Original Article

Three-dimensional comparative evaluation of articular disc position and other temporomandibular joint morphology in Class II horizontal and vertical cases with Class I malocclusion: *A magnetic resonance imaging study*

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ABSTRACT

Objective: To evaluate and compare articular disk position, condylar position, and joint spaces in Class II vertical, Class II horizontal, and Class I cases. The purpose was to assess the potential for development of temporomandibular disorders (TMDs) in the three groups.

Materials and Methods: A sample of 75 cases, 25 cases in each group of Class I, Class II vertical, and Class II horizontal, were selected based on inclusion and exclusion criteria. Magnetic resonance imaging (MRI) assessments were made with a 1.5-Tesla basic system with a closed-mouth technique for evaluating articular disk position in the sagittal and transverse planes, condylar position, and joint spaces in the sagittal plane. Philips 3.0 software was used to analyze the MR images.

Results: There was evidence of alterations in the temporomandibular joint (TMJ) morphology in both Class II vertical and Class II horizontal cases, with maximum discrepancy in Class II vertical cases. MRI evaluation suggested a tendency for antero-medial disk displacement with anteriorly positioned condyles in Class II vertical cases. The discrepancy was milder in the Class II horizontal group.

Conclusions: Class II vertical cases are more susceptible to the development of TMDs and should be subjected to TMJ evaluation before starting any orthodontic treatment to intercept and prevent a mild asymptomatic TMD from developing into a more severe form. Class II vertical cases should be subjected to MRI evaluation before starting any orthodontic treatment. (*Angle Orthod.* 2020;90:707–714.)

KEY WORDS: Temporomandibular joint; Magnetic resonance imaging; TMD; Malocclusion; Orthodontics

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Table 1 Cephalometric Parameters for Case Selection

Cephalometric Measurement	Class I Cases	Class II Vertical Cases	Class II Horizontal Cases
FMA, °	22–28	>30	<20
Mandibular plane angle (Downs analysis), °	17–20	>22	<15
y-axis, °	53–66	>68	51
Wits appraisal	BO ahead of AO by 1 mm		BO behind AO by 4 mm
Beta angle, °	30–35	<27	<27
ANB angle, °	1–2	>2	>2

INTRODUCTION

There has been an increase in the number of temporomandibular disorders (TMDs).[1] One of the most common reasons for an increased likelihood of developing a more aggravated form of TMD is a stressful lifestyle and potential risk factors. One of the important goals in orthodontics is achieving static and dynamic occlusion for maintenance of healthy teeth, jaws, and surrounding hard and soft tissue structures. It was stated in the early 1970s and again in 1996 by Roth that the condylar position must be evaluated to determine the stability of orthodontic treatment, which he referred to as gnathostatic evaluation.[2,3]

There has been debate about the role of occlusal prematurities as a cause for TMDs.[1] Some studies failed to find a link, stating multiple reasons such as lack of proper method of evaluation and paucity of standardized data correlating occlusion and TMDs.[4] In 1999, a study stated that altered condylar position and articular disk position were the key features of Class II malocclusions, and if not treated early, they could progress to severe forms.[5] The conflict still exists, and research diagnostic criteria for TMD were developed as a screening protocol to evaluate both symptomatic and asymptomatic TMD cases. The criteria evaluated both hard and soft tissues.[6]

The most common form of TMD includes internal derangement, in which the articular disk is displaced from its ideal position over the condyle.[7] There are multiple methods for temporomandibular joint (TMJ) evaluation, and magnetic resonance imaging (MRI) is considered the gold standard, as it provides excellent contrast for soft tissue evaluation, which could not be differentiated using other radiographic methods.[8]

Initially, it was accepted that class III malocclusions had the potential for development of TMDs but, later on, even Class II cases were considered as high risk for TMDs due to altered disk and condylar positions.[9,10] Some authors found Class II horizontal cases with higher possibilities for TMDs due to retruded incisors locking the mandible and altering functional contacts.[10] Contrasting studies also found Class II vertical cases to be associated with TMDs due to altered condylar position and disk alterations in the form of an anteriorly displaced disk, leading to altered TMJ stability.[5,11,12]

Therefore, this study was planned to evaluate TMJ morphology in Class II vertical cases and Class II horizontal cases and to compare them with Class I cases to evaluate using MRI whether potential or higher-risk factors for the development of TMDs existed in these groups.

