RESEARCH PAPER

Comparative Evaluation of Condylar Position Before and After Levelling and Alignment in class I, class II division 1 and class II division 2 Malocclusion Groups: A CBCT and Cephalometric Study

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ABSTRACT:
Background: To evaluate changes in condylar position among Class I, Class II Division 1, and Class II Division 2 malocclusion subjects following the levelling and alignment phase of orthodontic treatment using CBCT and cephalometric analysis. **Materials and Methods:** Thirty-nine subjects were divided equally into three groups: Class I, Class II Division 1, and Class II Division 2 malocclusions (n=13 each). CBCT scans and lateral cephalograms were obtained before treatment and after levelling and alignment using the MBT appliance system. Changes in condylar position, skeletal, and dentoalveolar parameters were analyzed using one-way ANOVA and Bonferroni post hoc tests.**Results:** Significant intergroup differences were observed for mandibular plane angle, Y-axis angle, inter-incisal angle, lower incisor–occlusal plane angle, Co-Pog, and HRP-Ae ($p<0.005$). Class I subjects demonstrated greater skeletal and dentoalveolar adaptations compared with Class II subjects. However, no significant differences were found in condylar inclination or articular eminence angle among the groups ($p>0.05$). **Conclusion:** Levelling and alignment produced significant skeletal and dentoalveolar changes but did not significantly alter condylar position in Class I, Class II Division 1, or Class II Division 2 malocclusion subjects. These findings suggest that the initial phase of orthodontic treatment has minimal influence on TMJ condylar position.
Keywords: Condylar position, CBCT, TMJ, Class II malocclusion, Orthodontic treatment
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INTRODUCTION

The importance of condylar position in maintaining proper function of the stomatognathic system has been widely studied and debated in dental science.[1] The oral cavity, dentition, and associated muscles of mastication are closely related to the temporomandibular joint (TMJ). Along with the masticatory muscles, these oral structures help regulate the position and function of the TMJ. Collectively, these components play an essential role in mandibular movements and in distributing the stresses generated during functions such as mastication, swallowing, and speech.[2]

The morphology of the temporomandibular joint (TMJ) varies among individuals, and functional loading is considered one of the factors influencing its shape. Due to the close relationship between form and function, differences in condylar and mandibular fossa morphology may be observed among individuals with different types of malocclusion.[3] The temporomandibular joint (TMJ) can be evaluated using various imaging modalities. Cone-beam computed tomography (CBCT) has gained increasing use in dental maxillofacial imaging due to its relatively low radiation dose and high spatial resolution.[4]

Understanding the morphology of the temporomandibular joint (TMJ) and its spatial relationship in Class I, Class II, and Class III malocclusion groups remains challenging for clinicians. Knowledge of variations in the normal condyle–glenoid fossa relationship may help clinicians identify early signs of degenerative joint disease or detect existing joint abnormalities. Furthermore, such information can aid in improved treatment planning aimed at achieving relationships closer to normal values. Accurate assessment of these parameters, combined with clinical findings, is therefore essential for effective diagnosis and treatment planning in patients with different skeletal relationships.[5]

MATERIALS AND METHODS

Subjects were selected from the OPD reporting in the Department of Orthodontics and Dentofacial Orthopaedics, amongst which those patients with Class I, Class II Division 1 and Class II Division 2 malocclusion those fulfilling the following inclusion criteria were included in the study.

1) Patients with Class I molar relation bilaterally, intra-arch malocclusions and
Class I skeletal bases
2) Patients with Class II molar relation bilaterally and retrognathic mandible
3) Patients with retroclination of upper incisors and Deep bite
4) Patients with increased Overjet
5) Age group:- 14 years and above
6) Patients with no congenital defects
7) Patients without any history of Orthodontic treatment
8) No signs and symptoms of TMJ disorders
9) Patients with good periodontal status

A total of 39 patients participated in this study, comprising 26 females and 13 males, aged between 14 to 28 years.
The subjects were distributed into three groups based on their dental malocclusion classification: Group 1- Class I malocclusion (n= 13), Group 2-Class II Division 1 malocclusion (n= 13) and Group 3- Class II Division 2 malocclusion (n= 13). All patients underwent standardized fixed Orthodontic treatment Using MBT bracket system.

