

Transverse Malocclusion and Temporomandibular Disorders: Verification of the Controversy

Nehal M. Amer, BDS, MSc

Amira A. Aboalnaga, BDS, MSc

Department of Orthodontics
Faculty of Dentistry
Cairo University
Cairo, Egypt

**Mona M. Salah Fayed, BDS, MSc,
PhD, Dr Med Dent**

Department of Orthodontics
Faculty of Dentistry
Cairo University
Cairo, Egypt;
Department of Pediatric Dentistry and
Orthodontics
Faculty of Dentistry
University of Malaya
Kuala Lumpur, Malaysia

Amr H. Labib, BDS, MSc, PhD

Department of Orthodontics
Faculty of Dentistry
Cairo University
Cairo, Egypt

Correspondence to:

Prof Mona Mohamed Salah Fayed
Department of Orthodontics
Faculty of Dentistry, Cairo University
11 Saraya ElManial Street, Cairo, Egypt
Fax: +6 03-7967 4800
Email: mona.fayed@dentistry.cu.edu.eg,
mona.fayed@um.edu.my

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Aims: To investigate the transverse dental and skeletal aspects of malocclusion in a sample of temporomandibular disorders (TMD) patients and to assess the correlations of these aspects with the signs and symptoms of TMD. **Methods:** A total of 150 TMD patients diagnosed according to the Diagnostic Criteria for TMD were divided into five groups: Group 1 (myalgia), Group 2 (disc displacement with reduction [DDWR]), Group 3 (disc displacement without reduction [DDWOR]), Group 4 (degenerative disorders), and Group 5 (subluxation). The transverse occlusion was assessed clinically, and any posterior crossbite present was recorded. Using cone beam computed tomography, several skeletal and dental transverse measurements were evaluated in each patient to diagnose the presence of skeletal posterior crossbite and possible facial and dental asymmetry. One-way analysis of variance was used to compare the means of more than two groups. Pearson correlation coefficient was used to assess the correlations of quantitative continuous variables. Significance level was considered at $P < .05$. **Results:** Posterior crossbite was found in only 18% of the sample, while 28.7% of the subjects showed transverse skeletal crossbite. All skeletal and dental measurements evaluating symmetry showed no statistically significant differences between the groups except for the occlusal plane cant, which was significantly higher in Group 2 compared to Group 1. Dental and skeletal transverse discrepancies showed no correlation with TMD. **Conclusions:** Transverse malocclusion is not correlated with the signs and symptoms of TMD. *J Oral Facial Pain Headache 2019;33:355–361. doi: 10.11607/ofph.2286*

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Temporomandibular disorders (TMD) is a collective term that embraces a number of clinical problems involving the masticatory muscles, the temporomandibular joint(s) (TMJs), and/or associated orofacial structures.¹ Whether an association exists between TMD and posterior crossbite seems to be one of the most controversial topics in the TMD literature. Different findings on this association have been presented,^{2–11} and these differences could be attributed to the different choices of TMD signs and symptoms evaluated and also due to a lack of differentiation between subjects with true skeletal crossbite and others with only dental crossbite. A systematic review² also suggested that the lack of description of the type of dental posterior crossbite (true or functional) in the previous studies could be the reason behind the controversy in the literature.

To the authors' knowledge, no study so far in the orthodontic literature has been conducted to analyze transverse skeletal parameters using clinical measurements and cone beam computed tomography (CBCT) in TMD patients.

Posterior crossbite has been defined as having one or more of the posterior teeth in an irregular (at least one cusp wide) buccolingual or buccopalatal relationship.¹² Depending on the degree of transverse dysplasia, posterior crossbites can be unilateral, bilateral, skeletal, dental, or a combination of these.

Table 1 Differential Diagnosis of TMD According to the DC/TMD

Disorder		Clinical picture
Pain disorders	Group 1: Myalgia	- Pain in a masticatory structure - Pain modified by jaw movement, function, or parafunction - Pain on palpation or maximum opening in at least three sites, at least one of which is on the same side of the reported pain
Joint disorders	Group 2: Disc displacement with reduction	- Reciprocal click on opening and closing OR -Opening or closing clicks, and click with lateral or protrusive movements
	Group 3: Disc displacement without reduction	-Absence of TMJ clicking, but a reported history of clicking -With limited opening: Maximum assisted opening < 40 mm -Without limited opening: Maximum assisted opening > 40 mm
	Group 4: Degenerative joint disease	-Crepitus during jaw movement
	Group 5: Subluxation	-TMJ locking or catching in wide-open jaw position and unable to close mouth without specific maneuver

It has been suggested that the altered morphologic relationship between the maxillary and mandibular dentition may cause occlusal interferences¹³ and may also result in asymmetry in masticatory muscles and the condyle-fossa relationship, leading to an increased tendency for tenderness of the masticatory muscles and headache.^{14,15} Furthermore, it was suggested that these alterations of the disc-condyle relationship might be responsible for TMJ disc displacement and clicking.

