

# The effect of tonsillectomy on obstructive sleep apnea: an overview of systematic reviews

Lauren K Reckley  
Camilo Fernandez-Salvador  
Macario Camacho

Otolaryngology – Head and Neck  
Surgery, Tripler Army Medical Center,  
Honolulu, HI, USA

**Objective:** Tonsillectomy with adenoidectomy is a combination surgery that has been used to treat pediatric obstructive sleep apnea (OSA). For adults, tonsillectomy has also been reported as a primary treatment modality when the tissue is hypertrophied. The objective of this study is to provide an overview of published systematic reviews and meta-analyses of tonsillectomy with or without adenoidectomy as used in the treatment of OSA in children and adults.

**Data sources:** Nine databases, including PubMed/MEDLINE.

**Review methods:** Databases were searched from their inception through July 9, 2017. The PRISMA statement was followed.

**Results:** More than 20 recent systematic reviews and meta-analyses were identified regarding tonsillectomy as a treatment modality for OSA. There were four articles that addressed tonsillectomy's overall success, efficacy, and complications in otherwise healthy pediatric patients. Three studies evaluated tonsillectomy in obese children, and two specifically examined children with Down syndrome. Only one systematic review and meta-analysis discussed tonsillectomy as a treatment for OSA in the adult population.

**Conclusion:** Tonsillectomy as an isolated treatment modality is rarely performed in pediatric patients with OSA; however, tonsillectomy is commonly performed in combination with adenoidectomy and the combination has demonstrated efficacy as the primary treatment option for most children. In the limited adult data, tonsillectomy alone for OSA has a surprising success rate; yet, more research is required to determine long-term improvement and need for further treatment.

**Keywords:** tonsillectomy, sleep apnea syndromes, systematic review, review

## Introduction

Tonsillectomy is one of the most commonly performed surgeries in the United States and is typically performed with concurrent adenoidectomy for treatment of obstructive sleep apnea (OSA), especially in the pediatric population. Adenotonsillectomy has become the first-line treatment modality for pediatric OSA. The utility of tonsillectomy in pediatric population, especially adult tonsillectomy, has been controversial in the literature. The purpose of this article is to provide an overview of systematic reviews and meta-analyses of tonsillectomy as a surgical option for OSA treatment in various populations, evaluate complication risk, describe confounding variables, discuss successes and limitations, and encourage further research. The specific study search criteria using the PICOS acronym are as follows: 1) “Patients (P)”: pediatric or adult patients with OSA; 2) “Intervention (I)”: tonsillectomy with or without adenoidectomy; 3) “Comparison (C)”: outcomes for patients pre- and post-tonsillectomy;

Correspondence: Lauren K Reckley  
Otolaryngology – Head and Neck  
Surgery, 1 Jarrett White Road, Tripler  
Army Medical Center, Honolulu, HI  
96859, USA  
Email lreckley2014@gmail.com

4) “Outcomes (O)”: sleep study outcomes, complications, quality of life, sleepiness, and other variables; and (5) “Study design (S)”: systematic reviews with or without meta-analyses.

## Materials and methods

Three authors (MC, CFS, and LR) independently searched the international literature (in all languages) from the inception of each database through July 9, 2017. The databases that were systematically searched included PubMed/MEDLINE, The Cochrane Library, Web of Science, Book Citation Index – Science, Cumulative Index to Nursing and Allied Health (CINAHL), Scopus, Embase, Google Scholar, and Conference Proceedings Citation Index – Science from the inception of each database. An example of a search strategy for PubMed/MEDLINE is: (tonsillect\*) AND (“sleep apnea” OR “sleep apnoea” OR “apnea-hypopnea” OR “apnoea-hypopnoea” OR “respiratory disturbance” OR “sleep study” OR polysomnography). A separate search was also performed in each database with the following search strategy: (“isolated tonsillectomy” OR “tonsillectomy alone”) AND (“sleep apnea” OR “sleep apnoea” OR “apnea-hypopnea” OR “apnoea-hypopnoea” OR “respiratory disturbance” OR “sleep study” OR polysomnography) AND (“systematic review” OR meta\*). Attention was focused on systematic reviews and meta-analyses evaluating tonsillectomy as treatment for OSA. When analyzing these data, the authors attempted to distinguish the results based on several factors included in the original studies. For example, effects of polysomnography (PSG) results in different patient populations to include: obesity, adults, syndromic, or tonsillar hypertrophy.

