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Prevalence of malocclusion in children with obstructive sleep apnoea

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Structured Abstract

Objectives: To describe the prevalence of malocclusions in 2- to 10-year-old children suffering from obstructive sleep apnoea (OSA) and to evaluate the association between occlusal variables and OSA.

Setting and Sample Population: A total of 2101 consecutive patients referred to an otorhinolaryngology unit were considered for the study. One hundred and fifty-six children (range 2-10 years) with suspected OSA were selected for a sleep study. The final sample consisted of 139 children suffering from OSA and a control group of 137 children.

Materials and Methods: All patients included in the study underwent a clinical orthodontic examination to record the following occlusal variables: primary canine relationship, presence of a posterior crossbite, overjet and overbite. Odds ratios and 95% confidence intervals, comparing the demographic characteristics and dental parameters in OSA vs non-OSA children, were computed. Multivariable logistic regression models were developed to compare independent variables associated with OSA to non-OSA children.

Results: The prevalence of malocclusions in children with OSA was 89.9% compared to 60.6% in the control group ($P < 0.001$). Factors independently associated with OSA compared to the control group were posterior crossbite (OR = 3.38; 95%CI:1.73-6.58), reduced overbite (OR = 2.43; 95%CI:1.15-5.15.), increased overbite (OR = 2.19; 95%CI:1.12-4.28) and increased overjet (OR = 4.25; 95%CI:1.90-9.48).

Conclusions: This study showed a high prevalence of malocclusion in children with OSA compared to the control group. The posterior crossbite and deviations in overjet and overbite were significantly associated with OSA. The presence of these occlusal features shows the importance of an orthodontic evaluation in screening for paediatric OSA.

KEYWORDS
child, malocclusion, obstructive sleep apnoea, prevalence, sleep disorders

1 | INTRODUCTION

Obstructive sleep apnoea (OSA) is a breathing disorder characterized by repeated episodes of prolonged upper airway obstruction and/or intermittent complete obstruction that disrupts normal sleep patterns.[1] The symptoms include snoring, disturbed sleep and neurobehavioral problems. The prevalence of OSA in children is 1%-4%[2] and, if left untreated, it may result in severe complications[3] which include neurocognitive impairment, behavioural problems, failure to thrive and cor pulmonale. The aetiology is multifactorial,[4] and the main risk factors in children include adenotonsillar hypertrophy, obesity, neuromuscular disorders and craniofacial anomalies.[3,5] Adenotonsillar hypertrophy is the most commonly reported aetiological factor;[6] therefore, the treatment of choice for paediatric OSA is adenotonsillectomy. However, a recent review focused on emerging dental treatment options for children with OSA.[7] In adulthood, the use of oral appliances is a treatment option in the management of OSA.[8]

In children, mouth breathing has been reported to be associated with adenotonsillar hypertrophy[3] and dental malocclusions.[9-11] Although several cephalometric studies have defined the most common craniofacial anomalies associated with OSA in children, data regarding the prevalence of malocclusion in paediatric OSA patients are scarce.[12–14] Furthermore, previous investigations were limited by nonobjective sample selection and small sample size.

The aims of this study were to assess the prevalence of malocclusion in 2- to 10-year-old children suffering from OSA and to evaluate the association between different occlusal variables and the presence of OSA.

2 | MATERIALS AND METHODS

This study was approved by the Ethics Committee of the Bambino Gesù Children's Hospital in Rome, Italy (protocol number 1086_2016), and it was conducted in accordance with the principles of the Helsinki Declaration of 1975, as revised in 1983.

