Original Article

Association between malocclusion and articulation of phonemes in early childhood

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ABSTRACT

Objectives: To evaluate the relationship between dental malocclusion and speech to understand the etiology of speech sound disorders (SSD) in schoolchildren and to make a correct diagnosis and treatment plan.

Materials and Methods: Articulation and dental occlusion, oromyofunctional evaluation with orofacial praxis and musculature, resting tongue position, and swallowing pattern were analyzed in 290 schoolchildren between the ages of 4 and 7 years. Statistical tests were considered significant for $P < .05$.

Results: A significant association between dental malocclusions (Angle Class II and III, anterior open bite, edge-to-edge bite, overjet and anterior crossbite) and phonetic alterations ($P = .008$) was observed. Sigmatisms and rhotacisms were the most frequent disorders. Malocclusions also showed a significant association with oral habits and with orofacial praxis and muscle activity.

Conclusions: The presence of malocclusion can cause imbalances in the functions involved in the stomatognathic system. Awareness of this relationship in young children would help professionals to implement preventive measures for the optimum development of children's oral health. (*Angle Orthod.* 2022;92:505–511.)

KEY WORDS: Malocclusions; Atypical swallowing; Sound speech disorders; SSD

INTRODUCTION

Speech sound disorder (SSD), or difficulty articulating one or more phonemes, is the most common speech impairment in schoolchildren aged 3–10 years, with a prevalence of 48.1%.[1] The origin of SSD is functional and organic. Among the organic causes are dental dysglossia, which are articulation disorders due to an alteration in the position of teeth.

Various authors investigated how dental malocclusions affected phoneme articulation in different languages. In the anteroposterior plane, a relationship was found between dental overjet and the pronunciation of the phonemes: /s/ and /z/ in Portuguese;[2] the phonemes /s/, /sh/, /z/, and /zh/ in English;[3] the phonemes /s/ and /r/ in Finnish,[4] and the phonemes /l/, /n/, /d/, /t/, and /s/ in German.[5] Other authors found associations between Class II and III malocclusions and several articulation disorders in Italian;[6] English;[7] Portuguese,[8] and German.[5] In Iranian patients with skeletal Class III, these language alterations improved after orthodontic treatment combined with orthognathic surgery,[9] while patients with Class I malocclusions did not exhibit articulation errors.[8] In the vertical plane, a significant relationship was found between overbite and alteration of the phoneme /s/[10] or other phonemes, fricatives being outstanding with anterior open bite.[3,11–16] The transitional open bite caused by the

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premature loss of incisors during the change from deciduous to permanent teeth does affect speech, but does not interfere in the process of language acquisition.[17] Lastly, in the transverse dimension, posterior crossbite was shown to be related to certain phonetic alterations.[5,10,18] A Spanish population study concluded that terminal plane and occlusion type were related with omission and substitution of phonemes.[19]

Several studies showed associations between presence of oral habits and certain malocclusions[20,21] and orofacial muscle impediments,[22] while correction of malocclusions favors masseter and temporalis muscle activity.[23] One habit, atypical swallowing, displayed a significant relationship with anterior open bite and crossbite[12] and with certain phoneme alterations.[2,20] However, other authors did not find any relationship[24] due to compensatory movements of the jaw, tongue, and lips.[25] Orofacial labial praxis may be related to anterior open bite.[13]

This study was undertaken due to the controversy raised by previous investigations, the few studies carried out on language acquisition in Spanish[13,19] and because previous studies were not conducted in young age groups. Therefore, the aim of this study was to assess the relationship between dental malocclusion and oromyofunctional behavior with SSD in children aged 4 to 7 years, the age during which the process of language acquisition is usually active.

MATERIALS AND METHODS

Power analysis showed that a sample size of at least 150 patients would provide an 80% probability of detecting differences using an analysis of variance (ANOVA) model at a confidence level of 95% and assuming a correlation among repeated measurements of 0.5. This observational, descriptive, cross-sectional study was approved by the Ethics Committee for Research on Humans of the University of Valencia, Spain, and by the Regional Ministry for Education of Valencia, Spain. The study included 290 schoolchildren aged 4 to 7 years (mean age: 5.7 years), attending six different schools in the city of Valencia, Spain. Of those, 104 were in the primary dentition (35.8%) and 186 (64.2%) were in the mixed dentition, with a significant difference in the number of primary and mixed dentition children ($P < .0001$).

