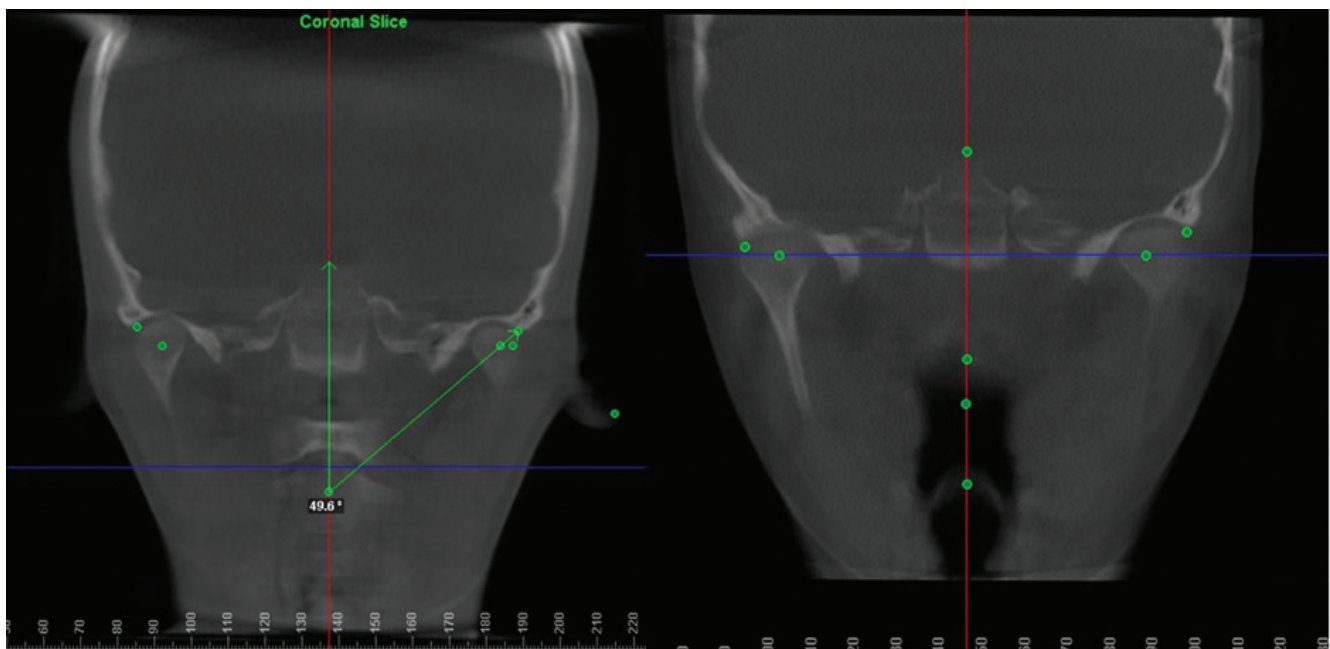**Figure 4: Axial Section measurement**

Figure 5: Coronal Section measurement

RESULT

Kolmogrov-Smirnov test showed that the data was normally distributed except for three measurements viz: APDC, VDC and VPC. ICC values were higher than 0.9 showing high reliability of measurement for all parameters. Paired t-test showed no significant difference between right and left condyle position either in Class I or Class III subjects (Table2). Centre of condyle was more anteriorly placed in Class I subjects as compared to Class III subject but condyle was more anteriorly inclined in Class III subjects. The inter-condylar distance was greater for Class III subjects as compared to Class I subjects. In coronal section parameters- medio-lateral inclination as indicated by CCA was nearly same for both Class I and Class III subjects. Antero-posterior difference between right and left condyle was greater in Class I subjects as compared to Class III. Vertical difference between right and left condyle was negligible and nearly equal for both classes. The difference between condyle position of skeletal Class I and Class III subjects was not statistically significant when compared in axial, coronal and sagittal planes.

