Prevalence of asthma, allergic rhinitis, and respiratory allergens in an orthodontic population

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ABSTRACT

Objective: To determine if there is a higher prevalence of increased vertical growth development, dolicocephalia, longignathia, and other dentofacial growth variations among orthodontic patients presenting with respiratory problems including asthma, allergic rhinitis, and environmental allergies.

Materials and Methods: A sample size of 260 orthodontic charts were obtained by random selection, with 125 meeting the criteria for environmental sensitivities, and 135 meeting the criteria for the control group. The p-value was set at 0.05 and Pearson's chi-squared test was used to determine the presence of statistically significant associations among the categorical variables.

Results: Mouth breathing and oro-nasal breathing were associated with increased mandibular plane angle (MPA), Y-axis, anterior nasal spine: menton (ANS: Me) and lip incompetency as compared to nasal breathing ($p<0.05$). The presence of any combination of environmental sensitivities was found to be associated with an increase in MPA values ($p=0.030$). Environmental allergies were found to be associated with an increase in MPA values ($p=0.035$), with seasonal allergies having a greater association with increased MPA as compared to perennial allergies ($p=0.006$). Asthma was found to be associated with an increased prevalence of lip incompetency ($p=0.027$). Severe forms of asthma were more likely to be associated with posterior cross bite in comparison to mild forms of asthma ($p=0.042$).

Conclusions: Respiratory problems resulting from environmental allergens are associated with vertical growth development of the craniofacial complex, more specifically MPA and lip incompetency. Seasonal allergies in particular are associated with MPA, and severe forms of asthma are associated with the development of posterior cross bite. Patients identified with environmental sensitivities, in particular seasonal allergies and severe forms of asthma, may benefit from early orthodontic referral and intervention.

INTRODUCTION

Nasal obstruction leading to mouth breathing can have a significant impact on craniofacial and dentofacial development, which in turn may cause or exacerbate orthodontic problems such as vertical growth development, dolicocephalia, and longignathia. Other orthodontic problems may include Class II malocclusion, steep mandibular plane angle, posterior cross bite, anterior open bite, and lip incompetency. While research linking mouth breathing to orthodontic problems has been documented in the literature, there is a current lack of research that demonstrates the prevalence of respiratory problems resulting from environmental allergens such as asthma, allergic rhinitis, and environmental allergies in orthodontic patients.

The rationale behind this study is that environmental allergens leading to respiratory problems (including asthma, allergic rhinitis, and environmental allergies) induce an allergic response that can block the nasal passages and lead orthodontic patients to compensate with mouth breathing. In doing so, these patients open and backwardly rotate their mandibles in a clockwise direction. This mandibular movement may cause vertical growth development, and exacerbate or induce dolicocephalia and longignathia, among other orthodontic anomalies.

Allergic rhinitis, more commonly known as hay fever, is one of the most common chronic diseases and usually presents in the first two decades of life.[1] It is a type I hypersensitivity reaction elicited by allergens.[2] These allergens bind to IgE antibodies on the surface of mast cells, triggering the hypersensitivity reaction.[2] The mast cells release histamine which induces vasodilation of the blood vessels within the nasal mucosa, resulting in the extravasation of plasma proteins, and rhinitis mucosal congestion.[3] In turn, this congestion may lead to nasal obstruction and the development of mouth breathing.[3] The reaction may take several forms, but in the case of allergic rhinitis, increased mucous secretion, and inflammation of the upper airways and sinuses is observed.[2] Allergens that may trigger allergic rhinitis include pollens (tree and grass), dust, dander, moulds, and other airborne particulate matter.[3] Allergic rhinitis leading to mouth breathing has been associated with orthodontic malocclusions.[4,5] One study found allergic rhinitis to be a significant risk factor for the development of malocclusions in general and found it to be associated with the development of posterior cross bite and increased overjet.[6]

Asthma is a chronic disorder of the conducting airways usually caused by an immunological reaction, marked by episodes of broncho-constriction, inflammation of the bronchial walls, and increased mucous secretion.[2] Atopic asthma, the most common type of asthma, is a Type I hypersensitivity reaction triggered by environmental allergens including dust, pollen, dander, and foods.[2] While asthma typically affects the lower airways, studies have shown that impairment of the upper airways is often observed.[7] This impairment may play a role in the development of the craniofacial complex and thus upper airway impairment in asthmatic patients may lead to dentofacial anomalies.[8,9] Several studies have also demonstrated a relationship between asthma and allergic rhinitis.[10,11,12]