Informed consent was obtained from each child's parent/guardian and the child had to be in attendance at school on the day of the examination. Exclusion criteria included previous orthodontic treatment or currently undergoing treatment, and presence of craniofacial anomalies or syndromes.

Participants underwent clinical examination by a single evaluator under the same conditions, which consisted of the following:

- Assessment of dental occlusion:

Sagittal Relationship

Class I: The mesiobuccal cusp of the maxillary permanent molar occluded with the mesiobuccal groove of the mandibular first permanent molar.

Class II: The mesiobuccal cusp of the maxillary permanent molar occluded mesial to the mesiobuccal groove of the mandibular first permanent molar. Class II-1: Proclined maxillary incisors, Class II-2: Retroclined maxillary incisors.

Class III: The mesiobuccal cusp of the maxillary permanent molar occluded distal to the mesiobuccal groove of the mandibular first permanent molar.

Overjet: Anterior-posterior distance between the maxillary and mandibular incisal edges. Normal: 1–2 mm, Slight: up to 3 mm; Moderate: 3–5 mm; Severe: $>$5 mm.

Edge-to-edge bite: The incisal edges of the maxillary incisors contacted the incisal edges of the mandibular incisors.

Anterior crossbite: The maxillary incisal edges were behind the mandibular incisors.

Vertical Relationship

Overbite: Vertical distance between the incisal edges of the maxillary incisors relative to the mandibular incisors. Normal: 1–2 mm; Slight: up to 3 mm; Moderate: 3–5 mm; Severe: $>$5 mm.

Anterior open bite: There was no vertical overlap between the incisal edges of the maxillary and mandibular incisors.

Transverse Relationship

Posterior crossbite: The buccal cusps of the maxillary premolars and molars occluded in the fossae of the mandibular premolars and molars.

Intra-Arch Relationship

Crowding: Discrepancy between the space available and the size of the teeth (Table 1S).

- Myofunctional assessment: Orofacial praxis and facial musculature were assessed. Praxis was assessed through observation and imitation of a series of images (Figure 1). Orofacial musculature was assessed by observing the buccinator muscles when blowing up a balloon and palpating the masseter muscle while the child clenched their teeth.

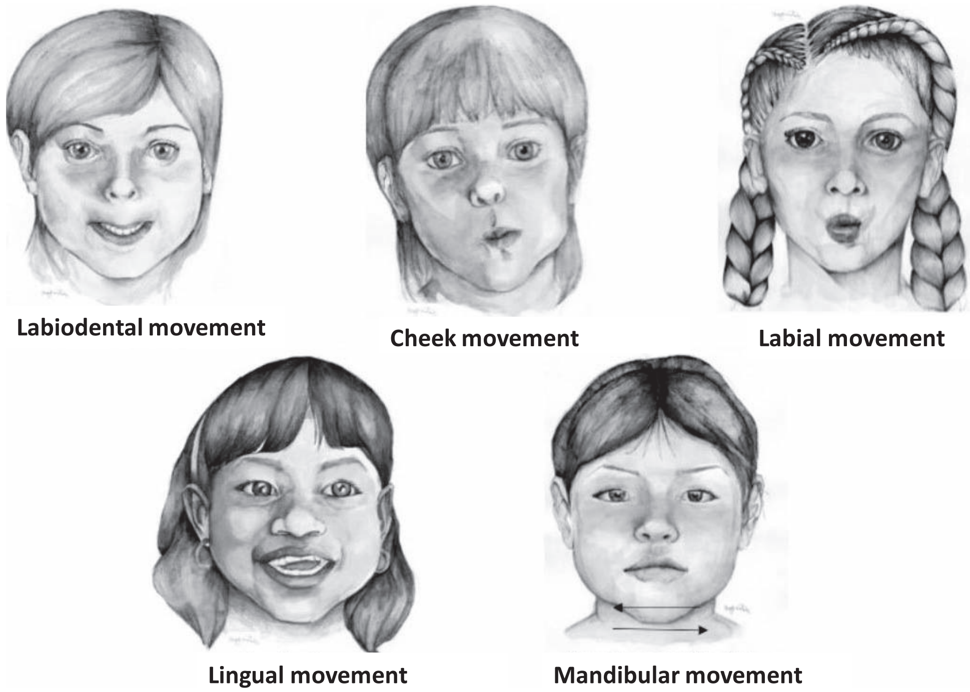

Figure 1. Images used in assessing orofacial praxis.