Cone-Beam Computed Tomography scans were obtained before the initiation of treatment (T1) and after completion of levelling and alignment (T2).

All CBCTs were taken using **Dentium CBCT, rainbowTM**. CBCT DICOM (Digital Imaging and Communication in Medicine) image files were available for measurement. Translucency and segmentation were adjusted initially and maintained on every DICOM for clear view. Original axial thickness was 0.150 mm, with FSV 94KV, FOV [16x10] hi resolution, 8mA, exposure time 20 sec and voxel size 300 um. The DICOM images were analyzed using Rainbow 3D viewer. The pretreatment condylar position was determined using 11 parameters.

The **CBCT Parameters** used for evaluating the condylar position before and
after leveling and alignment are as follows:

SR. NO.	PARAMETERS	MEASUREMENT PROTOCOL
1.	Anterior Joint space	Distance between the most anterior point of the condyle and the posterior wall of the articular eminence
2.	Posterior Joint space	Distance between the most posterior point of the condyle and the posterior wall of the mandibular fossa.
3.	Superior Joint space	Distance between the superior aspect of the condyle and the roof of glenoid fossa.
4.	Antero-posterior diameter of condyle	Distance between the most prominent point on anterior and posterior surfaces of the condyle
5.	Medio-lateral diameter of condyle	Distance between the most prominent point on the medial pole and lateral pole of the condylar head.
6.	Height of condylar head	Distance between the superior most point on the condylar head to a tangent drawn through the inferior most point of the sigmoid notch.
7.	Depth of mandibular fossa	Distance between the deepest point of the mandibular fossa and the horizontal reference line joining the maximum height of articular tubercle and pre-auricular tubercle.
8.	Width of Glenoid fossa	Distance between the most inferior point of the articular eminence and the most inferior point of the posterior glenoid process.
9.	Articular eminence height	The perpendicular distance between the lowest point of the articular eminence and the highest point of the glenoid fossa.
10.	Inclination of articular eminence	The angle formed by the slope of the eminence in relation to a horizontal reference plane.
11.	Inclination of condyle	The angle formed by the line connecting anterior most point and posterior most point of the condyle with the vertical reference plane.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 26. Descriptive statistics were expressed as mean ± standard deviation with 95% confidence intervals. Intergroup comparisons for continuous variables were analyzed using one-way analysis of variance (ANOVA), followed by post hoc pairwise comparisons with Bonferroni correction to adjust for multiple comparisons. The level of significance was set at $p < 0.05$, and after Bonferroni adjustment, $p < 0.005$ was considered statistically significant for parameters with multiple comparisons. Normality of data distribution was assessed prior to analysis.

RESULTS

Table 1- Demographic characteristics of study groups.

Parameters		Class 1	Class 2a	Class 2b	p-
Age	Years	19.92 ± 4.11	18.77 ± 2.89	18.85 ± 3.21	0.637
Sex	Male n (%)	4 (30.7)	5 (38.5)	6 (46.2)	0.223
	Female n (%)	9 (69.3)	8 (61.5)	7 (53.8)	

A total of 39 subjects were included in the study and were equally distributed among the three groups, comprising 13 subjects each in Class I, Class II Division 1, and Class II Division 2 malocclusion groups. The mean age of the participants was 19.92 ± 4.11 years in the Class I group, 18.77 ± 2.89 years in the Class II Division 1 group, and 18.85 ± 3.21 years in the Class II Division 2 group. No statistically significant difference was observed among the groups with respect to age (p = 0.637). Similarly, sex distribution was comparable among the three groups (p = 0.223). Therefore, the study groups were considered demographically homogeneous and suitable for comparison.

Table 2- Comparison of change in angular variables between groups with one way ANOVA.