MATERIALS AND METHODS

The study included a total of 75 cases within the age group of 18–30 years. After routine clinical and radiographic examination (Table 1), the samples were divided into three groups of 25 each: Class II vertical group, Class II horizontal group, and Class I group. The overjet for Class I and Class II cases was within the range of 2–4 mm and 2–7 mm, respectively. Ethical approval was obtained prior to the study (ref no. DMIMS [DU]/IEC/2017-18/6741, dated May 10, 2017) from the Institutional Ethical Committee, Datta Meghe Institute of Medical Sciences, Maharashtra, India.

Exclusion criteria included any history of TMJ surgeries, systemic problems, severe TMDs, orthodontic treatment, claustrophobia, or dental restorations/appliances that may have caused safety problems during an MRI scan.

Bilateral sagittal as well as coronal MRIs were taken with a 1.5-Tesla basic MRI system using the closed-mouth technique. MRIs were taken using the following parameters: high proton density–weighted images, slice thickness of 2 mm, field view of 20–20 mm^2, repetition time 2500 ms, echo time 20 ms, and 256 × 256 matrix. MRIs were stored on a 1.5-GB SIEMENS magnetic optical disk. For procuring images, Philips 3.0 software was used. Images were taken in both the sagittal and coronal dimensions. The three readings were taken on three consecutive days, and good intraobserver agreement was observed as evaluated by Kappa statistics.

The following measurements were made on the MRIs: (1) assessment for articular disk position in the horizontal plane, (2) assessment for articular disk position in the coronal plane, (3) assessment for condylar position (condylar concentricity), and (4) assessment of anterior and posterior joint spaces (PJSs).

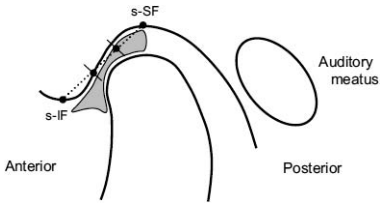

Figure 1. Evaluation method for articular disk position.

Assessment of Articular Disk in the Horizontal Plane

The articular disk was divided between the sagittal superior fossa and the sagittal inferior fossa into three equal parts (Figure 1). If the posterior border of the disk was in the middle-third of the metrically divided disk segment, it was considered as a partial anterior disk displacement, and if ahead of the middle-third segment, it was considered as anterior disk displacement. The normal range of disk position for this method was 1–1.7 mm. This method has been described in detail by Chintakanon et al.[13]

Assessment of Articular Disk in the Coronal Plane

A reference line was drawn along the long axis of the condylar pole and neck (Figure 2). Another line across the maximum width of the pole of the condyle was also constructed and then divided into 10 segments. The disc position was recorded with respect to the 1/10 divisions of the condylar width. Negative values suggested lateral disk displacement, and positive values suggested medial disk displacement, with 0 mm being the normal value, as per Chintakanon et al.[13]

Assessment of Condylar Position (Condylar Concentricity)

The short distance between the head of the condyle and eminence was measured as the anterior joint space (AJS), and the shortest distance in between the post glenoidal fossa and condylar head was marked as the PJS (Figure 3). These were the narrowest AJS and PJS (intra-articular) as proposed by Vargas-Pereira.[14]

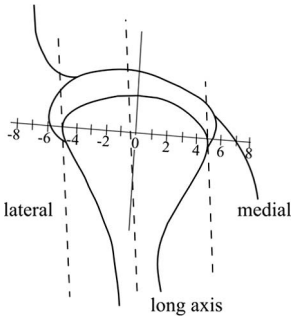

Figure 2. Evaluation method for coronal disk position.