- Assessment of the presence of anomalous habits: Carried out directly by the evaluator and was completed with answers to the questionnaire given to the parents/guardians about the child's habits. This questionnaire also assessed the languages spoken by the child at home and whether the children received special care at school (Table 2S).
- Assessment of swallowing pattern and resting tongue position: Swallowing was classified as normal, adaptive, or atypical. Atypical swallowing was assessed by observing the position of the tongue (low, intermediate, or in an anterior position against the incisors) and the involvement of the orofacial musculature (perioral or chin contraction, or lower lip suction).[26] To assess adaptive swallowing, children were observed for anterior open bite due to eruption and for marked diastemas (either due to tooth exfoliation or labial frenum). The position of the tongue at rest was also assessed, whether the tongue was in a low, intermediate, or anterior position (against the palatal side of the anterior teeth) or in a high (normal) position.
- Assessment of the articulation of phonemes: Spontaneous language was assessed by auditory discrimination and phoneme articulation based on the Induced Phonological Register Evaluation Test, RFI[27] (Table 3S).

Statistical Analysis

The SPSS v21 package (IBM SPSS Statistics for Windows, Version 21.0. IBM Corp., Armonk, NY) was used for statistical analysis. Given the sample size, parametric statistics were used for numerical variables (Student's *t*-test to compare two groups and ANOVA for three or more groups, with Scheffé test for multiple comparisons). Pearson's Chi-square and analysis of standardized residuals (SR) were used to analyze categorical variables. In all cases, the result was considered significant at $P < .05$.

RESULTS

Applying the inclusion and exclusion criteria, 290 children were included in the study as previously described. Some type of malocclusion was observed in 46.2% of the sample, with a high prevalence of crossbite, overbite, and overjet (Table 1).

Oromyofunctional Behavior

Table 2 shows the distribution of the sample by Angle Classification according to the existence or not of oral habits and muscular alterations. When analyzing whether there was an association with the malocclusion, a relationship of dependence ($P \ll .001$) was observed between masseter disorders and Angle Class II-1 and II-2 (SR = 1.7 and 2.0, respectively). There was also an association ($P < .004$) between buccinator impairment and Angle Class II-2 (SR = 1.6), and a significant relationship ($P < .03$) between the alteration in the praxis and Angle Class I and II-1 (SR = 1.6 for both).

Table 1. Distribution (Valid Percentages) Across Occlusal Parameters of the Sample for Sagittal, Vertical, Transverse Relationships, and Interarch Ratios

Sagittal Malocclusions (%)		Vertical Malocclusions (%)		Transverse Malocclusions (%)		Interarch Relationship (%)	
Angle Classes		Overbite		Posterior crossbite posterior	10.3	Crowding	2.8
Class I	53.7	Normal	64				
Class II-1	13.2	Slight	12.5				
Class II-2	28.9	Moderate	12.8				
Class III	4.1	Severe	10.7				
Overjet		Anterior open bite	2.4				
No	69.2						
Slight	12.5	Anterior open bite due to eruption	40.1				
Moderate	8.7						
Severe	9.6						
Edge-to-edge bite	4.1						
Anterior crossbite	3.8						

Table 3 shows oral habits in detail. More than one-quarter of the sample exhibited one or more oral habits. The habit of putting objects in the mouth was the most common ($P < .05$).

Tongue rest position was assessed as normal in 69.1%, low in 10.4%, intermediate in 8.7%, and anterior in 11.8%. There was no statistically significant difference among the proportions of abnormal positions.

There was no significant association among the three types of swallowing: normal, adaptive, and atypical (Table 3). In atypical swallowing, observed in 29.7%, a significant relationship was found with Angle Class ($P < .001$) (SR $=$ 2.0 for Class II-1; SR $=$ 2.4 for Class II-2, and SR $=$ 1.8 for Class III) (Table 2). In children with atypical swallowing, a significant difference was observed between the two atypical tongue positions: anterior and lateral tongue thrust ($P \ll .001$). During atypical swallowing, chin contraction was significantly more common than all other orofacial muscle involvement ($P \ll .001$). A significant relationship was also found between the presence of atypical swallowing and phonetic disturbances ($P \ll .001$), but there was no significant relationship between the type of dentition

Table 2. Cross-Table of Association Between Angle Class and Presence or Absence of Oral Habits and Muscular Alterations. Significance Values From Pearson's Chi-Square Test and Standardized Residual (SR) Value.