Upper airway obstruction has been associated with many dental and skeletal malocclusions, and recognizing and removing the problem at an early age has been encouraged.[13] Mouth breathing children have been shown to present with a cephalometric pattern different from nasal breathers.[14, 15] Furthermore, the mode of obstruction leading to mouth breathing in children has also been shown to differentially alter the cephalometric pattern.[14] It has been found that subjects with mouth breathing habits exhibit a significant increase in lower incisor proclination, lip incompetency, and convex facial profile.[16] Other studies have found that the majority of mouth breathing children, when compared to nasal breathing children, present with a retruded mandible, a vertical direction of mandibular plane growth, and a predominance of Class II malocclusion.[15] As well, studies have found that the prevalence of posterior cross bite is higher in mouth breathing children and that during the mixed dentition and permanent dentition, anterior open bite and Class II malocclusion were more likely to be present in mouth breathers.[17] This same study found that among mouth breathers the presence of rhinitis or the obstructive size of adenoids were not risk factors to the development of Class II malocclusion, anterior open bite, or posterior cross bite.[17] As well, most mouth-breathing children did not match the expected “mouth breathing dental stereotype”.[17]

The literature shows some variation in terms of the impact of mouth breathing on dental and facial development and whether or not the mode of nasal obstruction impacts the development. Thus, further studies examining the impact of mouth breathing and mode of nasal obstruction leading to mouth breathing in orthodontic patients is needed in order to obtain more conclusive results regarding development. This study will focus on the modes of nasal obstruction, more specifically the modes of nasal obstruction induced by environmental allergens, and whether or not they have a significant impact on craniofacial and dentofacial development.

These respiratory issues may be caused or further exacerbated by the harsh Canadian climate which necessitates indoor living for 6 months of the year and the ducted air systems which re-circulate allergens within the home. Americans spend 87% of their time indoors, and on average, Canadians spend similar amounts of time indoors.[18] With the majority of time being spent indoors, and the presence of reduced ventilation in energy-efficient buildings, indoor air quality becomes a major health concern.[19] Indoor air quality problems exist, and sixty percent of these indoor air quality problems are related to ventilation, and thirty percent are due to air contamination.[20] It has been found that air pollution is a significant cause for exacerbation of allergic airway diseases, and there is increasing evidence that pollutants can modulate the incidence of disease as well.[21] Furthermore, epidemiologic studies have shown the prevalence of allergic rhinitis to be rising world wide[22] and although the cause is unknown, some contributing factors include high concentrations of airborne allergens and less ventilation indoors.[23] Allergen exposure is one of the known environmental risk factors for asthma,[24] and indoor air exposures are more strongly linked to the increase in asthma prevalence when compared to outdoor air exposures.[25]

The aim of this study was to determine if there is a higher prevalence of respiratory problems such as asthma, allergic rhinitis and seasonal allergies among orthodontic patients presenting with increased vertical growth development, dolicocephalia, and longignathia, among other orthodontic problems.

MATERIALS AND METHODS

The Health Research Ethics Board (HREB) at the University of Manitoba granted study approval. Research was conducted through a retrospective chart audit of an orthodontic population, obtained from the orthodontic graduate records at the University of Manitoba. A sample size of 260 charts was obtained. Charts were selected at random and reviewed, with 125 meeting the criteria for the test group, and 135 meeting the criteria for the control group. Among the 260 charts, 113 were males and 147 were females, with ages ranging from 8 years-10 months to 18 years-10 months.

Test group inclusion criteria:

a. Presence of environmental sensitivities (including asthma and/or environmental allergies and/or allergic rhinitis)
b. 8-18 years old at the time orthodontic records were taken

Control group inclusion criteria:

a. Lack of environmental sensitivities (including asthma and/or environmental allergies and/or allergic rhinitis)
b. 8-18 years old at the time orthodontic records were taken

Test group and control group exclusion criteria:

a. Patients with anomalies of the craniofacial complex
b. Patients younger than 8 years
c. Patients older than 18 years

A data capture sheet was used to record numerous variables. Allergies were recorded based on presence, type, length of time present, and seasonal or perennial nature. Asthma was recorded based on presence, medications prescribed, medication usage (occasional or chronic), type/severity of asthma (intermittent, mild, moderate, severe, exercise-induced), and length of time present. Allergic rhinitis was recorded based on presence, duration, and seasonal or perennial nature. Presence of vertical growth development was recorded based on mandibular plane angle (MPA) greater than 38°, Y-axis greater than 70°, nasion: anterior nasal spine (Na: ANS) greater than 58 millimetres, and anterior nasal spine: menton (ANS: Me) greater than 70 millimetres. Dentofacial development was recorded based on presence of Class II malocclusion (overjet greater than 6 millimetres), posterior cross bite (bilateral or unilateral), anterior open bite, and lip incompetency greater than 5 millimetres. Other variables recorded included age, gender, mode of breathing (nasal-breathing, mouth-breathing, or oro-nasal), and tonsils and/or adenoid removal.

