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Allergic Rhinitis and Asthma: Relationship with Transverse Maxillary Contraction and Transverse Expansion Stability in Children

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Abstract: Background: Allergic rhinitis is a frequent cause of nasal obstruction in the pediatric population. The effect of prolonged mouth breathing on craniofacial growth continues to be a controversial topic in the orthodontic literature. This study investigates both the role of allergic rhinitis/asthma in the etiology of posterior crossbite and ogival palate and the influence of allergic rhinitis/asthma on the long-term stability produced by transverse expansion treatment. Methods: A retrospective analysis of the clinical records of 319 subjects between 5 and 12 years, presenting for an orthodontic evaluation was performed. The sample was divided into study and control groups depending on the presence/absence of posterior crossbite and/or ogival palate. Data regarding the subjects' breathing patterns and allergic respiratory diseases were collected. The relapse rate of transverse expansion treatment was evaluated. Results: An association (p = 0.05) was found between posterior crossbite/ogival palate and the presence of allergies. Multivariate analyses uncovered that both allergic rhinitis and younger ages were associated with posterior crossbite/ogival palate (p = 0.029890; p = 0.000283, respectively). No association was found between allergies and/or asthma and relapse following orthodontic treatment. Conclusions: Although data analysis suggests that allergies can induce transverse maxillary contraction in children, their presence did not seem to affect the outcome of orthodontic expansion treatment.

Keywords: allergic rhinitis; maxillary contraction; orthodontic treatment; relapse

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1. Introduction

It is well established that craniofacial growth is a complex phenomenon determined by genetic and environmental factors. Identifying and eliminating variables that may determine skeletal deformities by altering normal facial growth are considered some of the primary goals of the orthodontist [1]. According to Melvin Moss' Functional Matrix hypothesis, functional needs and soft tissues are important determinants of craniofacial morphology [2]. Breathing, swallowing, breastfeeding, and digit or pacifier-sucking habits play an important role in the growth of the craniofacial skeleton [3–5].

The effect of prolonged mouth breathing on craniofacial growth continues to be a debated issue in the orthodontic literature. Some authors sustain that a prolonged mouth-breathing habit can be considered a risk factor for malocclusion as it can interfere with normal facial growth [4,6]. Mouth breathing in children can lead to adaptations in the stomatognathic system that include changes in the position of the tongue and lips (lowered tongue position and incompetent lip seal at rest), posteroinferior rotation of the mandible, elongated face, mentalis muscle hypertrophy, and other dental and skeletal alterations [7]. The normal function of the nose can also be impaired by some anatomical and pathological conditions. A child affected by these conditions may be constrained to breathe through the mouth in response to obstructed nasal passage.

Respiratory allergies have become a major public health problem in the last decades. According to the World Health Organization (WHO), more than 20% of the world's population suffers from IgE-mediated allergic diseases and these percentages are likely to increase in the future. Allergic rhinitis (AR), which is an inflammation of the nasal mucosa, is mediated by immunoglobulin E induced by exposure to environmental allergens [8]. In response to allergen exposure, IgE bound to the mast cells present in the nasal mucosa triggers an excessive immune response characterized by a release of neuroactive and vasoactive substances such as histamine, prostaglandins, and leukotrienes. An inflammatory process is initiated in the mucosa and, should the stimuli persist, the inflammation can become chronic [8]. AR can be seasonal or perennial, depending on the timing of the allergen exposure (if it occurs at certain times of the year or is present year-round) [9] and it is characterized by symptoms such as rhinorrhea, itching, sneezing, nasal obstruction, concomitant conjunctivitis, etc. Subjects affected by AR have a significantly higher risk of asthma, decreased sleep quality, and other conditions such as chronic sinusitis and otitis media [10].

While a number of studies have shown that altered breathing patterns due to AR and asthma are associated with reduced inter-canine and intermolar distances, a higher prevalence of posterior crossbite and anterior open-bite, and increased palatal height [11–14], none have examined the effect of these pathologies on the long-term stability of transverse expansion treatments. This retrospective study aimed to evaluate the prevalence of AR and/or asthma in a large group of children affected by posterior crossbite and/or ogival palate with respect to that in a control group. It also aimed to assess the influence of AR and/or asthma on the stability of transverse expansion treatments in children between 5–12 over a 2-year follow-up period.