This research project also aimed to explain the relationship between TMD and posterior dental crossbite, skeletal crossbite, and craniofacial transverse asymmetry.

Materials and Methods

Independent samples *t* test was utilized for sample size calculation, based on a previous study.²⁹ Since the mean mandibular plane angles in the control and joint disorder groups were 19.64 ± 5.22 degrees and 23.26 ± 5.05 degrees, respectively, a sample size of 30 patients per group (masticatory muscle disorder and joint disorder groups) was indicated, assuming an alpha error of 0.05 and power of 80%. As one of the aims of the study was to evaluate the prevalence of different malocclusions within the TMD population, it was decided to include consecutive TMD patients; therefore, the previously reported³⁰ prevalence of masticatory muscle disorders among the TMD population (30%) was used to calculate the least total required number of consecutive patients, which was 100 patients. This was increased to 150 patients for better reliability of the results and to ensure higher statistical power.

A total of 150 patients were recruited for this cross-sectional study from the Outpatient Clinic of the Department of Orthodontics, Cairo University. Patients were informed about the study procedures,

and written consents were signed by the patients or parents.

The inclusion criteria were: patients suffering from pain in the TMJs and/or jaw muscles; pain on mandibular movement; joint sounds or restricted mandibular movements; and full permanent dentition (excluding third molars). The exclusion criteria were: history of previous TMD and/or orthodontic treatment and/or history of growth disorders, polyarthritis, acute traumatic injuries, infections, developmental defects, or neoplasia of the TMJs.

Customized history was taken, and a clinical examination chart was used following the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD)¹⁶ and Okeson.¹⁷ Three well-trained operators (A.A., N.A., and M.N.) performed the history-taking and clinical examinations. Their clinical measurements of an initial pilot sample of 10 patients were calibrated by a clinician experienced with TMD (M.F.). Intraobserver and interobserver reliability were confirmed statistically before commencement of the research project.

Transverse occlusion was recorded for each patient, and assessment of the transverse occlusion was performed and the presence of posterior crossbite recorded. The type of crossbite (unilateral/bilateral, palatal/buccal) and nature of crossbite (true/functional) were also recorded, and the nature of the crossbite was evaluated through functional examination.

Diagnosis of the patient's TMD was done according to the DC/TMD¹⁶ criteria and categorized into five TMD groups (Table 1):

- Group 1: Myalgia
- Group 2: Disc displacement with reduction (DDWR)
- Group 3: Disc displacement without reduction (DDWOR)
- Group 4: Degenerative disorders
- Group 5: Subluxation

Table 2 Skeletal and Dental Transverse Measurements Used in CBCT Analysis

Measurement	Abbreviation	Definition
Skeletal		
Effective maxillary width (mm) ⁵	J-J	Distance between landmarks JR (right jugale) and JL (left jugale)
Effective mandibular width (mm) ⁵	AG-GA	Distance between landmarks AG (right antegonion) and GA (left antegonion)
Maxillomandibular base ratio ⁶	Mx/Md ratio	Ratio between maxillary effective width and mandibular effective width
Menton to midsagittal (mm)	Me-MSP	Horizontal distance between menton and the midsagittal plane, evaluating mandibular symmetry
Maxillary plane transverse inclination (maxillary cant)	MxP/TRL	Angle between maxillary plane and transverse reference line (line connecting the landmarks Zf-right to Zf-left)
Dental		
Occlusal plane transverse inclination (functional occlusal cant)	FOP/ TRL	Angle between functional occlusal plane and transverse reference line
Dental midline shift (mm)	ML-shift	Distance between the maxillary and mandibular centerlines

Zf = zygomatic suture point (medial and anterior junction of zygomatic bone with frontal bone).