Statistical analysis was carried out using IBM SPSS Statistics software (version 24). The P value was set at 0.05 and Pearson's chi-squared test was used to determine the presence of statistically significant associations among the categorical variables noted above. When cells had expected counts less than 5, Fisher's exact test was used to determine the statistical significance of variable associations for 2x2 contingency tables.

Independent variables were tested against dependent variables to determine statistically significant associations. Dependent variables included MPA, Y-axis, Na:

ANS, ANS: Me, class II malocclusion, posterior cross bite, anterior open bite, and lip incompetency. The following associations were tested using either Pearson's chi-squared test or Fisher's exact test when appropriate:

a. Gender vs. dependent variables
b. Mode of breathing (MOB)(nasal-breathing, mouth-breathing, or oro-nasal) vs. dependent variables
c. Tonsils or adenoids removed vs. dependent variables
d. Environmental sensitivity (environmental allergies, asthma, or allergic rhinitis) vs. dependent variables:
e. Allergy:
    a. No environmental sensitivity or environmental allergy only vs. dependent variables
    b. Allergy medication (yes or no) vs. dependent variables
    c. Type of allergy (environmental or other) vs. dependent variables
    d. Seasonal or perennial allergy vs. dependent variables
f. Asthma:
    a. No environmental sensitivity or asthma only vs. dependent variables
    b. Asthma medication (yes or no) vs. dependent variables
    c. Asthma medication type vs. dependent variables
    d. Medication use (occasional/intermittent or consistent) vs. dependent variables
    e. Asthma duration vs. dependent variables
    f. Trigger (known vs. unknown) vs. dependent variables
    g. Severity (intermittent-mild or moderate-severe) vs. dependent variables
g. Allergic rhinitis vs. dependent variables with subgroup:
    a. Seasonal or perennial allergic rhinitis vs. dependent variables

RESULTS

Gender

Gender differences were statistically significant for the variable ANS: Me, with males being more likely than females to have increased ANS: Me (p=0.000).

Mode of Breathing

A statistically significant association was shown between mode of breathing and the variables MPA, Y-axis, ANS: Me, and lip incompetency (see table 1). Those with mouth breathing or oro-nasal modes of breathing were more likely to present with increased values for MPA, Y-axis, ANS: Me and were more likely to present with lip incompetency as compared to nasal breathing.

Tonsils or Adenoids Removed

Tonsil or adenoid removal was associated with overjet (p=0.001) and posterior cross bite (p=0.024). Subjects without tonsil or adenoid removal were more likely to present with increased overjet and decreased prevalence of posterior cross bite as compared to subjects with tonsil or adenoid removal.

Environmental Sensitivity

The presence of an environmental sensitivity (including environmental allergy, asthma, and/or allergic rhinitis) was shown to have a statistically significant association with variables MOB (p=0.031) and MPA (p=0.030). Among MOB, those with environmental sensitivities were most likely to present with an oro-nasal mode of breathing. Among MPA, those with environmental sensitivities were more likely to present with increased MPA compared to those without environmental sensitivities (table 2). No statistically significant association was shown between environmental sensitivity and lip incompetency (p=0.082).

Allergy

In comparing the group with environmental allergy only against those without environmental sensitivities, chi-squared tests showed significant associations between environmental allergy and the variables MOB (p=0.018), and MPA (p=0.035). Allergy only was more likely to present with oro-nasal or mouth breathing and was more likely to present with increased MPA (table 2).

No statistically significant association was shown between the need for allergy medication and the dependent variables (p>0.05).

An increase in MPA was associated with environmental allergies as compared to other types of allergies (p=0.041), as well as among seasonal allergies as compared to perennial allergies (p=0.006).