Parameter	Class 1		Class 2a		Class 2b		F	P
	Mean (SD)	**CI at 95% U, L**	**Mean (SD)**	**CI at 95% U, L**	**Mean (SD)**	**CI at 95% U, L**		
Facial angle (deg)	0.385 (3.618)	-1.802, 2.571	-0.077 (3.402)	-2.133, 1.979	-0.385 (0.506)	-0.691, -0.079	0.24	0.792
Mandibular plane angle (deg)	5.462 (5.953)	1.864, 9.059	-4.615 (6.935)	-8.806, -0.425	-0.308 (1.601)	-1.275, 0.660	11.58	***0.001****
Y-axis angle (deg)	2.846 (3.387)	0.799, 4.893	-1.538 (4.054)	-3.988, 0.911	-0.077 (0.954)	-0.653, 0.500	7.01	***0.003****
SNA (deg)	0.769 (3.586)	-1.398, 2.936	0.077 (3.774)	-2.204, 2.358	0.692 (0.630)	0.311, 1.073	0.20	0.816
SNB (deg)	1.846 (4.947)	-1.143, 4.836	-1.154 (4.997)	-4.174, 1.866	-0.231 (0.599)	-0.593, 0.131	1.85	0.172
ANB (deg)	-1.154 (3.078)	-3.014, 0.706	1.308 (3.093)	-0.561, 3.177	0.923 (0.760)	0.464, 1.382	3.49	0.041
Condylar inclination (deg)	0.769 (7.726)	-3.900, 5.438	3.000 (7.767)	-1.694, 7.694	1.077 (5.438)	-2.210, 4.363	0.38	0.686
Articular eminence angle (deg)	-1.308 (9.268)	-6.908, 4.293	-3.615 (9.862)	-9.575, 2.344	-0.077 (4.071)	-2.537, 2.383	0.63	0.538
Inter-incisal angle (deg)	-35.923 (20.549)	-48.340, -23.506	-1.538 (30.325)	-19.864, 16.787	-6.308 (7.353)	-10.751, -1.864	9.70	***0.001****
Lower incisor-Occlusal plane (deg)	16.154 (14.519)	7.380, 24.928	-1.615 (11.057)	-8.297, 5.066	0.846 (5.871)	-2.702, 4.394	9.84	***0.001****
Lower incisor-Mandibular plane (deg)	8.846 (12.307)	1.409, 16.283	6.077 (8.119)	1.171, 10.983	2.923 (2.290)	1.539, 4.307	1.54	***0.228***

Bonferroni correction for multiple comparison applied (p<0.005 significant)

The changes in angular cephalometric parameters following levelling and alignment are presented in **Table 2.**

One-way ANOVA demonstrated statistically significant intergroup differences for mandibular plane angle (F = 11.58, p = 0.001), Y-axis angle (F = 7.01, p = 0.003), inter-incisal angle (F = 9.70, p = 0.001), and lower incisor–occlusal plane angle (F = 9.84, p = 0.001). No significant differences were observed for facial angle, SNA, SNB, condylar inclination, articular eminence angle, or lower incisor–mandibular plane angle.

The Class I group demonstrated a greater increase in mandibular plane angle and Y-axis angle compared with both Class II Division 1 and Class II Division 2 groups. A marked reduction in inter-incisal angle and a greater increase in lower incisor–occlusal plane angle were also observed in the Class I group, indicating more pronounced dentoalveolar adaptation during levelling and alignment.

Although ANB angle showed a statistically significant difference on initial analysis (p = 0.041), it did not remain significant following Bonferroni correction.

Importantly, no statistically significant differences were observed among the groups with respect to condylar inclination (p = 0.686) and articular eminence angle (p = 0.538), suggesting that levelling and alignment produced minimal alterations in condylar position-related angular parameters.