2.1 | Subjects

A total of 2101 consecutive patients referred for an examination to the Otorhinolaryngology Unit of the Bambino Gesù Children's Hospital in Palidoro (Rome, Italy) between March and July 2016 were initially considered for this study. Exclusion criteria were genetic syndromes, recent acute infections of the upper airways or acute otitis media, previous history of orthodontic treatment or adenoidectomy and/or tonsillectomy, dental anomalies or missing teeth. One hundred and fifty-six patients (range 2-10 years), whose parents reported snoring on a regular basis and signs or symptoms of OSA,[5] were prescribed a nocturnal at-home pulse oximetry. According to the McGill Oximetry Score[15] (MOS), the patients were classified into 4 categories. One hundred and twenty-seven patients with a MOS of 2 to 4 were included in the study. Twenty-nine patients with a MOS 1, inconclusive for an OSA diagnosis, underwent an at-home cardiorespiratory polygraphy (PG) to confirm or rule out OSA.[16] Of these, seventeen children with mixed-obstructive apnoea-hypopnea index (MOAHI) values of <1.0 events/hr of total sleep time were excluded from the study. On the basis of these findings, the study group of 139 children with diagnosed OSA was formed.

The control group comprised 137 patients, aged 2-10 years and in good general health, referred to Bambino Gesù Children's Hospital for a general paediatric examination. Children with a history of signs or symptoms of sleep-disordered breathing, genetic syndromes, previous orthodontic treatment, previous adenoidectomy and/or tonsillectomy, dental anomalies or missing teeth were excluded from the study.

2.2 | Methods

2.2.1 | Pulse Oximetry and Cardiorespiratory PG

Pulse oximetry was performed as described by Nixon et al[17] and Brouillette et al.[18] Motion-resistant pulse oximeters set for a 2-sec averaging time for haemoglobin saturation (SpO_2) (RAD 5, Masimo, Irvine, CA, USA) were used. Data were analysed using Profox Oximetry Software, Version Masimo 0706.05D. Pulse oximetry recordings were scored as previously described.[18] This method has shown a high positive predictive value (PPV, 97%) compared to polysomnography (PSG), considered the reference standard.[18] The MOS was used to assess the severity of OSA as previously described.[15]

Overnight at-home PGs were performed in children with a MOS of 1. A MOAHI≥1 event/hour was considered diagnostic of OSA as previously described.[19]

2.2.2 | Dental examination

All children underwent a specific dental examination by the same expert orthodontist who was blinded to the study protocol at the Dentistry Unit of the Bambino Gesù Children's Hospital in Palidoro (Rome, Italy).

Body mass index (BMI) was recorded, and the presence of allergies (food, drug, seasonal, skin allergies) was investigated.

The following occlusal variables were evaluated:

Primary canine relationship: Class I, II or III according to the Angle classification. Due to the small number of children with an asymmetric canine relationship, they were combined as Class II or Class III canine relationship.
Posterior crossbite: present, absent. A posterior crossbite was recorded if the buccal cusp of at least one upper primary or permanent molar tooth occluded lingually to the buccal cusp of the corresponding lower tooth.
Overjet (OVJ): It was recorded as normal, reduced (<2 mm) or increased (>4 mm).
Overbite (OVB): It was recorded as normal, reduced (<2 mm) or increased (>4 mm).

The presence of malocclusion was assessed when one or more occlusal parameters were deviated.

The measurements were taken manually using a calibrated calliper, and the other variables were assessed by direct inspection by one author (VV) who was blinded to the study material and protocol.

2.3 | Statistical methods

All statistical analyses were performed using STATA, Statistical Software: Release 13 (StataCorp LP, College Station, TX, USA).

The statistical significance was set at $P < 0.05$. The Shapiro-Wilk test was used to assess the normality of the data. Categorical variables were summarized by absolute frequencies and percentages, and continuous variables by median and interquartile range (IQR). To determine statistical differences between groups, the chi-square was used for categorical variables, while the Mann-Whitney test was used for continuous variables. Furthermore, the patients were divided into two groups according to age (age <6 years old, n = 204 subjects; age ≥6 years old, n = 72 subjects), and a subgroup analysis was performed. To determine statistical differences between the age subgroups, we used the chi-square test or Fisher's exact test and a nonparametric equality-of-medians test to compare characteristics of children with or without OSA. Odds ratios (OR) and 95% confidence intervals (CI), comparing the demographic characteristics and dental parameters in OSA vs non-OSA children, were computed. Multivariable logistic regression models were developed to assess independent variables associated with OSA compared to non-OSA children. A further multivariable logistic analysis was performed in the subgroup of children with age <6 years, whereas the subgroup of children with age ≥6 years was too small to be analysed.