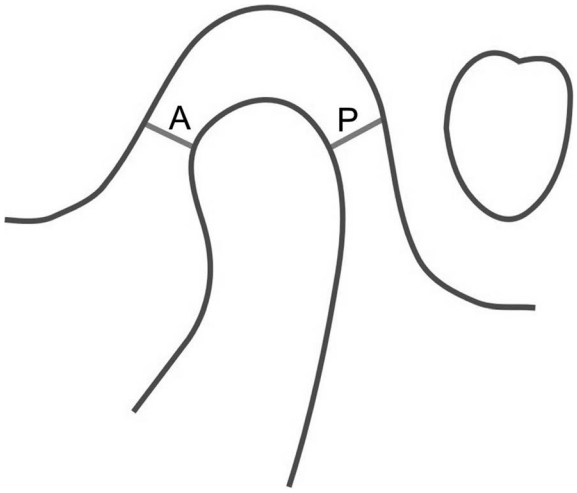

Figure 3. Evaluation method for condylar position and joint spaces.

After measuring the AJS and PJS, the values were entered into the following formula: $JSI = [(P - A)/(P + A)] \times 100$, where JSI is the joint space index, A is the AJS, and P is the PJS. Any positive value indicated the anterior position of the condyle with respect to the glenoid fossa, and a negative value indicated a posterior location of the condyle, with the physiologic limit for the condylar position ranging from –32.5% to 21.1%.[13]

Assessment of the AJS and PJS

For evaluation of the AJS and PJS, the same method was used as that for condylar concentricity, but the joint space index formula was not used (Figure 3).

RESULTS

The Statistical Package for Social Sciences (SPSS) version 24.0 (IBM Corporation, Chicago, Ill) was used for statistical analyses. The normality of data was analyzed by Shapiro-Wilk test. To calculate the mean differences and to check for significant variance among the groups for normally distributed data, a one-way analysis of variance test was used. Post hoc analysis was done using Tukey's honestly significant difference test to conduct a comparison between the three groups and compare the right and left sides.

Measurement of Articular Disk Position in the Sagittal Plane

The mean value for articular disk position in the Class I group was 1.38 ± 0.20 mm, which was within the normal range (Table 2). The mean articular disk position in the Class II vertical group was 2.50 ± 0.20 mm, which was significantly the highest among the

Table 2. Comparison of Articular Disk Position (Horizontal) Among the Three Groups

Group	Sample	Normal Value (Range), mm	Mean (Left)	SD	*P* Value	Mean (Right)	SD	*P* Value	Difference Between Left and Right
Class I cases	25	−1.1 to 1.7	1.38	±0.20	<.001*	1.41	±0.25	<.001*	0.03
Class II vertical cases	25		2.50	±0.49		2.43	±0.51		0.07
Class II horizontal cases	25		1.51	±0.20		1.54	±0.17		0.03

* Significant at $P < .05$, derived from one-way analysis of variance test.

Table 3. Comparison of Coronal Disk Position Among the Three Groups (Linear in mm)

Class	Sample	Mean (Left)	SD	*P* Value	Mean (Right)	SD	*P* Value	Difference Between Left and Right
Class I cases	25	1.2	±0.09	<.001*	1.4	±0.16	<.001*	0.2
Class II vertical cases	25	2.9	±0.12		2.82	±0.15		0.09
Class II horizontal cases	25	2	±0.11		2.1	±0.19		0.1

*$P < .05$, derived from one-way analysis of variance test.

Table 4. Comparison of Condylar Concentricity Among the Three Groups

Class	Sample	Normal Value	Mean (Left)	SD	*P* Value	Mean (Right)	SD	*P* Value	Difference Between Left and Right
Class I cases	25	−32 to 21	5.21	±2.71	<.001*	4.96	±3.25	<.001*	0.25
Class II vertical cases	25		22.78	±2.78		23.10	±2.90		0.32
Class II horizontal cases	25		6.16	±2.77		6.55	±2.70		0.39

* Significant at $P < .05$, derived from one-way analysis of variance test.

groups, showing a tendency for anterior disk displacement. The mean articular disk position in the Class II horizontal group was 1.51 ± 0.20 mm, indicating anterior disk displacement, which was greater compared with the Class I group and outside the normal range but to a lesser extent than the Class II vertical group.