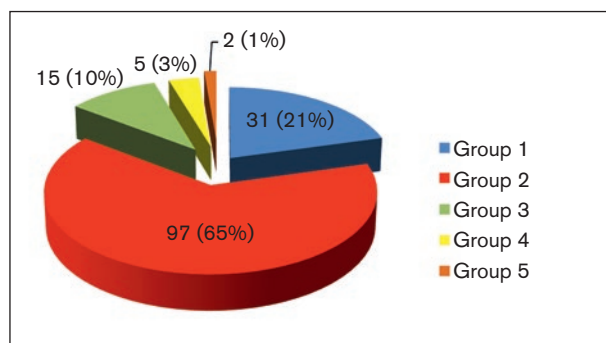


Fig 1 Pie chart showing the number (percent) of patients within the different TMD groups. Group 1 = myalgia; Group 2 = disc displacement with reduction; Group 3 = disc displacement without reduction; Group 4 = degenerative disorders; Group 5 = subluxation.

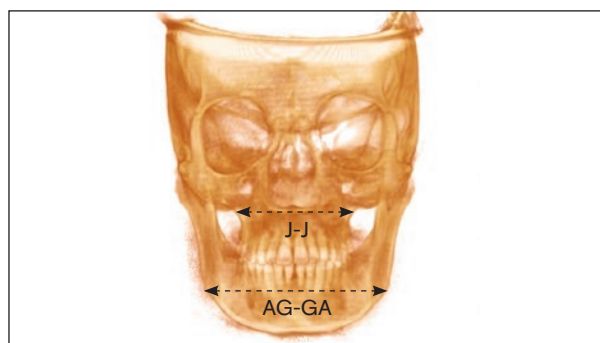


Fig 2 Coronal view showing the effective maxillary width (J-J) and effective mandibular width (AG-GA) measured in the transverse skeletal analysis.

CBCT Imaging and Assessment

After clinically diagnosing the subject's TMD, the skull was imaged using CBCT with the mandible closed in the maximum dental intercuspation position. The field of view was large (17 cm) at 120 kV, 18.5 mAs, and 8.9 seconds exposure time. Images were acquired using the next generation i-CAT CBCT unit. Fully reconstructed three-dimensional volumetric images were generated using Anatomage image processing software version 5.01, and several skeletal and dental transverse measurements (Fig 2, Table 2) were evaluated in each patient to diagnose the presence of skeletal posterior crossbite and possible facial and dental asymmetry.

Statistical Analyses

The statistical analysis was performed using SPSS software (version 17). Kolmogorov-Smirnov and Shapiro-Wilk tests of normality were used to test normality hypothesis of quantitative data. Independent samples *t* test was used for comparing the means of two groups, and one-way analysis of variance (ANOVA) was used for comparing the means of more than two

groups. Multiple comparisons Bonferroni method was used for comparing two groups when the ANOVA yielded statistically significant results. Chi-square test was used for categorical data in contingency tables. Kruskal-Wallis test was used for comparison of the means of more than two groups (nonparametric data). Pearson correlation coefficient was used for assessing the correlation of quantitative continuous variables. The significance level was $P < .05$, and $P < .01$ was considered highly significant. Two-tailed tests were assumed throughout the analysis for all statistical tests. For inter- and intraobserver reliability analysis of all measured variables, Dahlberg error (DE) and relative Dahlberg error (RDE) tests were used, respectively, together with concordance correlation coefficients (CCC), including 95% confidence limits (CLs).

Results

The present study included 150 TMD patients. The sample was divided into five groups according to TMD diagnosis (Fig 1).

Table 3 Comparative Statistical Analysis of Transverse Occlusion Within the Different TMD Groups

Group/transverse occlusion	Group 1 (n = 31)		Group 2 (n = 97)		Group 3 (n = 15)		Group 4 (n = 5)		Group 5 (n = 2)		Total (n = 150)		χ ²	P value
	n	%	n	%	n	%	n	%	n	%	n	%		
Normal	28	90.3	76	78.4	13	86.7	5	100	1	50	123	82.0	3.70	.2957
True bilateral crossbite	0	0.0	8	8.2	1	6.7	0	0.0	0	0.0	9	6.0	NA	NA
True unilateral crossbite	3	9.7	2	2.1	1	6.7	0	0.0	0	0.0	6	4.0	NA	NA
Functional unilateral crossbite	0	0.0	9	9.3	0	0.0	0	0.0	0	0.0	9	6.0	NA	NA
Buccal crossbite	0	0.0	2	2.1	0	0.0	0	0.0	1	50	3	2.0	NA	NA

Chi-square test.

