The Impact of Obstructive Sleep Apnea on the Development of Refractory Nasal Symptoms After Adenoidectomy

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Objectives: Chronic rhinitis may contribute to a persistently decreased quality of life in patients undergoing surgical treatment for obstructive sleep apnea (OSA). This study aimed to characterize the role of OSA in pediatric patients with refractory chronic rhinitis after adenoidectomy. Methods: We reviewed the charts of patients <18 years of age with a history of OSA who underwent adenoidectomy at an academic medical center from October 2012 to December 2018 and that were seen in the clinic for follow-up. They were identified through the Current Procedural Terminology (CPT) codes 42830 and 42831 with the exclusion of CPT 42820 for tonsillectomy and adenoidectomy. Patients with a prior diagnosis of OSA who had refractory symptoms were compared with those who had symptoms resolution using chi-square analysis and t-tests. Results: Thirty-six (35.0%) patients with refractory symptoms following adenoidectomy and 52 (37.4%) patients without refractory symptoms had a history of OSA before surgery (p=0.80). In patients with refractory symptoms, the average age (3.8 years) and male sex (n=24, 66.7%) did not differ significantly from the age (4.42 years) and male sex (n=36, 69.2%) percentages of patients without refractory symptoms. The mean apnea/hypopnea-index (AHI) (p=0.91), completion of the sleep study (p=0.41), history of snoring (p=0.92), and tonsil size (p=0.42) did not differ significantly between the groups. However, patients with refractory symptoms had a significantly higher mean body mass index (BMI) (19.58) than those who did not (17.77, p=0.04) and completed a higher number of allergy evaluations (p=0.02). Conclusions: While the history and severity of OSA did not differ significantly in patients with refractory nasal symptoms after adenoidectomy, these patients had a significantly higher BMI and completion of allergy evaluation.

INTRODUCTION

Chronic rhinitis represents a large burden of disease in the pediatric population and plays a significant role in the quality of life of these patients.1 It frequently presents with nasal obstruction, rhinorrhea, and mouth breathing, and may impact the quality of sleep in children.1 Adenoid hypertrophy has been estimated to affect at least one-third of pediatric patients,2 and there is prior evidence that children with this condition have significantly higher sleep disturbances.3 Adenoidal hypertrophy is associated with more severe chronic rhinitis in children,4 and the removal of adenoid tissue may improve symptoms.5 However, a meta-analysis estimated that approximately 30% of patients have refractory nasal congestion even after adenoidectomy.5

Pediatric obstructive sleep apnea (OSA) is a common co-morbid condition that may present with witnessed apneas, hyperactivity, and difficulty concentrating, which can affect school performance.6,7 In children, tonsillectomy and adenoidectomy are commonly performed to treat this condition and may improve or resolve the symptoms; however, the presence of chronic rhinitis in these patients may be a predictor of surgical failure.8 Although there is limited evidence on the relationship between chronic rhinitis and OSA, prior evidence suggests that mouth breathing associated with nasal congestion may result in upper airway collapse.9 Another study suggested that adenoid hypertrophy is significantly correlated with OSA.10 In addition, mucosal inflammation causing increased airway resistance may contribute to worsening of OSA.8

Keywords: Obstructive sleep apnea; Rhinitis; Otolaryngology; Adenoidectomy; Nasal blockage.
ical and surgical treatment of rhinitis has been shown to significantly reduce the apnea-hypopnea index (AHI) in adults.\textsuperscript{11,12} However, despite AHI improvement in adults treated for rhinitis, few studies have examined whether a similar relationship exists in children. In addition, given the potential relationship between OSA and chronic rhinitis, it is unclear whether patients who develop refractory symptoms after adenoidectomy have a worse underlying severity of OSA or if there are demographic differences in patients who have OSA that may contribute to postoperative symptoms. Therefore, the aim of this study was to determine whether pediatric patients with chronic rhinitis who had refractory symptoms after adenoidectomy had worse OSA and related variables, such as AHI, tonsil size, and adenoid size, than those with resolution and to determine whether there were clear demographic differences between patients with OSA who had refractory symptoms and those who did not.

METHODS

A retrospective review of cases was conducted following approval from the Institutional Review Board of Boston Medical Center (IRB H-38405). The IRB waived the requirement for informed consent. We included the charts of patients <18 years of age who underwent adenoidectomy, identified through the Current Procedural Terminology (CPT) codes 42830 and 42831, from October 2012 to December 2018. After excluding 12 cases lost to follow-up and 22 cases with adenoidectomy indications other than rhinitis, a final sample of 242 patients was obtained. The variables collected included history of snoring, completion of a sleep study, AHI, tonsil size, preoperative medication use, and allergy evaluation. Demographic variables, including age, sex, primary language, and body mass index (BMI) were also recorded. Preoperative adenoid size was assessed by flexible endoscopy in the clinic and measured as a percentage of choanal obstruction. Tonsillectomy and adenoidectomy were completed intraorally using an electrosurgical, with indirect transoral mirror examination to visualize and assess the adenoid pad.