Measurement of Articular Disk Position in the Coronal Plane

The mean value for articular disk position in the Class I group was 1.2 ± 0.09 mm, which was within the normal range (Table 3). The mean articular disk position in the Class II vertical group was 2.9 ± 0.12 mm, which was significantly the highest among the groups, showing a greater tendency for medial disk displacement. The mean articular disk position in the Class II horizontal cases was 2 ± 0.11 mm, which was greater compared with the Class I group but less than the Class II vertical group.

Measurement of Condylar Position (Sagittal Concentricity)

The mean value for condylar concentricity in the Class I group was 5.21 ± 2.71, which was within the normal range (Table 4). The mean condylar concentricity in the Class II vertical group was 22.78 ± 2.78, which was significantly the highest among the groups, showing a greater tendency for an anteriorly positioned condyle. The mean condylar concentricity in the Class II horizontal cases was 6.16 ± 2.77, which was greater compared with the Class I group but less than the Class II vertical group, suggesting a tendency for an anteriorly positioned condyle.

Measurement of Joint Spaces

Anterior joint space. The mean value for the AJS in the Class I group was 2.82 ± 0.16 mm (Table 5). The mean AJS in the Class II vertical group was 2.28 ± 0.12 mm, which was significantly the highest among the groups, showing reduced AJS due to an anteriorly positioned condyle. The mean AJS in the Class II horizontal cases was 2.72 ± 0.18 mm, which was greater compared with the Class I group but less than the Class II vertical group, suggesting a mild reduction in AJS.

Posterior joint space. The mean value for the PJS in the Class I group was 3.11 ± 0.10 mm, which was within the normal range. (Table 6). The mean PJS in the Class II vertical group was 3.35 ± 0.17 mm, which was significantly the highest among the groups, showing increased PJS due to an anteriorly positioned condyle. The mean PJS in the Class II horizontal cases was 3.08 ± 0.12 mm, which was greater compared with the Class I group but less than the Class II vertical group, suggesting a mild increase in PJS.

Table 5. Comparison of Anterior Joint Space Among the Three Groups (Linear in mm)

Class	Sample	Mean (Left)	SD	*P* Value	Mean (Right)	SD	*P* Value	Difference Between Left and Right
Class I cases	25	2.82	±0.16	<.001*	2.86	±0.16	<.001*	0.01
Class II vertical cases	25	2.28	±0.12		2.30	±0.15		0.05
Class II horizontal cases	25	2.72	±0.18		2.73	±0.19		-0.03

* Significant at $P < .05$, derived from one-way analysis of variance test.

Table 6. Comparison of Posterior Joint Space Among the Three Groups (Linear in mm)

Class	Sample	Mean (Left)	SD	*P* Value	Mean (Right)	SD	*P* Value	Difference Between Left and Right
Class I cases	25	3.11	±0.10	<.001*	3.10	±0.11	<.001*	0.01
Class II vertical cases	25	3.35	±0.17		3.30	±0.20		0.05
Class II horizontal cases	25	3.08	±0.12		3.11	±0.11		-0.03

* Significant at $P < .05$, derived from one-way analysis of variance test.