Asthma

In comparing the variables asthma only to no environmental sensitivity, chi-squared tests showed a significant association between asthma and lip incompetency (p=0.027). Asthma only was more likely to present with lip incompetency (table 3).

No statistically significant association was shown between reported asthma medication, type of asthma medication, and medication usage frequency when compared to the dependent variables (p>0.05).

The associations between asthma duration and asthma trigger in comparison to dependent variables could not be calculated, as too few cases were reported.

An increase in posterior cross bite was associated with severe asthma as compared to those with mild asthma (p=0.042, table 4).

Allergic Rhinitis

No statistically significant association was found between allergic rhinitis and dependent variables ($p>0.05$).

Seasonal versus perennial allergic rhinitis could not be statistically analyzed as too few cases were reported.

DISCUSSION

Research linking mouth breathing to orthodontic problems has been well documented in the literature[13, 14,15,16,17, 26]; however, the literature shows some variation in terms of the impact of mouth breathing on dental and facial development and whether or not the mode of nasal obstruction impacts the development[17].

In our research, patients presenting with mouth breathing or oro-nasal modes of breathing (irrespective of cause) were more likely to present with increased vertical growth development in the form of increased MPA, Y-axis, ANS: ME and lip incompetency (see table 1). Past studies demonstrate similar findings, in which subjects with mouth breathing habits exhibit a significant increase in lower incisor proclination, lip incompetency, and convex facial profile.[16] Likewise, other studies have found that the majority of mouth breathing children, when compared to nasal breathing children, present with a retruded mandible, a vertical direction of mandibular plane growth, and a predominance of Class II malocclusion.[15] Despite the variation in the literature, the majority of research points towards an association between mouth breathing and orthodontic problems.

Furthermore, there is a current lack of research that demonstrates the prevalence of respiratory problems resulting from environmental allergens such as asthma, allergic rhinitis, and seasonal allergies in orthodontic patients. In the present study, we observed an increased prevalence of vertical growth development among patients presenting with nasal obstruction resulting from environmental sensitivities, particularly in the form of increased MPA and lip incompetency (see tables 2 and 3).

When observing environmental sensitivities as a group in comparison to the control group, subjects with environmental sensitivities demonstrated an increased MPA ($p=0.030$). While an increased prevalence of lip incompetency was not statistically significant ($p=0.082$), 32% of subjects with environmental sensitivities presented with lip incompetency, whereas only 22.4% of the control group presented with lip incompetency.

The group with environmental allergies demonstrated an increased MPA ($p=0.035$). Again, an increased prevalence of lip incompetency was not statistically significant ($p=0.143$), however 33.3% of subjects with environmental allergies presented with lip incompetency, whereas only 22.4% of the control group presented with lip incompetency. Studies of allergic rhinitis and chronically allergic children demonstrate similar results of increased vertical growth in the form of longer faces. [5, 27]

The group with asthma demonstrated an increased prevalence of lip incompetency ($p=0.027$). Results for MPA were not statistically significant among subjects with asthma ($p=0.052$), however 27.9% of subjects with asthma had an increased MPA, whereas only 14.8% of the control group presented with an increased MPA. Faria et al. reported similar results with respect to asthma and lip incompetency, in addition to other orthodontic manifestations.[8]

A larger sample size in future studies may help to determine if the near significant p-values for lip incompetency and MPA noted are in fact statistically significant for a larger sample size. Nonetheless, these results are of particular interest, as they demonstrate the potential to use environmental sensitivities as predictors of future orthodontic problems and the need for early intervention. Several studies have also demonstrated a relationship between asthma and allergic rhinitis.[10,11,12] This relationship demonstrates a common underlying process, and reiterates the potential to use environmental sensitivities as predictors of future orthodontic problems.

Another finding of interest was the increase in MPA (p=0.006) among subjects with seasonal allergies in comparison to those with perennial allergies. 55.6% of subjects with seasonal allergies presented with increased MPA, whereas only 18.2% of subjects with perennial allergies presented with increased MPA. A difference in lip incompetency was not statistically significant (p=0.177), however 38.9% of subjects with seasonal allergies demonstrated lip incompetency, whereas only 18.2% of subjects with perennial allergies demonstrated lip incompetency. Perennial allergens, while of longer duration, may not present as severe a nasal obstruction as seasonal allergens, and thus, based on our results, do not seem to impact vertical growth development to the same extent as seasonal allergens. These findings are supported by a previous study, which noted differences between seasonal allergens and perennial allergens, with worst severity of rhinitis related to seasonal allergens, and worst severity of asthma related to perennial allergens.[28] As well, allergic rhinitis was more frequent in seasonal allergen allergic patients whereas asthma was more frequent in perennial allergen allergic patients.[28]