## Protocol approval

The Department of Clinical Investigation at Tripler Army Medical Center was contacted, a protocol was submitted, and the protocol was approved (Protocol TAMC 16N14) to perform this study, and as a review article, formal consent of patients was not required.

## Results

### Sleep study outcomes

Four systematic reviews were identified based on the overall success, cure, and failure rates of pediatric tonsillectomy often combined with adenoidectomy. In 2006, Brietzke and Gallagher<sup>1</sup> identified 14 case series with an average sample size of 28 pediatric patients undergoing adenotonsillectomy for OSA. The average patient age was 4.9 years. All patients had pre- and postoperative PSG data, and the average time until PSG after

surgery was 98 days. The average preoperative apnea-hypopnea index (AHI) was 16.8 with a decrease of 13.92 events per hour. The mean postoperative AHI was 2.4 events per hour.<sup>1</sup>

Friedman et al updated the systematic review 3 years later. He identified 23 studies and included a meta-analysis of the success rates in obese and comorbid populations with healthy children less than 20 years of age. The meta-analysis included 1079 patients with an average study size of 42 and a mean age of 6 years. The rate of postoperative AHI <1 event per hour was 59%, while AHI <5 events per hour was 66%. The mean change after surgery was a decrease in AHI of 12.4 events per hour. In children with comorbid conditions such as obesity, age less than 3 years, or severe OSA, the cure rate was 38%.<sup>2</sup>

More recently, a Cochrane systematic review by Venekamp et al<sup>3</sup> in 2015 discussed tonsillectomy ± adenoidectomy vs nonsurgical management of OSA in pediatric patients. Venekamp selected three randomized controlled trials comparing the efficacy of the tonsillectomy with or without adenoidectomy, no surgery, or continuous positive airway pressure (CPAP) in 562 patients between 2 and 16 years of age. The largest trial (CHAT trial) of 453 patients aged 5–9 years demonstrated improved quality of life and symptom measures at 7 months compared to observation. There was no significant difference in similar measures between surgery and CPAP among 80 children with mild-to-moderate OSA. The CHAT trial had a complication rate of 3%, Goldstein<sup>4</sup> did not report adverse events, and Sudarsan’s<sup>5</sup> study had a surgical complication rate of 5% with a CPAP complication rate of 3%. In the CHAT trial, 79% of patients showed normalization of respiratory events after surgery compared to 46% of observed patients.<sup>3</sup>

Chinnadurai et al published a meta-analysis of tonsillectomy vs observation in pediatric patients with OSA. Chinnadurai included sleep as well as cognitive, behavioral, and health outcomes. There were 11 studies included in the systematic review and only three with the required data were used for meta-analysis, which demonstrated a 4.8 events per hour improvement in AHI in children undergoing tonsillectomy. In children who did not have surgery and instead underwent observation also improved but not to as large of an extent. Sleep-related quality of life measures and negative behaviors improved; however, data regarding executive functioning and health were not significant.<sup>6</sup>

### Syndromic children

OSA is more prevalent in children with neurodegenerative disorders, syndromes, and craniofacial abnormalities. The most widely studied syndrome showing an association with

OSA is Down syndrome. There were two systematic reviews published in the first half of 2017 that evaluated the efficacy of adenotonsillectomy in pediatric patients with Down syndrome. Nations and Brigger found 21 patients with Down syndrome undergoing adenotonsillectomy alone, with five articles meeting inclusion criteria for qualitative analysis and three articles available for quantitative analysis. The average patient age was 3.7 years. Only 5% of patients had a normal postoperative PSG if considering elevated arousal index (AI) to be normal; however, a 50% reduction in AHI can be predicted based on their small sample size with up to 75% of patients still requiring positive pressure ventilation postoperatively.<sup>7</sup> Farhood et al performed a similar analysis; however, he identified six articles and included retrospective institutional data with a total of 148 patients. Improvement in AHI was noted; however, adenotonsillectomy as monotherapy was unlikely to cure most patients with Down syndrome. Twenty percent of the institutional patients demonstrated an AHI <1 event per hour postoperatively.<sup>8</sup>