Table 7. Comparison of Mean Disc Position, Concentricity, and Joint Spaces (Left and Right Side) Among the Three Groups: Group I: Class I Malocclusion, Group II: Class II Vertical, and Group III: Class II Horizontal[a]

			Group (Mean ± SD)				Multicomparison of Tukey Test		
Side	Parameter	n	GI: Class I	GII: Class II Vertical	GIII: Class II Horizontal	ANOVA Test	GI vs GII	GI vs GIII	GII vs GIII
Left	Disk position (horizontal)	25	1.38 ± 0.20	2.50 ± 0.49	1.51± 0.20	<.001*†	<.001**†	.325**	.093**
	Disc position (coronal)	25	1.2 ± 0.09	2.9 ± 0.12	2 ± 0.11	<.001*†	<.001**†	.214**	<.001**†
	Condyle position	25	5.21 ± 2.71	22.78 ± 2.78	6.16 ± 2.77	<.001*†	<.001**†	.452**	<.001**†
	PJS	25	3.11 ± 0.10	3.35 ± 0.17	3.08 ± 0.12	<.001*†	<.001**†	.452**	.021**†
	AJS	25	2.82 ± 0.16	2.28 ± 0.12	2.72 ± 0.18	<.001*†	<.001**†	.076**	.021**†
Right	Disk position (horizontal)	25	1.41 ± 0.25	2.43 ± 0.51	1.54 ± 0.17	<.001*†	<.001**†	.381**	.021**†
	Disc position (coronal)	25	1.4 ± 0.16	2.82 ± 0.15	2.1 ± 0.19	<.001*†	<.001**†	.008**†	.021**†
	Condyle position	25	4.96 ± 3.04	23.10 ± 2.90	6.55 ± 2.70	<.001*†	<.001**†	.134**	.021**†
	PJS	25	3.10 ± 0.11	3.30 ± 0.20	3.11 ± 0.11	<.001*†	<.001**†	.925**	.021**†
	AJS	25	2.86 ± 0.16	2.30 ± 0.15	2.73 ± 0.19	<.001*†	<.001**†	.452**	.021**†

[a] G indicates group.
* *P* value derived from analysis of variance test.
** *P* value derived from Tukey's post hoc honestly significant difference test.
† Significant at $P < .05$.

Comparison Among the Three Groups

Significant intergroup variations were observed when post hoc analysis was done (Table 7). When the articular disk position (horizontal) for the Class II vertical group was compared with the Class I group, the mean difference of 1.12 mm (95% confidence interval [CI], −1.35 to 0.90) was statistically significant ($P < .001$). When the Class II horizontal group was compared with the Class I group, the mean difference of 0.03 mm (95% CI, −0.36 to 0.08) was not statistically significant ($P = .325$). When the Class II vertical group was compared with the Class II horizontal group, the mean difference of 0.99 mm (95% CI, 0.46 to 1.33) was statistically significant ($P < .001$).

When the articular disk position (coronal) in the Class II vertical group was compared with the Class I group, the mean difference of −1.7 mm (95% CI, 0.43–0.65) was statistically significant ($P < .001$). When the Class II horizontal group was compared with the Class I group, the mean difference of 0.08 mm (95% CI, −2.74 to 0.46) was not statistically significant ($P = .022$). When the Class II vertical group was compared with the Class II horizontal group, the mean difference of −0.9 mm (95% CI, 17.83–21.05) was statistically significant ($P < .001$).

When condylar position in the Class II vertical group was compared with the Class I group, the mean difference of −17.57 (95% CI, −19.44 to −15.70) was statistically significant ($P < .001$). When the Class II horizontal group was compared with the Class I group, the mean difference of −0.94 (95% CI, −2.81 to 0.92) was not statistically significant ($P = .452$). When the Class II vertical group was compared with the Class II horizontal group, the mean difference of 16.62 (95% CI, 14.75–21.05) was statistically significant ($P < .001$).