A statistically significant association with vertical growth development was consistently demonstrated among our results, but fewer findings supported an association between environmental sensitivities and the presence of malocclusion. The only significant association demonstrated was an increased prevalence of posterior cross bite dependent on asthma severity (see table 4). Patients with increased asthma severity presented with posterior cross bite more often than those with mild asthma. Previous studies demonstrate a relationship between asthma and cross bite, although severity of the asthma is not indicated.[8, 9] In one study, asthma severity was found to be associated with craniofacial morphology, in particular related to more retrognathic mandibles, while the presence of asthma altered dentoalveolar relations in comparison to controls.[29] While the findings in regards to severity vary in terms of orthodontic manifestation, both results point toward an association between asthma severity and orthodontic problems.

Gender differences in ANS:Me, as demonstrated in our study, have been similarly shown in previous studies, with males being more likely to have increased ANS:Me as a result of sexual dimorphism.[30]

Confounding factors in regard to tonsil and adenoid removal, including age at which tonsils and adenoids were removed and the cause of hyperplasia, could not be corrected for, due to a lack of reporting. As such, despite statistically significant results, no conclusions could be drawn in regard to tonsil and adenoid removal and its association with overjet and posterior cross bite.

A lack of reporting of allergic rhinitis was a major limitation, as few cases were reported, and statistically significant results were difficult to determine based on the small sample size reported. One study set out to determine the criteria for the definition of allergic rhinitis, and further noted that studies evaluating the signs and symptoms for diagnosis were not available.[31] As well, criteria for diagnosis were determined to include allergens such as pollen, and precipitating factors including house dust, smoke, weather change, animal hair, spray, mould, and flowers.[31] Allergic rhinitis is one of the most common chronic diseases, however with the overlap between allergens responsible for allergic rhinitis and environmental allergies and the lack of definitive criteria for diagnosis, it is likely that allergic rhinitis was misreported or misdiagnosed as environmental allergies, thus accounting for the lack of allergic rhinitis reported. Another explanation may be that allergic rhinitis is a manifestation of environmental allergies, and the two entities are one in the same. In addition, the seasonal or perennial nature of allergic rhinitis may differentially impact mode of breathing, craniofacial growth development and malocclusion, as was noted in the study results for seasonal allergies. Future studies on this topic would benefit from improved reporting on the presence, and the nature of allergic rhinitis.

Based on our results, and previous research[29], it is plausible that asthma severity and control play a role in the mode of breathing, as well as craniofacial growth development and malocclusion. Upon chart review, asthma was frequently reported, yet the severity and level of control was inconsistently reported. According to the 2007 NHLBI Guidelines for the Diagnosis and Treatment of Asthma Expert Panel Report 3, asthma severity can be classified as intermittent or persistent, and among persistent, can be further classified into mild, moderate, and severe.[32] As well, the level of control can be classified as well controlled, not well controlled, and very poorly controlled.[32] Future studies may use prompts to ensure the reporting of level of severity, level of control, and medication use in the presence of asthma, to gain a better understanding of the role asthma plays in mode of breathing, craniofacial growth development, and malocclusion.

Despite the limitations noted, our results demonstrate that respiratory problems resulting from environmental allergens are associated with the vertical growth development of the craniofacial complex, more specifically MPA and lip incompetency. Seasonal allergies in particular are associated with MPA, and severe forms of asthma are associated with the development of posterior cross bite. Patients identified with environmental sensitivities, in particular seasonal allergies and severe forms of asthma, may benefit from early orthodontic referral and intervention.

CONCLUSION

Respiratory problems resulting from environmental allergens are associated with vertical growth development of the craniofacial complex. Mouth breathing and oro-nasal modes of breathing are associated with increased MPA, Y-axis, ANS: Me and lip incompetency as compared to nasal breathing. Environmental sensitivities are associated with increased MPA values. Environmental allergies, in particular seasonal allergies, are associated with increased MPA values, while asthma is associated with an increased prevalence of lip incompetency. Severe forms of asthma are more likely to be associated with posterior cross bite in comparison to mild forms of asthma. Our results demonstrate that patients with environmental sensitivities may benefit from early orthodontic referral and intervention, however, further research is required to determine the potential for use of environmental sensitivities as predictors of future orthodontic problems. Furthermore, it can be recommended that in cold climates where the growing child spends significant time indoors and thus subject to ventilated air, frequent duct cleaning of the home would potentially reduce allergens, improve the air quality and in this way potentially reduce vertical growth and lip incompetency.