Table 3- Post hoc analysis for significant angular variable for pair wise comparison

Variables		**Class 1 vs Class2a**	**Class 1 vs Class2b**	**Class2a vs Class2b**
Mandibular plane angle (deg)	Mean diff	10.077	5.769	-4.308
	T	4.796	2.746	-2.05
	P	***<.001****	***0.025****	0.115
Y-axis angle (deg)	Mean diff	4.385	2.923	-1.462
	T	3.607	2.404	-1.202
	P	***0.003****	0.055	0.46
Inter-incisal angle(deg)	Mean diff	-34.385	-29.615	4.769
	T	-4.064	-3.5	0.564
	P	< .001*	0.004*	0.84
Lower incisor-Occlusal plane(deg)	Mean diff	17.769	15.308	-2.462
	t	4.093	3.526	-0.567
	p	< .001*	0.003*	0.838

Post hoc pairwise comparisons revealed that mandibular plane angle increased significantly more in the Class I group compared with Class II Division 1 (mean difference = 10.08°, p < 0.001). Significant differences were also observed between Class I and Class II Division 2 groups.

Similarly, the increase in Y-axis angle was significantly greater in Class I than in Class II Division 1 subjects (mean difference = 4.39°, p = 0.003).

The reduction in inter-incisal angle was significantly greater in Class I subjects than in both Class II Division 1 (mean difference = –34.39°, p < 0.001) and Class II Division 2 (mean difference = –29.62°, p = 0.004) subjects.

Likewise, lower incisor–occlusal plane angle increased significantly more in Class I subjects than in both Class II subdivisions.

No significant differences were observed between Class II Division 1 and Class II Division 2 groups for any of the angular variables evaluated.

Table 4- Comparison of change in linear variables between groups with one way ANOVA.

Parameter	Class 1		Class 2a		Class 2b		F	P
	Mean (SD)	CI at 95% U, L	Mean (SD)	CI at 95% U, L	Mean (SD)	CI at 95% U, L		
Co-Pog (mm)	4.846 (10.699)	-1.619, 11.312	-5.538 (7.043)	-9.794, -1.282	-1.154 (1.345)	-1.966, -0.341	6.39	***0.004****
Co-S (mm)	0.000 (3.697)	-2.234, 2.234	0.000 (5.228)	-3.159, 3.159	-0.154 (1.068)	-0.799, 0.492	0.01	0.983
S-Go (mm)	-0.923 (7.921)	-5.710, 3.864	0.231 (6.809)	-3.884, 4.345	-0.462 (2.295)	-1.849, 0.926	0.12	0.892
Go-B (mm)	1.308 (6.588)	-2.673, 5.289	-0.846 (3.826)	-3.158, 1.466	-0.154 (1.405)	-1.003, 0.695	0.79	0.463
Co-B (mm)	3.308 (9.340)	-2.336, 8.952	-3.615 (5.091)	-6.692, -0.539	-0.231 (1.878)	-1.365, 0.904	4.01	0.027
Ar-Go (mm)	-1.538 (6.603)	-5.529, 2.452	0.077 (4.991)	-2.939, 3.093	-0.462 (2.470)	-1.954, 1.031	0.35	0.705
HRP-Co (mm)	-0.769 (2.279)	-2.146, 0.608	0.000 (2.739)	-1.655, 1.655	-0.231 (1.589)	-1.191, 0.730	0.40	0.674
HRP-GF (mm)	0.308 (2.136)	-0.983, 1.599	-0.769 (3.833)	-3.086, 1.547	-0.077 (1.256)	-0.836, 0.682	0.56	0.577
HRP-Ae (mm)	-1.231 (2.088)	-2.492, 0.031	0.846 (1.214)	0.112, 1.580	0.000 (0.913)	-0.552, 0.552	6.38	***0.004****
VRP-Co (mm)	-0.462 (2.402)	-1.913, 0.990	0.385 (3.015)	-1.437, 2.207	0.154 (0.899)	-0.389, 0.697	0.48	0.625
VRP-GF (mm)	0.154 (2.478)	-1.344, 1.651	-0.077 (3.593)	-2.248, 2.094	-0.385 (1.044)	-1.015, 0.246	0.14	0.869
VRP-Ae (mm)	1.154 (2.444)	-0.323, 2.631	-0.615 (4.174)	-3.138, 1.907	0.077 (1.320)	-0.721, 0.875	1.23	0.303
Co-Go (mm)	-1.615 (7.018)	-5.856, 2.626	-1.077 (4.368)	-3.716, 1.562	-0.923 (2.722)	-2.568, 0.722	0.07	0.934
Protrusion of maxillary incisors (mm)	5.923 (4.425)	3.249, 8.597	3.769 (4.935)	0.787, 6.752	2.538 (1.613)	1.564, 3.513	2.46	0.101