When the AJS for the Class II vertical group was compared with the Class I group, the mean difference

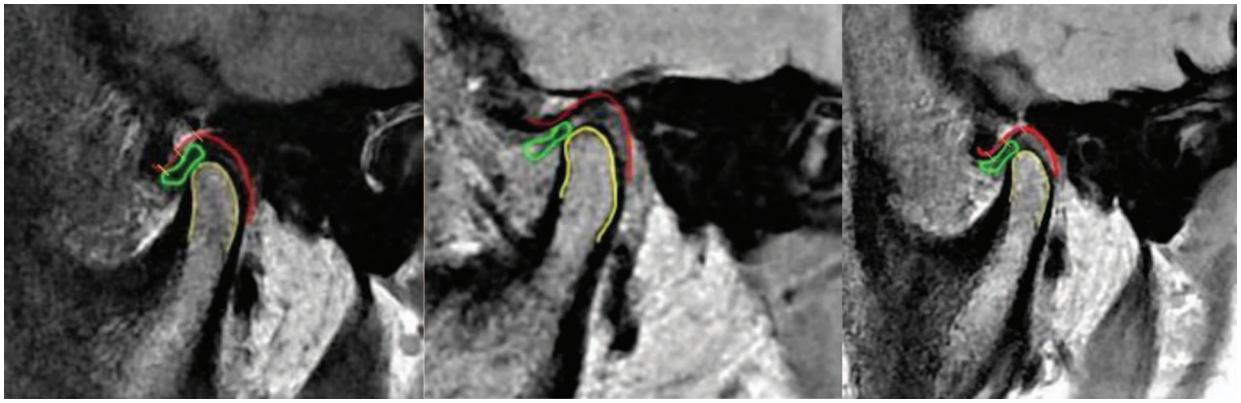

Figure 4. MRI image showing articular disk position (horizontal) in Class I, Class II vertical, and Class II horizontal cases.

of 0.54 mm (95% CI, 0.43 to 0.65) was statistically significant ($P < .001$). When the Class II horizontal group was compared with the Class I group, the mean difference of 0.10 mm (95% CI, –0.00 to 0.20) was not statistically significant ($P = .452$). When the Class II vertical group was compared with the Class II horizontal group, the mean difference of –0.44 mm (95% CI, –0.55 to –0.33) was statistically significant ($P < .001$).

When the PJS for the Class II vertical group was compared with the Class I group, the mean difference of –0.24 mm (95% CI, –0.33 to –0.15) was statistically significant ($P < .001$). When the Class II horizontal group was compared with the Class I group, the mean difference of 0.02 mm (95% CI, –0.06 to 0.11) was not statistically significant ($P = .452$). When the Class II vertical group was compared with the Class II horizontal group, the mean difference of 0.26 mm (95% CI, 0.17 to 0.35) was statistically significant ($P < .001$). No significant differences were found between the left and right sides for the articular disk, condylar position, or joint spaces.

DISCUSSION

Anterior disk displacement can result in clicking, joint pain, and other associated symptoms, as shown by Xie et al.[15] This causes the bilaminar zone to be compressed between the condyle and glenoid fossa, leading to severe pain, which is often managed with occlusal splint therapy.[16] The findings of the current study suggested that Class II vertical cases had a higher risk of developing into TMDs due to altered condylar position, joint spaces, and also articular disk position. These cases should be screened for the presence of TMD symptoms before, during, and after orthodontic treatment. On assessment, it was found that Class II vertical cases had the greatest degree of anterior disk displacement among the three groups (Table 2; Figure 4). In addition, the tendency for medial disk displacement was greater in Class II vertical cases (Table 3; Figure 5). Altered condylar position was more significant in the Class II vertical group, in which the condyle was found to be more anteriorly positioned (Table 4; Figure 6). Maximum alterations in joint spaces were observed in Class II vertical cases, in which there was a reduction in AJS and increased PJS as compared with the other two groups (Tables 5 and 6). In Class II horizontal cases, similar alterations were found with mild anterior and medial disk displacement, anteriorly displaced condyle, and a mild reduction in AJS. The alterations were greater compared with the control group but less than the Class II vertical group. With a greater degree of anterior and medial disk displacement in the Class II vertical group, these cases may have a higher risk for the development or aggravation of TMDs and therefore should be viewed