Sample sizes of 139 OSA children and 137 children in the control group achieve 80% power to detect an odds ratio in the group proportions of 2.00. The significance level was set at 0.05. The proportion in the control group was assumed equal to 0.50.

3 | RESULTS

The demographic characteristics of the children are described in Table 1.

TABLE 1 Comparisons of demographic characteristics and dental parameters in OSA children and control group

	OSA children (n.139)		Control group (n.137)		
	Median	IQR	Median	IQR	*P* value
Age (y)	4.83	3.83-6.16	5.08	4.25-6.00	0.308
BMI (kg/m^2)	16.00	14.57-18.40	19.94	14.58-17.54	0.350
	n	%	n	%	
Sex					
Male	83	59.71	75	54.74	0.404
Female	56	40.29	62	45.26	
Allergies					
No	120	86.33	122	89.05	0.492
Yes	19	13.67	15	10.95	
Malocclusion					
No	14	10.07	83	39.42	<0.001
Yes	125	89.93	54	60.58	
Primary canine relationship					
Class I	79	56.83	96	70.07	0.036
Class II	47	33.81	36	26.28	
Class III	13	9.35	5	3.65	
Posterior crossbite					
No	49	35.25	116	84.67	<0.001
Yes	90	64.75	21	15.33	
Overjet					
Normal	58	41.73	100	72.99	<0.001
Increased	63	45.32	32	23.36	
Reduced	18	12.95	5	3.65	
Overbite					
Normal	39	28.06	74	54.01	<0.001
Increased	51	36.69	41	29.93	
Reduced	49	35.25	22	16.06	

IQR, interquartile range.

3.1 | Comparison of OSA and control groups

No statistically significant differences were found when comparing age, BMI, gender distribution and allergies in children with OSA and in controls. The subgroup analysis did not show any significant difference between the two groups assessed (data not shown in tables). Significant differences were found for the presence of malocclusion ($P < 0.001$), posterior crossbite ($P < 0.001$), overjet ($P < 0.001$) and overbite ($P < 0.001$) in the same groups. Table 1 shows detailed results of the univariate analysis.

3.2 | Analysis of association between demographic characteristics and risk of OSA

Multivariable logistic regression was applied to analyse the associations between demographic characteristics and OSA (Table 2). In the multilogistic regression model, age, gender, BMI and allergies were not significantly associated with OSA. Multivariable logistic regression performed in the subgroup of children with age <6 years showed no significant associations (data not shown in tables).

3.3 | Analysis of association between occlusal features and risk of OSA

A multivariable logistic regression model analysed the associations between occlusal features and OSA (Table 2). An association between posterior crossbite (OR = 3.38; 95%CI:1.73-6.58), reduced overbite (OR = 2.43; 95%CI:1.15-5.15.), increased overbite (OR = 2.19; 95%CI:1.12-4.28) and increased overjet (OR = 4.25; 95%CI:1.90-9.48) was shown in OSA children compared to the control group. Multivariable logistic regression in the subgroup of children with age <6 years showed an association between posterior crossbite (OR = 3.12; 95%CI:1.37-7.06), reduced overbite (OR = 4.16; 95%CI:1.67-10.35.), increased overbite (OR = 3.26; 95%CI:1.49-7.15) and increased overjet (OR = 3.28; 95%CI:1.17-9.16) in OSA children compared to the control group (data not shown in tables).

4 | DISCUSSION

Our data show a significantly higher prevalence of malocclusion in OSA children compared to the control group. The data of the