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Table 1 MOB vs. Dependent Variables

Variable	Total	Nasal	Oro-Nasal	Mouth	P-Value
MPA					
>38°	52	15 (12.1%)	22 (22.4%)	15 (39.5%)	
<38°	208	109 (87.9%)	76 (77.6%)	23 (60.5%)	0.001a
Y-axis					
>70°	81	31 (25.2%)	30 (30.6%)	20 (52.6%)	
<70°	178	92 (74.8%)	68 (69.4%)	18 (47.4%)	0.006a
ANS:Me					
>70mm	85	26 (21.0%)	42 (42.9%)	17 (44.7%)	
<70mm	175	98 (79.0%)	56 (57.1%)	21 (55.3%)	0.001a
Lip Incompetency					
>5mm	70	23 (18.5%)	31 (32.0%)	16 (42.1%)	
<5mm	189	101 (81.5%)	66 (68.0%)	22 (57.9%)	0.006a

[a]Chi Square

Table 2 Mandibular Plane Angle (MPA) vs. Independent Variables

Variable	Total	No	Yes	P-Value
Gender				
Male	112	93 (83.0%)	19 (17.0%)	
Female	147	114 (77.6%)	33 (22.4%)	0.275a
MOB				
Nasal	124	109 (87.9%)	15 (12.1%)	
Both	98	76 (77.6%)	22 (22.4%)	
Mouth	38	23 (60.5%)	15 (39.5%)	0.001a
Tonsil or Adenoid Removal				
No	208	165 (79.3%)	43 (20.7%)	
Yes	48	39 (81.3%)	9 (18.8%)	0.765a
Environmental Sensitivity (ES)				
No	135	115 (85.2%)	20 (14.8%)	0.030a
Yes	125	93 (74.4%)	32 (25.6%)	
Environmental Allergy				
No ES	135	115 (85.2%)	20 (14.8%)	
Yes (allergy only)	45	32 (71.1%)	13 (28.9%)	0.035a
Allergy Type				
Environmental	75	57 (76.0%)	18 (24.0%)	
Other	30	28 (93.3%)	2 (6.7%)	0.041a
Allergy Presentation				
Seasonal	18	8 (44.4%)	10 (55.6%)	
Perennial	33	27 (81.8%	6 (18.2%)	0.006a

Asthma				
No ES	135	115 (85.2%)	20 (14.8%)	
Yes (asthma only)	43	31 (72.1%)	12 (27.9%)	0.052a

[a]Chi Square

Table 3 Lip Incompetency vs. Independent Variables

Variable	Total	No	Yes	P-Value
Gender				
Male	112	87 (77.7%)	25 (22.3%)	
Female	146	101(69.2%)	45 (30.8%)	0.128a
MOB				
Nasal	124	101 (81.5%)	23 (18.5%)	
Oro-Nasal	97	66 (68.0%)	31 (32.0%)	
Mouth	38	22 (57.9%)	16 (42.1%)	0.006a
Tonsil or Adenoid Removal				
No	207	154 (74.4%)	53 (25.6%)	
Yes	48	32 (66.7%)	16 (33.3%)	0.277a
Environmental Sensitivity (ES)				
No	134	104 (77.6%)	30 (22.4%)	0.082a
Yes	125	85 (68.0%)	40 (32.0%)	
Environmental Allergy				
No ES	134	104 (77.6%)	30 (22.4%)	
Yes (allergy only)	45	30 (66.7%)	15 (33.3%)	0.143a
Allergy Presentation				
Seasonal	18	11 (61.1%)	7 (38.9%)	
Perennial	33	27 (81.8%)	6 (18.2%)	0.177b
Asthma				
No ES	134	104 (77.6%)	30 (22.4%)	
Yes (asthma only)	43	26 (60.5%)	17 (39.5%)	0.027a

[a]Chi square
[b]Fisher's Exact Test

Table 4 Posterior Cross Bite vs. Independent Variables

Variable	Total	No	Yes	P=Value
Asthma Severity				
Mild	54	44 (81.5%)	10 (18.5%)	
Severe	7	3 (42.9%)	4 (57.1%)	0.042b

[b]Fisher's Exact Test