	Class I	Class II-1	Class II-2	Class III
Oral habits				
Pacifier, objects, thumb-, and lip-sucking				
P				<.01
SR				3.4
Atypical swallowing				
P		≪.001	≪.001	≪.001
SR		2.0	2.4	1.8
Muscle alterations				
Masetter				
P		≪.001	≪.001	
SR		1.7	2.0	
Buccinator				
P			<.004	
SR			1.6	
Orofacial praxis				
P	≪.001		<.004	
SR	1.6		1.6	

Table 3. Distribution of the Sample Depending on Presence or Absence of Oral Habits. Number of Valid Percentages, *P* Value.

	Presence of Oral Habits (%)	Absence of Oral Habits (%)	Total (%)	*P* Value
Total sample	27.2	72.7	100	
Type of oral habit				
Pacifier	0.4	99.6	100	
Objects	17.2	82.8	100	<.05
Thumb sucking	9.7	90.3	100	
Lip sucking	6.8	93.2	100	
Swallowing				
Normal swallowing	36.9	63.1	100	
Adapted swallowing	38.3	61.7	100	
Atypical swallowing	30.7	69.3	100	
Tongue thrust				
Normal	0	69.3	69.3	
Anterior	23.7	0	23.7	≪.001
Lateral	7	0	7	
Total	30.7	69.3	100	
Muscle contraction				
No	0	70.8	70.8	
Perioral	7.5	0	7.5	
Chin	16.4	0	16.4	≪.001
Suction	5.3	0	5.3	
Total	29.2	70.8	100	
Tongue position at rest				
Normal	69.1			
Altered				
Low	10.4			
Intermediate	8.7			
Anterior	11.8			
Total	100			
Phonetic alterations				
No	8.7	40.7	49.4	
Yes	22.2	28.4	50.6	≪.001
Total	30.9	69.1	100	

Table 4. Cross-Table of Associations Between Alteration of Groups of Phonemes and Type of Malocclusion. Only Cases in Which the Test $P <$ .05 Was Significant Are Indicated and Standardized Residual (SR) Value has Been Added to Show Specific Association. Values of SR $\geq$ 1.5 Are Considered Significant.

	/r/, /rr/	/s/	/z/	/f/	/ch/	/p, b/	/t, d/	/l, ll/	/m, n, ñ/	/k, g, x/
n (%), N=290	82 (28.3)	129 (44.8)	109 (37.6)	54 (18.6)	46 (15.9)	6 (2.1)	15 (5.2)	21 (7.2)	3 (1.0)	6 (2.1)
Dental relationship										
Edge-to-edge										
P	.017	.030	.031					<.001		
SR	2.0	1.6	1.7					3.3		
Anterior crossbite										
P				.018			.048			
SR				2.1			1.9			
Anterior open bite										
P		.026	.007	<.001	<.001					
SR		1.6	2.1	4.2	3.7					
Overjet										
P	.033			.007	.008	.005	.011			
SR	1.5			2.0	2.0	2.3	2.1			
Crossbite										
P		.028	.002							
SR		1.6	2.4							
Angle Classes										
P	.002	<.001	.001	<.001	<.001			.002		
SR										
Class II	1.3	1.6	1.5	2.5	2.8					
Class III	2.0	1.6	1.7					3.3		

(primary or mixed) and the presence of atypical swallowing.

Phoneme Articulation

The sample was divided according to the number of malocclusion characteristics: from 0 to 2 malocclusion characteristics (75.3% of the schoolchildren) and three or more than three malocclusion characteristics (24.7%). There was a significant association between phonetic disturbances and the presence of three or more malocclusion characteristics ($P =$ .008).

A difficulty in the production of one or more phonemes was found in 51.1% of the children. There was a statistically significant association between the impairment of the phonemes /f/ and /ch/ and molar Class II ($P =$ .002 and an SR of 2.5 and 2.8, respectively) and between the phonemes /l, ll/ and /r, rr/ and molar Class III (Table 4).

There was a strong association between crossbite and impairment of the phoneme /z/ ($P =$ .002) and between overjet and impairment of the phonemes /f/, /ch/, /p, b/, /t, d/ ($P =$ .007, .008, .005, and .011, respectively). Anterior open bite was associated with the phonemes /ch/, /f/, and /z/ ($P <$ .001, $P <$ .001, and $P =$ .007, respectively); the phoneme /ch/ stood out with an SR of 3.7. Edge-to-edge bite was associated with alteration of the phonemes /l, ll/ and /r, rr/ ($P =$ .003 and .017, respectively), and with alteration of the phonemes /l, ll/ with an SR of 3.3. Anterior crossbite was associated with the phoneme /f/ ($P =$ .018).