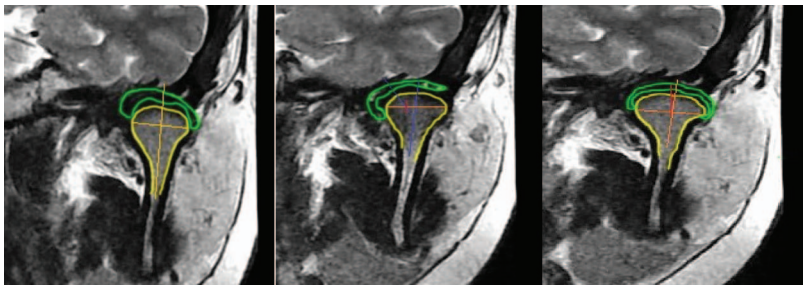

Figure 5. MRI image showing articular disk position (coronal) in Class I, Class II vertical, and Class II horizontal cases.

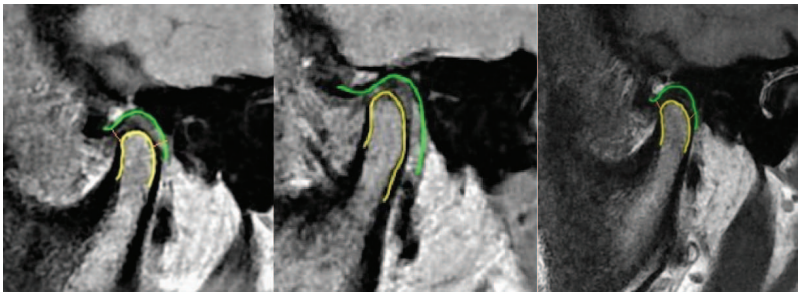

Figure 6. MRI image showing condylar position and joint spaces in Class I, Class II vertical and Class II horizontal cases.

with proper caution. Also, with a higher tendency for medial disk displacement, such cases may be more prone to TMDs, as this could lead to asymmetric movement of the condyle with more stresses in the TMJ of the affected side.

The current findings were in agreement with a study conducted by Abdel Emam and Refai,[11] who evaluated TMJ morphology with MRIs in Class II division 1 cases and found that the condyles were anteriorly positioned with respect to the glenoid fossa, encroaching on the AJS, showing anterior disk displacement, stretching the discal lamina, and causing pain in pretreatment records.[11] It was previously claimed that condyles were posteriorly positioned in Class II cases, which was incorrectly diagnosed due to the unavailability of better diagnostic tools.[17] In a study by Chavan et al[14] of Class II division 1 cases, pretreatment MRIs revealed that the articular disk was displaced anteriorly, increasing the risk for the development of TMD.[14] If not treated or intercepted early, this could lead to irreversible changes in the articular disk in the form of total disk displacement. Also, condylar position was anterior with respect to the glenoid fossa.

The current study advocates early diagnosis of any form of TMD in cases requiring orthodontic treatment, especially Class II cases. If present, orthodontic treatment should be stopped, and TMD should be addressed to prevent it from becoming aggravated to a severe form. Orthodontic treatment should be started only when the TMD symptoms have subsided. According to the findings from this study, it is not only the condylar position that determines the stability of the TMJ but also the joint spaces and disk position that can affect the stability of the results achieved. Cases with mild to moderate forms of TMDs should be evaluated by MRI to evaluate alterations in the TMJ morphology. Along with condylar position, it is very important to assess the articular disk position before, during, and after treatment to eliminate the presence of TMDs, prevent a milder form of TMD to become aggravated into a more severe form, and to achieve stable results after orthodontic treatment.

CONCLUSIONS

- Class II vertical cases showed maximum alterations in the disk position, condylar position, and joint spaces. There was a tendency for anterior and medial disk displacement with more anteriorly positioned condyles compared with other groups. The highest number of cases with signs and symptoms of TMD were observed in this group.
- Class II cases, and especially vertical cases, must be thoroughly evaluated for the presence of signs and symptoms of TMDs, and if clinical examination shows positive results, then the cases should be subjected to MRI evaluation.

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