Bonferroni correction for multiple comparison applied (p<0.005 significant)

The changes in linear cephalometric measurements following levelling and alignment are shown in **Table 4.**

Among the linear parameters evaluated, significant intergroup differences were observed for Co-Pog (F = 6.39, p = 0.004) and HRP-Ae (F = 6.38, p = 0.004). Co-B demonstrated a nominal difference (p = 0.027), which did not remain significant after Bonferroni correction.

The Class I group demonstrated a greater increase in Co-Pog compared with the Class II groups. Similarly, a reduction in HRP-Ae was observed in the Class I group, whereas Class II Division 1 subjects demonstrated a slight increase.

No statistically significant differences were observed among the groups for Co-S, S-Go, Go-B, Ar-Go, HRP-Co, HRP-GF, VRP-Co, VRP-GF, VRP-Ae, Co-Go, or protrusion of maxillary incisors.

Table 5- Post hoc analysis for significant linear variable for pair wise comparison

ariables		Class 1 vs Class2a	Class 1 vs Class2b	Class2a vs Class2b
Co-Pog(mm)	Mean diff	10.385	6	-4.385
	t	3.56	2.057	-1.503
	p	***0.003****	0.113	0.301
HRP-Ae(mm)	Mean diff	-2.077	-1.231	0.846
	t	-3.552	-2.105	1.447
	p	***0.003****	0.103	0.328

post hoc pairwise comparisons demonstrated that the increase in Co-Pog was significantly greater in the Class I group than in the Class II Division 1 group (mean difference = 10.39 mm, p = 0.003).

Similarly, HRP-Ae showed a significantly greater reduction in the Class I group compared with the Class II Division 1 group (mean difference = –2.08 mm, p = 0.003).

No significant differences were identified between Class I and Class II Division 2 groups or between the two Class II subdivisions.

The present study demonstrated significant differences among malocclusion groups in selected skeletal and dentoalveolar parameters following levelling and alignment. Class I subjects exhibited greater changes in mandibular plane angle, Y-axis angle, inter-incisal angle, lower incisor–occlusal plane angle, Co-Pog, and HRP-Ae compared with Class II subjects.

However, condylar inclination and articular eminence angle did not demonstrate significant intergroup differences. These findings suggest that although levelling and alignment may induce measurable skeletal and dentoalveolar adaptations, its influence on condylar position appears limited across Class I, Class II Division 1, and Class II Division 2 malocclusion groups.

DISCUSSION

The present study evaluated changes in condylar position between Class I, Class II Division 1, and Class II Division 2 malocclusion subjects after the levelling and alignment phase of orthodontic treatment using lateral cephalometric and CBCT. The principal finding was that although significant dentoalveolar and skeletal changes occurred during treatment, condylar inclination and articular eminence angle did not show statistically significant intergroup differences. These findings suggest that the initial phase of fixed orthodontic treatment exerts minimal influence on condylar position irrespective of malocclusion type.

The relationship between malocclusion and condylar position has been extensively studied because of its potential influence on temporomandibular joint (TMJ) function and orthodontic treatment outcomes. Rivero-Millan et al.[6] evaluated condylar position using CBCT in subjects with normal occlusion, Class II Division 1, Class II Division 2, and Class III malocclusions and reported that condyles in normal occlusion were generally positioned more concentrically within the glenoid fossa, whereas malocclusion groups exhibited greater positional variability. The authors concluded that condylar position is associated with sagittal skeletal relationships but is also characterized by considerable individual variation.

In the present investigation, no statistically significant differences were observed in condylar inclination or articular eminence angle among the three malocclusion groups after levelling and alignment. These findings suggest that the tooth movements occurring during the alignment phase may not be sufficient to induce measurable alterations in the osseous components of the TMJ. Rather than causing substantial condylar displacement, orthodontic alignment appears to be accommodated through dentoalveolar adaptation and neuromuscular adjustment while maintaining relative stability of the condyle-fossa relationship.