Table 2: Comparison between left and right side condyle position

	Class I			Mean ANB		
	Right (Mean±SD)	Left (Mean±SD)	*p*-Value	Right (Mean±SD)	Left (Mean±SD)	*p*-Value
ACA	84.4±5.02	83.9±5.1	0.63	81.6±6.4	78.9±8.7	0.06
LLPC	43.5±2.2	43.1±3.0	0.70	46.7±4.8	46.9±6.21	0.73
CCA	58.7±4.2	60.7±6.5	0.12	60.4±6.3	58.8±5.4	0.57
APC	8.5±1.4	8.4±1.9	0.75	7.8±1.0	7.1±0.9	0.09
VPC	0.0	0.20	0.34	0.0	0.26	0.34

Table 3: Independent T-test for comparison of Class I & Class III condyle position

	Class I	Class III	*p*-Value
ACA	84.1±4.9	80.3±7.3	0.19
LLPC	43.3±2.2	46.8±5.4	0.09
CCA	119.0±10.6	119.2±8.2	0.95
APC	8.4±1.5	7.5±0.83	0.13

Table 4: Comparison of Class I and Class III condyle position

	Class I		Mean ANB		p-Value
	Median	**Range**	**Median**	**Range**	
APDC	1.6	0-3.2	1.4	0-5.9	0.49
VDC	0	0-1.8	0.5	0-1.7	0.78
VPC	0	0-0.95	0	0-1.3	1.00

(ACA: axial condylar angle, LLPC: laterolateral position of condyle, CCA: coronal condylar angle, APC: antero-posterior position of condyle, VPC: vertical position of condyle, APDC: antero-posterior difference of condyle, VDC: vertical difference of condyle)

DISCUSSION

In the present study, ANB angle was used to classify subjects in two skeletal groups. Despite its shortcomings ANB angle is most commonly used to differentiate sagittal skeletal patterns.[15] The accuracy and reliability of Dolphin software for linear and angular measurements has been established by previous studies.[16] CBCT images are accurate and provide detailed images with good spatial resolution for assessing TMJ while the exposure is very low as compared to conventional CT.[5,9] Relationship between occlusion and TMJ morphology has been reported by several previous studies,[17-20] however very few studies have compared mandibular condyle position between skeletal Class I and Class III subjects.[5,8-9] In some studies, lateral cephalograms were used to evaluate the position of condyle which cannot be considered reliable because of the superimposition of surrounding structures like petrous temporal bone, mastoid process and articular eminence; making visualization of condyle difficult.[5,8] In this study we have modified the methodology of Melgaco et al[13] in two ways. First, the head orientation was not reestablished after land mark orientation. Second, a large slice thickness was used when two landmarks were not visible in single slice. This was true mainly for measurement of coronal condylar angle. As suggested by Balachandran et al,[14] this could increase the chances of error but we could not find any suitable alternate method.

Marrieta et al[5] reported some spatial difference in condylar position between Class I, Class II and Class III groups. They found that condyle in Class III was more superiorly and anteriorly placed as compared to Class I and the difference was statistically significant. Previous studies showed variation in condyle position in subjects with hyperdivergent and hypodivergent subjects.[21] In our study all subjects had average growth pattern, hence the findings could not be directly compared.

Alhammadi et al[9] reported significant difference between vertical position and antero-posterior inclination in Class I and Class III subjects. In their study anteroposterior inclination of condyle was higher in Class III subjects while centre of condyle was more anteriorly placed in Class I subjects. These findings are similar to our study. The intercondylar distance was higher in Class I subjects as compared to Class III subjects which is in contrast to our findings. This disparity may be due to the difference in growth status of study sample and difference in landmark measurement parameters between the studies.

The authors could find only three similar previous studies and all those studies have differences in landmark identification and measurement methodology. No previous studies have used methodology similar to ours, thus direct comparison of these studies are not possible.

In the present study, the subjects were in growing stage, hence the position of condyle may also change with aging. The power of the study is inadequate because of small sample size. All the CBCT images were retrieved from archives and no image was obtained for purpose of this study.

CONCLUSION

Three dimensional CBCT analyses revealed no difference in condylar position between skeletal Class I and Class III growing subjects.

OJN

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