2. Materials and Methods

The clinical records of all the children presenting in a tertiary hospital for orthodontic evaluation over the past two years were reviewed. Patients who had undergone previous orthodontic treatments or presented genetic malformations were not included in the study.

The following data from the children's records were collected: the presence of perennial or seasonal respiratory allergies and/or asthma, if any medical therapy had been prescribed for AR/asthma, the patient's skeletal and dental class, if the subject had an ogival palate; this was determined by comparing the width/length ratio of the palate drawn from patients intraoral photographs with the normal values listed by Lione et al. [11].

The sample was then divided into the study and control groups. The study group consisted of 174 subjects affected by mono- or bilateral posterior crossbite and/or ogival palate. The control group consisted of 145 subjects who were without malocclusion or were affected by a malocclusion other than a posterior crossbite. The prevalence of AR and asthma in each of the groups was calculated. The association between AR and/or asthma and posterior crossbite and/or ogival palate were analyzed. Furthermore, the influence of AR and/or asthma on the stability of two years of transverse expansion treatment in the children of the study group who had undergone orthodontic therapy (n. 108), had complete dentition including the second permanent molar, and had mobile post-treatment retention was evaluated. A relapse was defined as the reappearance of posterior crossbite within 2 years after the treatment was completed [15].

This investigation was conducted in accordance with the 1996 Helsinki declaration. Written informed consent was obtained from all the children's parents before undertaking any study-related procedures. The data was processed in accordance with the Italian privacy and sensitive data laws and regulations [D.Lgs.2018/101; GDPR (UE 2016/679)].

3. Results

The total study population consisted of 319 children between the ages of 5 and 12 years. The study group consisted of 174 subjects (67 males, 107 females) between 5 and 12 years (mean = 8.9 ± 1.96); the prevalence of AR was 24.13% (42 subjects); the prevalence of asthma was 5.7% (10 subjects); 28% of the allergic/asthmatic subjects were prescribed drug therapy for AR/asthma (12 subjects) (Table 1).

Table 1. The number of children (%) affected by AR and asthma in the study and control groups (* $p = 0.05$ for AR; $p = 0.61$ for asthma).

	Crossbite/Ogival Palate [n. 174 (%)]	No Crossbite/Ogival Palate [n. 145 (%)]
Age (mean)	8.9 yr	9.7 yr
Sex	67 Males (38.5%) 107 Females (61.5%)	64 Males (44.1%) 81 Females (55.9%)
No allergic rhinitis (n.)	132 (75.87%) *	123 (84.83%)
Allergic rhinitis (n.)	42 (24.13%)	22 (15.17%)
No asthma (n.)	164 (94.3%)	139 (95.87%)
Asthma (n.)	10 (5.7%)	6 (4.13%)
Adenoid hypertrophy (n.)	1 (2.4%)	2 (9.1%)
Tonsils hypertrophy (n.)	1 (2.4%)	1 (4.5%)
Adenoidectomy (n.)	4 (7.7% of AR/Asthma patients)	2 (7.1%) of AR/Asthma patients)
Anti-allergic therapy (n.)	12 (27.2% of AR/Asthma patients)	8 (29%) of AR/asthma patients)
Skeletric class (n.)	I 37 (21.26%) II 90 (51.72%) III 47 (27.01%)	I 28 (19.31%) II 102 (70.34%) III 15 (10.34%)
Dental class (n.)	I 38 (21.83%) II 106 (60.91%) III 30 (17.24%)	I 35 (24.13%) II 97 (66.89%) III 13 (8.96%)
Maxillary width (mean)	44.9 mm	48.05 mm

yr: years; n.: number of subjects; AR: allergic Rhinitis; I: first class; II: second class; III: third class; mm: millimeters.

One hundred eight subjects had completed the orthodontic treatment cycle at the time the data were collected. Thirty-one children had a relapse (Table 2).

Table 2. The number of stable cases and relapses in the allergic, no allergic rhinitis, asthma, and no asthma groups ($p = 0.34$).

	Stable Results	Relapse
No allergic rhinitis (n.)	59 (76.6%)	21 (68%)
Allergic rhinitis (n.)	18 (23.4%)	10 (32%)
No asthma (n.)	70 (90.9%)	28 (90.3%)
Asthma (n.)	7 (9.1%)	3 (9.7%)

n.: number of subjects.