The observed stability of condylar position is supported by previous evidence indicating that routine orthodontic treatment generally produces limited changes in TMJ morphology. A recent review by Pan et al.[7] emphasized that although orthodontic treatment may influence joint remodelling through occlusal modification, the condyle in healthy individuals generally maintains a relatively stable position within the glenoid fossa and major positional alterations are uncommon. This concept is consistent with the findings of the present study, where significant dental and skeletal changes occurred without corresponding changes in condylar inclination or articular eminence angle.

Several studies have showed that substantial condylar positional changes are more commonly associated with functional orthopaedic interventions or comprehensive correction of skeletal discrepancies than with the initial alignment phase alone. A recent systematic review reported that functional appliance therapy may be associated with anterior condylar displacement, changes in joint spaces, and adaptive remodelling of the glenoid fossa; however, the overall quality of evidence was low and findings were inconsistent among studies.[8] Therefore, the absence of significant condylar changes in the present investigation may be explained by the fact that only the levelling and alignment phase was evaluated rather than the entire course of orthodontic treatment.

An additional finding of the present study was the presence of significant differences in selected cephalometric variables among the groups. Mandibular plane angle and Y-axis angle demonstrated significant intergroup differences, with the Class I group showing greater increases compared with the Class II groups. These findings may indicate greater vertical adaptation during treatment in Class I subjects. Furthermore, significant reductions in inter-incisal angle and increases in lower incisor–occlusal plane angle were observed, particularly in the Class I group, suggesting greater incisor proclination and alignment. These observations are consistent with the biomechanical effects expected during the levelling and alignment stage, where correction of crowding and arch coordination commonly result in changes in incisor inclination.

Among the linear measurements, Co-Pog and HRP-Ae demonstrated statistically significant intergroup differences. The increase in Co-Pog observed in the Class I group may reflect favorable sagittal adaptation of mandibular skeletal structures during treatment. However, because condylar inclination and articular eminence angle remained unchanged, these findings are more likely attributable to dentoalveolar and skeletal adaptation than to true displacement of the condyle within the glenoid fossa.

The clinical implications of the present findings are important. Concerns are occasionally raised regarding the possibility that fixed orthodontic appliances may adversely affect TMJ position. The present results suggest that routine levelling and alignment procedures do not produce clinically significant alterations in condylar position in Class I, Class II Division 1, or Class II Division 2 malocclusion subjects. Therefore, the early phase of orthodontic treatment appears to be compatible with maintenance of TMJ structural stability.

The present study has certain limitations. First, the sample size was relatively small, which may have limited the detection of subtle condylar changes. Second, only the levelling and alignment phase of treatment was assessed; further adaptations may occur during space closure, finishing, and retention phases. Third, although lateral cephalograms provide valuable skeletal information, they remain two-dimensional representations of complex three-dimensional structures. Finally, long-term follow-up was not performed, preventing assessment of the stability of the observed findings.

Future studies incorporating larger sample sizes, comprehensive CBCT joint-space analyses, and long-term follow-up are recommended to further elucidate the effects of orthodontic treatment on condylar position and TMJ adaptation.

Within the limitations of the present study, it can be concluded that levelling and alignment resulted in significant dentoalveolar and skeletal changes but did not produce significant alterations in condylar inclination or articular eminence angle among Class I, Class II Division 1, and Class II Division 2 malocclusion subjects. These findings suggest that the initial phase of orthodontic treatment has minimal influence on condylar position and supports the concept of TMJ stability during early orthodontic therapy.

CONCLUSION

Within the limitations of the present study, levelling and alignment resulted in significant dentoalveolar and skeletal changes among Class I, Class II Division 1, and Class II Division 2 malocclusion subjects. However, no significant alterations were observed in condylar inclination or articular eminence angle following treatment. These findings suggest that the initial phase of fixed orthodontic therapy has minimal influence on condylar position and supports the maintenance of temporomandibular joint stability during early orthodontic treatment.

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