DISCUSSION

The main objective of this study was to analyze the relationship between the two most frequent orofacial dysfunctions in schoolchildren: malocclusion and dyslalia. For this purpose, oral habits and muscular alterations were also studied.

There have been few epidemiological studies that related malocclusion to dyslalia in children, since most of them were done in adult patients. The sample in the present study was one of the largest because 290 children between 4 and 7 years old were studied.[15,20]

The examination revealed that more than half of the children exhibited Angle Class I, followed by Class II and, in a lower percentage, Class III. These data and the values for posterior crossbite were similar to other studies.[5,20,21] Other studies obtained different results[21] on overbite and overjet due to the size of the sample, age, type of dentition, and the methodology used. The presence of mild, moderate, and severe overjet were also evaluated, although other examiners did not assess mild overjet because it may become normalized with age.[21]

The present study indicated a relationship between muscular alterations and Angle Classification and the results showed that lip praxis was performed with greater difficulty in subjects with open bite. These data were consistent with other studies.[22,13] A significant relationship between the different malocclusions and poor oral habits was also reported.[12,20,21]

The significant relationship between dental malocclusion and speech articulation was confirmed in the present study, as in others.[7,15,19] The phonemes with the least error were nasal and occlusal and, those with the greatest difficulty, were /s/, /r/, and /rr/.

The phonemes: /r/, /rr/, /s/, /z/, /f/, and /ch/ were directly related to the presence of Angle Class II malocclusion due to the difficulty in performing a correct lip seal, of bringing the lower lip against the palatal side of the upper incisors, or the difficulty of producing airflow at the anterior level due to an increase in the overbite or overjet. Also, the phonemes /r/, /rr/, /l/, /s/, /z/, and /ch/ were related to the presence of Class III[8] due to the low position of the tongue at rest and during swallowing.[2,3,7,9]

In the present study, edge-to-edge bite was related to the phoneme disorders /r/, /s/, /z/ /t, d/, /l, ll/. Many cases of edge-to-edge bite at the anterior level would be related at the posterior level to Angle Class III, so there was a significant association with /l, ll/. The phonemes that were affected by the anterior crossbite were /ch/, /s/ and /t, d/. This alteration was related to the position of the tongue in relation to the upper incisors, coinciding with other studies in the English laguage.[7]

In the present investigation, anterior open bite showed significant association with the alteration of the fricative phonemes /s/, /ch/, /z/ and the affricate /ch/ due to a defective air outlet, as there was no occlusion between the anterior teeth. Alteration of the fricative phonemes /s/, /z/, /f/, and /v/[16] and /s/, /sh/, /z/, /zh/, /th/, /t/, and /d/ [3] in English was observed while, in Portuguese, the presence of anterior open bite was related to lips and dyslalia in /t/, /d/, /n/, /l/ [12] and, in Hindi, to /t/, /d/, /n/, /l/.[11] The influence of atypical swallowing on open bites and phoneme alteration was also observed.[14] In Spanish, anterior open bite was related to dyslalia of phonemes /d/, /t/, /s/, /ch/, and /ñ/[13] and to distortion of /t/, /d/, /s/.[28] There was a significant relationship between the fricative phonemes /z/ /s/ and /f/ and posterior crossbite. According to the literature review, patients with articulatory defects had a narrower palate than usual.[4,18] On the contrary, there were other studies in which this relationship was not as strong.[10]

The present study was an early analysis of the problem as phonemes could be self-corrected with age as well as some malocclusions. The advantages of early intervention in speech and occlusion are essential. The results of this research agreed with numerous investigations on speech disturbances in patients with Class II and III malocclusions. Given the cross-section in the anatomy and physiology of the laryngeal, pharyngeal, and oral cavity framework, it is fair to deduce that dentofacial malocclusions may be accompanied by alterations in swallowing and phoneme articulation. This may be attributed to commonality in neuromuscular supply and that the orofacial musculature involved in speech may be affected by the presence of malocclusion.

CONCLUSIONS

- There is a relationship between malocclusion and speech disorders. Both may be associated with oral habits and muscular alterations, causing orofacial dysfunction that requires interdisciplinary cooperation. Malocclusion and phonological disorders have a multifactorial etiology.
- Pediatric dentists and orthodontists must consider and assess the physiological factors that influence the development of the dentition and the extent to which they influence speech development in children.

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SUPPLEMENTAL MATERIALS

Supplemental Tables 1, 2, and 3 are available online.

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