Data from patients with and without refractory symptoms were compared by chi-square analysis and Fisher’s exact test for categorical variables, Mann-Whitney U-test (for variables not demonstrating normal distribution using the Shapiro-Wilk test) and t-tests for quantitative variables using R statistical software version 3.4.3 (packages “readxl,” “tidyverse”; R Core Team, R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at $p<0.05$.

RESULTS

In total, 276 patients underwent adenoidectomy between October 2012 and December 2018. After excluding 12 cases without demonstrating normal distribution using the Shapiro-Wilk test) and t-tests for quantitative variables using R statistical software version 3.4.3 (packages “readxl,” “tidyverse”; R Core Team, R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at $p<0.05$.

In total, 276 patients underwent adenoidectomy between October 2012 and December 2018. After excluding 12 cases lost to follow-up and 22 cases with adenoidectomy indications other than rhinitis, a final sample of 242 patients was obtained. A total of 103 patients had refractory symptoms after adenoidectomy and 139 patients did not have refractory symptoms. Thirty-six patients (35.0%) with refractory symptoms had a history of OSA and 52 patients (37.4%) without refractory symptoms had a history of OSA.

The average age of the patients with refractory symptoms (3.80 years) and those without (4.42 years) did not differ significantly. In addition, the prevalence of male patients with refractory symptoms (n=24, 66.7%) and those without them (n=36, 69.2%) was not significantly different between these groups (Table 1). The variables collected included history of snoring, completion of a sleep study, AHI, tonsil size, preoperative medication use, and allergy evaluation. Demographic variables, including age, sex, primary language, and body mass index (BMI) were also recorded. Preoperative adenoid size was assessed by flexible endoscopy in the clinic and measured as a percentage of choanal obstruction. Tonsillectomy and adenoidectomy were completed intraorally using an electrosurgical, with indirect transoral mirror examination to visualize and assess the adenoid pad.

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The history of snoring, completion of a sleep study, and the AHI were not significantly different between the groups (Table 2). Tonsil size did not differ significantly between patients who developed residual rhinitis and those who did not, and preoperative adenoid size did not differ significantly between groups (81.67% vs. 81.79%, $p=0.77$) (Table 2). However, the patients with refractory symptoms had a higher degree of preoperative medication use (Table 3).

Demographic variables were not significantly different between the groups (Table 1). However, patients with refractory symptoms had a significantly higher mean BMI than those without them (19.58 vs. 17.77, $p=0.04$). In addition, a significantly higher proportion of patients with refractory symptoms underwent allergy evaluations ($p=0.02$) (Table 3).
DISCUSSION

The history or severity of OSA did not differ significantly between patients who had refractory symptoms after adenoidectomy and those who did not. While chronic rhinitis is associated with OSA, these findings suggest that the severity of OSA is not associated with surgical failures in patients with rhinitis. Despite prior evidence suggesting that adenoid hypertrophy and inflammation may be associated with upper airway collapse and increased airway resistance, the findings of this study suggest that patients with more severe OSA do not necessarily have a worse obstruction or residual rhinitis.

Patients with refractory symptoms had a significantly higher BMI than those without refractory symptoms. While the reasons for this finding remain unclear, possible explanations include more severe chronic rhinitis in patients with a higher BMI, as supported by prior evidence,\(^1\) or that complete removal of adenoid tissue may have been more difficult to achieve in patients with elevated BMIs. Alternatively, patients with a higher BMI may have had more comorbid conditions that required more frequent medical evaluation, therefore, they probably reported their symptoms more often. However, despite the etiology of these findings, this study highlights the importance of considering BMI as a factor in surgical planning, as patients with OSA who have higher BMI may not achieve the same level of symptom resolution following adenoidectomy as those with lower BMI, similar to prior evidence that identified an inverse relationship between BMI and AH1 improvement after adenotonsillectomy.\(^14\) In these patients, consideration of whether adenoidectomy is a significantly effective procedure may guide decision-making in this population.

Additionally, a significantly higher proportion of patients who developed residual rhinitis underwent allergy testing preoperatively or postoperatively during rhinitis evaluation and treatment. Although there was no significant difference in positive allergy evaluations, the majority of patients did not undergo allergy testing, and many patients may have underdiagnosed allergic rhinitis. Patients with refractory rhinitis completed a higher proportion of allergy testing and had significantly higher BMI compared to patients without refractory rhinitis, supporting prior evidence that obesity may have a positive association with allergic rhinitis.\(^15\) As OSA, obesity, and allergic rhinitis are pro-inflammatory states,\(^13,16\) providers should consider whether more extensive medical treatment of the possible inflammation underlying these conditions may be warranted prior to further surgical management in these patients.