Group 1 = myalgia; Group 2 = disc displacement with reduction; Group 3 = disc displacement without reduction; Group 4 = degenerative disorders; Group 5 = subluxation; NA = not available.

Table 4 Comparative Statistical Analysis of Transverse Skeletal and Dental Measurements Within the Different TMD Groups

Craniofacial transverse measurement	Reported norms (Mean ± SD)	Group (Mean ± SD)					Total (n = 150)	ANOVA	
		1 (n = 31)	2 (n = 97)	3 (n = 15)	4 (n = 5)	5 (n = 2)		F	P value
Skeletal									
J-J ⁷³	66.3 ± 3	62.62 ± 3.53	63.20 ± 3.87	61.91 ± 4.86	60.16 ± 3.30	58.66 ± 5.25	62.79 ± 0.94	1.38	.25095
AG-GA ⁷³	85.8 ± 3	80.16 ± 5.51	79.65 ± 5.43	78.21 ± 4.88	80.62 ± 7.92	77.72 ± 6.79	79.62 ± 5.45	0.49	.69278
Mx/Md ratio ⁸⁰	≥ 0.77	0.78 ± 0.05	0.80 ± 0.06	0.79 ± 0.07	0.75 ± 0.06	0.76 ± 0.01	0.79 ± 0.06	1.16	.32707
Me-MSP	0 indicates perfect symmetry	1.72 ± 1.23	2.10 ± 1.92	1.97 ± 1.40	1.47 ± 0.64	3.30 ± 0.64	2.00 ± 1.71	0.53	.66540
MxP/TRL	0 indicates perfect symmetry	1.55 ± 1.43	1.93 ± 1.67	1.69 ± 1.81	1.56 ± 0.62	0.75 ± 0.06	1.80 ± 1.60	0.51	.67500
Dental									
FOP/TRL	0 indicates perfect symmetry	0.8 ± 0.62 ^a	1.47 ± 1.17 ^b	1.18 ± 0.81	2.05 ± 1.29	1.84 ± 0.33	1.33 ± 1.08	3.87	.01066*
ML-shift	0 indicates perfect symmetry	0.91 ± 0.78	0.99 ± 1.02	0.93 ± 0.80	0.75 ± 1.11	0.24 ± 0.30	0.95 ± 0.95	0.15	.92864

Group 1 = myalgia; Group 2 = disc displacement with reduction; Group 3 = disc displacement without reduction; Group 4 = degenerative disorders; Group 5 = subluxation; ANOVA = analysis of variance; J-J = effective maxillary width; AG-GA = distance between right antegonion and left antegonion; Mx/Md ratio = ratio between maxillary effective width and mandibular effective width; Me-MSP = horizontal distance between menton and midsagittal plane; MxP/TRL = angle between maxillary plane and transverse reference line; FOP/TRL = angle between functional occlusal plane and transverse reference line; ML-shift = distance between maxillary and mandibular centerlines.

*P < .05. Different superscript letters indicate highly statistically significant differences (P < .01) using multiple comparison test (Bonferroni method).

Normal transverse occlusion was found in 123 patients (82.0%) (Table 3), while posterior crossbite was found in only 27 patients (18.0%), distributed as follows: true bilateral crossbite and functional unilateral crossbite were each found in nine patients (6.0%); true unilateral crossbite was found in six patients (4.0%); and buccal crossbite was found in three patients (2.0%). Comparing the different TMD groups, no statistical significance was found.

The CBCT measurements showed a mean maxillomandibular base ratio value of 0.79 ± 0.06 for the total sample, with no statistical significance between groups (Table 4). The prevalence of transverse discrepancy in the total sample was 28.7% (43 patients), also with no statistical significance between the groups (Table 5).

All skeletal and dental measurements evaluating symmetry showed no statistical significance between groups (Table 4), except the occlusal plane cant (FOP/TRL), which showed a statistical difference between Group 1 (lowest value: 0.82 ± 0.62 degrees) and Group 2 (1.47 ± 1.17 degrees).

Based on the maxillomandibular ratio measurements, the prevalence of transverse discrepancy in the total sample was 28.7% (43 patients), with no statistical significance between the groups (Table 5).