The control group consisted of 145 subjects (64 males, 81 females) between 5 and 12 (mean = 9.7 ± 1.93); the prevalence of AR was 15.17% (22 subjects); the prevalence of asthma was 4.13% (6 subjects, all suffered from AR) (Tables 1 and 2); 29% (8) of the allergic/asthmatic subjects were prescribed drug therapy for AR/asthma.

There was a marginally significant association between the presence of AR and the presence of posterior crossbite (p-value = 0.05, odds ratio = 1.77). No significant association was found between posterior crossbite/ogival palate and asthma.

Using a model to investigate the variables that frequently affect the crossbite/ogival palate, it became apparent that only AR and age had a significant effect. Given AR, age has an inverse significant association with crossbite/ogival palate (every year the probability to have crossbite/ogival palate is about 90% of the previous one), instead given age, AR has a significant positive association with it (AR patients have almost double the probability of having crossbite/ogival palate with respect to non-AR patients). None of the other variables considered (sex, asthma, previous adenoidectomy, medical therapy, oral respiration, skeletric class) were selected by AIC to enter the final model, meaning that they did not appear to have a positive or negative association with crossbite/ogival palate (Table 3).

Table 3. Multiple regression model on the effect of age and allergic rhinitis on malocclusion (Crossbite/Ogival palate).

Coefficients					
	Estimate	**Exp (Estimate)**	**Std. Error**	**z Value**	**Pr (>z)**
(Intercept)	1.81334		0.49636	3.653	0.000259 ***
Allergic rhinitis	0.64921	1.9403	0.29896	2.172	0.029890 *
Age	−0.11330	0.8929	0.03121	−3.631	0.000283 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

No significant association was found between AR and/or asthma and the relapse of posterior crossbite after expansion treatment (p-value = 0.34).

4. Discussion

Although some authors consider the relationship between nasal obstruction and craniofacial growth unclear [16], others have reported that the presence of obstacles in the nose and pharyngeal areas can cause an increase in nasal airway resistance, even in a pediatric population [17], and affect lower facial height and maxillary length [18] producing malocclusion [11,12] and ogival palate [19]. It has been reported that an anatomically narrow airway is a predisposing factor, particularly in a child, for mouth breathing [20]. Hypertrophy of the adenoids and tonsils [17] and unilateral choana atresia or sinonasal tumors (even in children) such as lymphomas or sarcomas [21,22] are some of the conditions most commonly associated with an increase in nasal airway resistance in children. As it causes upper airway obstruction, AR has also been found to be a risk factor for malocclusion [11,12]. A study comparing sibling pairs with and without AR uncovered that mouth breathing was associated with an increased palatal height [23]. These results confirm earlier reports that allergic rhinitis may be associated with altered facial growth. Interestingly, some have noted that even when these factors are removed, many continue to breathe through the mouth out of habit [24]. It has been shown that the adaptation from nasal to mouth breathing can affect facial growth. The typical facial characteristics of the mouth-breathing subject have, in fact, been described as the "adenoid face" or "long face syndrome". It is typically associated with a number of classical features including a longer lower third of the face, under-developed nose, narrow nostrils, lip incompetence at rest, and short hypertrophic upper lip [7,25].

The prevalence of malocclusion in mouth-breathing children is highly variable, reaching its highest point of 81.4% [26]. The variability could be due to the type of malocclusion [27], but also to the presence of AR and increased nasal resistance. Furthermore, malocclusion can have an impact on nasal obstruction due to reduced maxillary expansion [28], thus promoting inflammation of the nasal mucosa and nasal obstruction even in absence of AR.