This study has several limitations. First, it was a retrospective case series that was unable to compare the difference between preoperative and postoperative AH1 in patients with refractory symptoms, and instead focused on preoperative OSA severity only. Second, symptoms and medication use were patient-reported, making it difficult to quantify and qualify the

Table 1. Demographic characteristics of patients undergoing adenoidecmy

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Refractory symptoms (n=36)</th>
<th>No symptoms (n=52)</th>
<th>p</th>
<th>Analysis method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>3.80</td>
<td>4.42</td>
<td>0.46</td>
<td>t-test</td>
</tr>
<tr>
<td>Male</td>
<td>24 (66.7)</td>
<td>36 (69.2)</td>
<td>0.98</td>
<td>Chi-square</td>
</tr>
<tr>
<td>Caucasian race</td>
<td>8 (22.2)</td>
<td>17 (32.7)</td>
<td>0.41</td>
<td>Chi-square</td>
</tr>
<tr>
<td>English</td>
<td>26 (72.2)</td>
<td>32 (61.5)</td>
<td>0.42</td>
<td>Chi-square</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>19.58</td>
<td>17.77</td>
<td>0.04*</td>
<td>t-test</td>
</tr>
<tr>
<td>History of asthma</td>
<td>8 (22.2)</td>
<td>7 (13.5)</td>
<td>0.43</td>
<td>Chi-square</td>
</tr>
</tbody>
</table>

Categorical variables are presented as n (%) and quantitative variables are presented as mean. *statistically significant. BMI, body mass index

Table 2. Sleep-related variables in patients undergoing adenoidectomy

<table>
<thead>
<tr>
<th>Variables</th>
<th>Refractory symptoms (n=36)</th>
<th>No symptoms (n=52)</th>
<th>p</th>
<th>Analysis method</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of snoring</td>
<td>35 (97.2)</td>
<td>52 (100)</td>
<td>0.85</td>
<td>Chi-square</td>
</tr>
<tr>
<td>Completion of sleep study</td>
<td>35 (97.2)</td>
<td>44 (84.6)</td>
<td>0.12</td>
<td>Chi-square</td>
</tr>
<tr>
<td>Apnea-hypopnea index</td>
<td>5.92</td>
<td>6.13</td>
<td>0.91</td>
<td>t-test</td>
</tr>
<tr>
<td>Tonsil size (Brodsky grading scale)</td>
<td>1.82 (n=14)</td>
<td>1.61 (n=19)</td>
<td>0.38</td>
<td>Mann-Whitney</td>
</tr>
<tr>
<td>Preoperative adenoid size (%)</td>
<td>81.67 (n=12)</td>
<td>81.79 (n=14)</td>
<td>0.77</td>
<td>Mann-Whitney</td>
</tr>
</tbody>
</table>

Categorical variables are presented as n (%) and quantitative variables are presented as mean.

Table 3. Preoperative medication use and allergy evaluations in patients with obstructive sleep apnea undergoing adenoidectomy

<table>
<thead>
<tr>
<th>Variables</th>
<th>Refractory symptoms (n=36)</th>
<th>No symptoms (n=52)</th>
<th>p</th>
<th>Analysis method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of preoperative medication</td>
<td>33 (91.7)</td>
<td>37 (71.2)</td>
<td>0.04</td>
<td>Chi-square</td>
</tr>
<tr>
<td>Number of preoperative medications</td>
<td>1.53</td>
<td>1.10</td>
<td>0.09</td>
<td>t-test</td>
</tr>
<tr>
<td>Allergy evaluation</td>
<td>9 (25)</td>
<td>3 (5.8)</td>
<td>0.02*</td>
<td>Chi-square</td>
</tr>
<tr>
<td>Reported history of allergies</td>
<td>7 (7.7)</td>
<td>4 (19.4)</td>
<td>0.19</td>
<td>Chi-square</td>
</tr>
<tr>
<td>Positive allergy evaluation</td>
<td>3 (75)</td>
<td>0 (0)</td>
<td>0.14</td>
<td>Fisher’s exact test</td>
</tr>
</tbody>
</table>

Categorical variables are presented as n (%) and quantitative variables are presented as mean. *statistically significant
severity and treatment of chronic rhinitis, both preoperatively and postoperatively. Third, confounding factors, including a history of reflux or environmental exposure, may have also contributed to the refractory symptoms. Finally, not all patients had documented tonsil or preoperative adenoid size, which represents a limitation in the comparison of these variables.

Future prospective studies should better demonstrate the relationship between patients with worse underlying OSA and the development of refractory symptoms. In addition, a larger sample size over a long period would improve the statistical power of this study and identify whether a higher BMI is truly a contributing factor for the development of refractory symptoms. A prospective study would also allow for a better understanding of whether the refractory symptoms following adenoidectomy were improved or unchanged preoperatively.

In conclusion, the history and severity of OSA were not significantly different between pediatric patients with OSA who had residual symptoms after adenoidectomy for chronic rhinitis and those with symptom resolution. However, patients with refractory symptoms had a significantly higher mean BMI, indicating that pediatric patients with a higher BMI who use medications preoperatively and have OSA may require more careful surgical planning. In addition, patients who developed residual symptoms had a significantly higher proportion of allergy evaluations, suggesting that for patients requiring more extensive diagnostic workup, adenoidectomy may not be fully curative for their rhinitis symptoms.

Conflicts of Interest
The authors have no potential conflicts of interest to disclose.

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REFERENCES