Transverse discrepancy, as evaluated clinically (true and functional posterior crossbite) and through CBCT (skeletal crossbite and facial and dental asymmetry), was tested for correlations with the TMD clinical parameters.

Table 5 Comparative Statistical Analysis of Craniofacial Transverse Jaw Relations Within the Different TMD Groups

	Group												χ^2	P value
	Group 1 (n = 31)		Group 2 (n = 97)		Group 3 (n = 15)		Group 4 (n = 5)		Group 5 (n = 2)		Total (n = 150)			
	n	%	n	%	n	%	n	%	n	%	n	%		
Transverse jaw relation														
Normal transverse jaw relation	22	71.0	69	71.1	12	80.0	3	60.0	1	50.0	107	71.3	0.87	.83310
Transverse jaw discrepancy	9	29.0	28	28.9	3	20.0	2	40.0	1	50.0	43	28.7	NA	NA

Chi-square test.

Group 1 = myalgia; Group 2 = disc displacement with reduction; Group 3 = disc displacement without reduction; Group 4 = degenerative disorders; Group 5 = subluxation; NA = not applicable for statistical testing (due to limited number of subjects).

Table 6 Comparative Statistical Analysis Showing Relations Between Clinical Transverse Occlusion and Clinical TMD Parameters

Transverse occlusion	No. of subjects	Clinical TMD parameter					
		Muscle pain severity			Joint pain severity		
		Mean \pm SD	ANOVA F	P value	Mean \pm SD	ANOVA F	P value
Group 1 (myalgia)							
Normal	28	15.68 \pm 9.79	0.028	.868	5.04 \pm 3.82	0.738	.397
True posterior crossbite	3	14.67 \pm 11.59			7.00 \pm 3.00		
Functional posterior crossbite	0						
Groups 2+3+4 (joint disorders)							
Normal	95	7.19 \pm 6.97	1.496	.228	4.06 \pm 2.89	2.753	.068
True posterior crossbite	13	5.92 \pm 5.69			4.15 \pm 2.85		
Functional posterior crossbite	9	3.33 \pm 3.24			1.78 \pm 1.72		

ANOVA = analysis of variance.

For more specific and reliable results, the results of Group 2 (DDWR), Group 3 (DDWOR), and Group 4 (degenerative disorders) were combined into one group (joint disorders [JD] group). Group 5 was excluded due to its small size, which made it not applicable for statistical testing. Therefore, all correlations were tested twice, once for Group 1 (myalgia) and a second time for the JD group.

No clinical or CBCT transverse measurements showed correlations with the TMD clinical parameters (Tables 6 and 7).

Discussion

There are still controversies concerning transverse discrepancy and the importance of establishing an ideal occlusion via orthodontic treatment. Although many studies have been performed to study the relationship between TMD and transverse malocclusion, the available literature reflects conflicting associations between them.

In the current study, history and clinical examination followed the DC/TMD,¹⁶ which is a diagnostic system with proven reliability¹⁶ that allows standardization and replication in the diagnosis and classification of TMD. Thus, a reliable study protocol was adopted.

Table 7 Correlation Between CBCT Transverse Measurements and Clinical TMD Parameters Using Pearson Correlation Test

CBCT transverse measurement	Clinical TMD parameter			
	Muscle pain severity		Joint pain severity	
	r	P value	r	P value
Group 1 (myalgia)				
Skeletal				
Mx/Md ratio	0.039	.835	-0.191	.302
Me-MSP	0.209	.259	0.276	.132
Maxillary cant	-0.103	.581	-0.042	.821
Dental				
Occlusal cant	-0.103	.581	-0.196	.291
ML-shift	-0.286	.119	-0.098	.601
Groups 2+3+4 (joint disorders)				
Skeletal				
Mx/Md ratio	0.120	.199	0.167	.072
Me-MSP	0.126	.176	0.083	.372
Maxillary cant	-0.021	.820	0.030	.749
Dental				
Occlusal cant	-0.028	.764	-0.044	.641
ML-shift	0.028	.769	0.058	.535

Mx/Md ratio = ratio between maxillary effective width and mandibular effective width; Me-MSP = horizontal distance between menton and midsagittal plane; ML-shift = distance between maxillary and mandibular centerlines.