Previous studies have shown that the transverse dimension of the upper arch is significantly smaller in children affected by mouth breathing due to AR [11,12]. While it is true that some studies performed until now have demonstrated contrasting results [11–13,19,27], most were conducted on small groups of patients or were not controlled studies. Although retrospective, the current study is a controlled one conducted on a large group of homogeneous children (all treated by the same group of orthodontists) with the aim to evaluate the influence of AR and asthma on maxillary transverse contraction/expansion. The posterior arch width was smaller in the study than in the control group. This supports the fact that posterior arch width is a good support for the diagnosis of posterior crossbite The presence of AR was found to be marginally significant (not quite at the 5% level) meaning that AR has only a slight effect on the presence of posterior crossbite/ogival palate. Since some studies have demonstrated that upper and lower airway functions are strictly correlated [29,30] even in pediatric populations [31], the presence of asthma was also considered in order to evaluate its possible influence on malocclusion in children. In this study, differently from AR and previous experiences conducted on children/adolescents affected by lower airway obstruction [14,32], the percentage of subjects with asthma did not differ in the two groups. This result could be explained by the fact that the children affected by asthma enrolled in the study showed higher adherence to the therapy (50%) than those affected by AR (26%), or, more probably, by the fact that although a large population was considered, there was only a very low percentage (about 5%) of subjects with asthma in the two groups. More studies examining larger groups of asthmatic children are warranted.

When all the variables that could have influenced the crossbite or ogival palate were analyzed, not only AR but also age were found to be important factors. When a backward stepwise regression model was used, in fact, we observed that AR and age did influence crossbite/ogival palate, while all the other variables including asthma did not. In particular, it became apparent that those with AR had almost double the risk of having a crossbite/ogival palate (194%). On the other hand, with each additional year of age, the risk of having crossbite/ogival palate was reduced to 90% of that of the previous year (Table 3). These results not only confirm that by causing upper airway obstruction, AR is a significant risk factor for developing crossbite/ogival palate, but they also highlight the fact that orofacial dysfunction may begin very early in terms of age and may become evident at the time crossbite/ogival palate presents. Independently of oral habits, AR is implicated in malocclusion as it is able early on to produce nasal obstruction leading to craniofacial growth changes in children with mixed dentition [33]. As the children grew older, we observed a reduced probability of crossbite and/or ogival palate, probably because the craniofacial growth that had taken place was able to reduce the effect/s of nasal obstruction and its consequences on the malocclusion.

Data regarding breathing habits and the presence of AR/asthma were analyzed in the 108 children in the study group who had completed the treatment cycle at the time the study was carried out. This was conducted in an effort to evaluate if the presence of AR and/or asthma affected the treatment's outcome. Interestingly, although AR was found to have an effect on crossbite/ogival palate, neither AR nor asthma were correlated with treatment relapse. This result could be explained by the hypothesis that the significant improvement in the nasal airflow and patency produced by the transverse expansion treatment [28,34] exceeds the effect/s of allergy and asthma on the upper airways. Nevertheless, it is possible that this result is linked to the retrospective nature of the study. Moreover, as we did not have information about the type of allergy (perennial or seasonal) affecting the patients, we were unable to study if the lack of correlation between AR and the treatment relapse could also be due to a higher prevalence of seasonal than perennial AR.

The main limitations of this study are its retrospective nature, the relatively short follow-up, and the lack of data regarding the immunologic status of the study and control populations and the genetic and epigenetic variables that could influence facial growth patterns or cause allergic rhinitis/asthma [35].

5. Conclusions

Although there is no unanimity in the results of the studies regarding the transverse dimension, the data outlined here suggest that allergic rhinitis can affect facial morphology and in particular palatal height which is manifested as the ogival palate. The increase in maxillary transverse dimension obtained through rapid maxillary expansion can improve nasal function after orthodontic treatment, explaining the lack of influence of AR on orthodontic treatment outcomes and relapse found in this study [36]. The current investigation allowed us to evaluate the association between maxillary contraction/expansion and respiratory allergic diseases in a pediatric population. Data analysis and multivariate analysis uncovered that there was an association between the presence of posterior crossbite/ogival palate and the presence of AR. Interestingly, as the children became older, they showed a reduced risk of having crossbite/ogival palate, presumably because their craniofacial growth reduced their nasal obstruction and thus the risk of malocclusion and its morphological consequences. Data analysis did not uncover a significant association between transverse expansion treatment relapse and the presence of AR and/or asthma.

To conclude, as AR is an increasing problem [37], it is important for medical doctors and orthodontists to be aware of this association and the importance of referring these patients to an allergy specialist for appropriate diagnosis and treatment. Finally, as already suggested [36], further studies investigating this correlation and the stability of transverse expansion treatment in allergic and asthmatic children are certainly warranted.

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