TABLE 2 Results of uni- and multivariable logistic regression analysis

	Univariate logistic regression model			Multivariable logistic regression model		
Variable	OR	(95% CI)	*P*	OR Adj[a]	(95% CI)	*P*
Age (y)	0.99	(0.87-1.13)	0.926	0.97	(0.83-1.14)	0.721
Sex						
M	1.0			1.0		
F	0.82	(0.51-1.32)	0.404	0.55	(0.31-0.96)	0.035
BMI (kg/m^2)	1.06	(0.98-1.15)	0.153	1.04	(0.95-1.14)	0.411
Allergies						
No	1.0			1.0		
Yes	1.29	(0.63-2.65)	0.493	1.63	(0.72-3.67)	0.237
Primary canine relationship						
Class I	1.0			1.0		
Class II	1.58	(0.94-2.69)	0.086	0.48	(0.21-1.10)	0.084
Class III	3.16	(1.08-9.24)	0.036	0.31	(0.03-3.48)	0.340
Posterior crossbite						
No	1.0			1.0		
Yes	3.00	(1.68-5.37)	<0.001	3.38	(1.73-6.58)	<0.001
OVB						
Normal	1.0			1.0		
Reduced	4.23	(2.24-7.98)	<0.001	2.43	(1.15-5.15)	0.020
Increased	2.36	(1.34-4.15)	0.003	2.19	(1.12-4.28)	0.022
OVJ						
Normal	1.0			1.0		
Reduced	6.21	(2.19-17.60)	0.001	9.04	(0.93-87.67)	0.057
Increased	3.39	(1.99-5.79)	<0.001	4.25	(1.90-9.48)	<0.001

[a]OR Adjusted for all variables.

control group are similar to those recently reported regarding the prevalence of malocclusion in normal Italian children.[20] We suppose therefore that there is an association between OSA and malocclusion in young children.

Our results demonstrate a significantly higher prevalence of posterior crossbite in OSA children compared to controls and a strong association between posterior crossbite and OSA. This finding is consistent with previous studies that show an association between snoring and crossbite.[12,21] As previously reported, the presence of a posterior crossbite is related to the altered equilibrium between the tongue and cheeks.[22] The low and anterior position of the tongue related to mouth breathing results in a lack of internal pressure, leading to a reduction of transversal growth of the upper arch with the development of lateral and posterior crossbite.[22] On the other hand, mouth breathing is associated with decreased nose prominence and width dimensions compared to normal children.[23] These facial characteristics could lead to a reduced upper airway space resulting in obstructive apnoea events.

We confirm the association between OSA and decreased overbite as previously reported.[12–14,21] In addition, we report that an increased overjet is significantly associated with OSA. This is in agreement with a study by Cazzolla et al[21] who found a statistically significant association between snoring and increased overjet. In contrast, Carvalho et al[12] reported no statistically significant association between sleep-disordered breathing and overjet in a pilot study. We suppose that both reduced overbite and increased overjet are associated with the vertically oriented craniofacial growth pattern that is a typical sign of OSA in children.[24]

Our results show an association between OSA and an increased overbite. These data do not agree with findings reported in some previous clinical studies[12–14,21] but they agree with those of Cozza et al[25] who report a significantly increased overbite in cephalometric findings of OSA patients compared to a control group. We hypothesize that the increased overbite in our sample could be an indication of a retruded position of the mandible, which has been regarded as a predisposing factor for the development of OSA.[5,26]

Based on this report, it can be suggested that a clinical orthodontic examination may be useful as an adjunct to medical history in the screening for OSA in children. When suspicious orthodontic features are identified, the child should be referred for further assessment of OSA. Furthermore, it has been demonstrated that orthodontic treatment options, like rapid maxillary expansion (RME) and mandibular advancement, may reduce OSA symptoms in children,[25,27] even though long-term follow-up studies of OSA in children after orthodontic treatment are limited.[27,28] It has also been reported that craniofacial abnormalities are risk factors for the development of OSA in adults.[29] In this regard, it can be hypothesized that performing orthodontic evaluations and treatment in children might reduce the development of OSA in adults.

This study has certain limitations. Orthodontic variables were not taken from dental casts but through direct inspection by an orthodontist (dental impressions were avoided because of the young age of the children examined). Furthermore, tongue posture and/or function were not recorded. Finally, the subgroup of children with age ≥6 years was too small to conduct a multivariable logistic regression analysis.

5 | CONCLUSION

This study showed a high prevalence of malocclusion in children with OSA compared to a control group. Posterior crossbite and deviations in overjet and overbite seem to be significantly associated with OSA. The presence of these occlusal features shows the importance of an orthodontic evaluation in screening for paediatric OSA.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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