The maxillary and mandibular widths were measured as proposed by Ricketts,¹⁸ as these measurements were shown to be valid and reliable when used on CBCT images.^{19,20}

Previous studies^{11,21-24} have reported the prevalence rates of posterior crossbite among the general adult populations of different nationalities as ranging between 7.9% and 30.6%, which is comparable to the results of the present study (18%) carried out in a TMD population.

The authors of a previous systematic review² suggested that functional crossbite needs to be identified separately from true crossbite, as they seemed to show weak positive associations with TMD in some studies. In the present study, posterior crossbite was further classified into true unilateral, true bilateral, functional unilateral, and buccal crossbite, with a prevalence of 6.0%, 4.0%, 6.0%, and 2.0%, respectively. This finding showed that no specific type of crossbite was highly prevalent in patients with TMD.

The prevalence of posterior crossbite was then compared between the different TMD groups and showed no significant difference, which is consistent with previous studies^{5,7} that showed no association between crossbite and DDWR or myalgia.

The results of the CBCT transverse skeletal analysis showed normal transverse jaw relation in 71.3% of the total sample, while 28.7% of the subjects showed transverse jaw discrepancy (transverse skeletal crossbite). The prevalence rates of skeletal crossbite in TMD patients or in the general population were not previously reported in the literature; accordingly, it was not possible to draw a conclusion as to whether this high prevalence shown in the present study is specific to the TMD population only or is a normal finding in the general population.

As previously discussed, the sample was divided into five TMD groups. Each group was treated as a separate entity due to the differences in the nature of arthrogenic and myogenic TMD, as well as their proposed etiologies. The prevalence of TMD differed within the studies, probably because of methodologic errors and lack of standardized definitions of TMD and its characteristics. Most previous studies,^{10,11,25-27} which were concerned with the correlation between transverse discrepancy and TMD, did not subdivide the TMD population into articular and nonarticular disorders.²⁸ The sample of this study was divided according to TMD diagnosis using the DC/TMD¹⁶ guidelines. Group 2 (DDWR) showed the highest number of patients (64.7%), followed by Group 1 (myalgia).

The results of the CBCT transverse skeletal analysis showed no significant difference between the different TMD groups regarding maxillary width, mandibular width, or maxillomandibular width ratio. Normal

transverse jaw relation was found in 71.3% of the total sample, while 28.7% of the subjects showed transverse jaw discrepancy (transverse skeletal crossbite). The prevalence rates of skeletal crossbite in TMD patients or in the general population have not been previously reported in the literature; accordingly, it was not possible to draw a conclusion as to whether this high prevalence shown in the present study is specific to the TMD population only or is a normal finding in the general population. Maxillary and mandibular asymmetry also showed no significant difference between the different groups, which is inconsistent with the results of previous studies^{4,6,29} that claimed asymmetry was more prevalent in certain TMDs.

The CBCT transverse dental analysis showed a statistically significant difference in the functional occlusal plane cant between Group 1 and Group 2, with Group 2 showing a significantly increased cant compared to Group 1. This finding is consistent with the results of a previous study,¹⁰ which showed that canting of the functional occlusal plane was highly correlated with TMD. Another study³⁰ by the same authors investigated how canted occlusal planes affect the masticatory force distribution and concluded that it caused a unilateral increase in stresses on the articular disc, which could lead to internal derangement of the joint.

No other transverse dental measurements showed significance between the different groups.

The results of this study indicate that transverse discrepancy (true dental crossbite, functional crossbite, skeletal crossbite, and transverse facial and dental asymmetry) showed no significant differences between different groups of TMD, except the occlusal plane cant (FOP/TRL), which was significantly higher in the DDWR group compared to the myalgia group. No correlation was found between any transverse malocclusion or asymmetry and TMD clinical parameters. This confirms the findings of previous studies^{5,7,31} that reported no evidence that posterior crossbite can be considered as a strong etiologic factor for TMD.

Study Limitations

The study sample was divided into five groups according to the most severe TMD diagnosis to avoid having a large number of study groups. Therefore, a limitation of this study is that Groups 2, 3, and 4 are not "pure" groups, as some of the patients in those groups also had myalgia.

Conclusions

Posterior crossbite was found in only 18% of the sample, while 28.7% of the subjects showed transverse skeletal crossbite. The DDWR group (Group 2)

showed statistically significantly increased functional occlusal plane cant compared to the myalgia group (Group 1). Dental and skeletal transverse discrepancy showed no correlation with TMD.

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The authors report no conflicts of interest.

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