## Obesity

One of the confounding variables to the success of tonsillectomy is obesity. Anderson et al<sup>9</sup> in 2016 performed a systematic review of the literature and identified six articles with children aged birth to 18 years undergoing adenotonsillectomy and compared the success rates between obese and non-obese children. They concluded that there was a lack of consistency in the definition of pediatric OSA as described in the literature, yet obese children were less likely to benefit from surgical treatment alone. Both treatment groups had significant reduction in postoperative compared to preoperative AHI, although the decrease in the obese children was less compared to the non-obese children. OSA also persisted in 25 of the 33 obese children (76%), whereas OSA persisted in 11 of the 39 (28%) non-obese children.<sup>9</sup> In 2016, Lee et al<sup>10</sup> reported similar findings in the meta-analysis of 51 articles with 3413 subjects evaluating pre- and postoperative PSG data for obese and non-obese children. They identified a 12.4 events per hour reduction in AHI along with a mean oxygenation and minimum saturation improvement. The overall cure rate, defined as AHI <1 event per hour, was found to be 34% for obese patients and 47% for non-obese. The success rate, defined as AHI <5 events per hour, was 61% for obese patients, 87% for non-obese, and 84% for both subsets of children. Lee et al was also able to demonstrate a positive correlation between AHI and body mass index preoperatively.<sup>10</sup> Van et al<sup>11</sup> also looked at obesity with respect to OSA and adenotonsillectomy in 2015. However, Van et al identified six articles and evaluated postoperative weight gain in children with preoperative body mass index (BMI) data. In

four articles, there was a significant increase in weight following surgery. These articles represented level-4 evidence. One article was a randomized controlled trial, which demonstrated significant weight gain within a 7-month follow-up period. There was no predilection for weight gain in obese or overweight children alone; however, those children are at most risk for further complications from excessive weight gain even in a short follow-up period.<sup>11</sup>

## Predictive factors

In 2017, Saur and Brietzke<sup>12</sup> at Walter Reed Army Medical Center evaluated preoperative PSG results and clinical factors to help predict postoperative respiratory complications in children. They identified 22 studies with a median of 157 patients. Major respiratory complications were defined as events requiring significant medical intervention by a staff member and include: positive airway pressure, intubation, unplanned admission, elevation of care, pulmonary edema, insertion of nasopharyngeal or oropharyngeal airway, or death. Desaturations or supplemental oxygen were not considered major respiratory complications. The median age of patients was 4.7 years with a standard deviation of 1.8 years. Most studies included multiple patients at high risk for respiratory complications. The rate of major respiratory complications was 5.8% with a moderate-to-severe AHI being the sole predictor of possible complication in 8.9% of children.<sup>12</sup> Major respiratory complications immediately following pediatric adenotonsillectomy are low even in high-risk children.

## Asthma

One of the long-term concerns following adenotonsillectomy is asthma, which can be a potential confounding airway disease in children with OSA. Kohli et al<sup>13</sup> performed a systematic review of asthma outcomes in pediatric patients following adenotonsillectomy, which has been a controversial topic on its own for half a century. Kohli identified four articles all of which demonstrated a significant reduction in respiratory medication use following adenotonsillectomy with average follow-up of 1 year. Three studies identified a significant reduction in asthma symptoms within 6 months to 1 year postoperatively. Two articles identified a significant reduction in asthma exacerbations within 1 year.<sup>13</sup>

## Cardiovascular parameters

There have been three recent systematic reviews discussing cardiovascular parameters in pediatric patients undergoing tonsillectomy for OSA. Teo et al were the first in 2013 to evaluate adenotonsillectomy in 418 pediatric patients from 14 articles

with an average age of 6 years. All studies reported improvements in OSA symptoms with only three having pre- and postoperative PSG data. Seven studies identified improvement in echocardiogram findings and three demonstrated blood pressure improvements, suggesting reversible cardiovascular morbidity.<sup>14</sup> The following year Weber et al performed a meta-analysis of five cohort studies based on the echocardiographic findings in children less than 12 years of age. Among two studies, there was a significant difference in preoperative mean pulmonary arterial pressure between children with OSA and those without. A significant reduction in postoperative mean pulmonary arterial pressure was also identified in children with OSA.<sup>15</sup> Ehsan et al published a meta-analysis in 2017 of 25 articles with 1418 subjects analyzing cardiovascular parameters in children following OSA treatment with 21 articles addressing adenotonsillectomy exclusively. All cardiovascular parameters were within normal limits preoperatively, and there was a significant improvement in mean pulmonary arterial pressure, right ventricular end diastolic diameter, heart rate, and C-reactive protein. On the other hand, there was no significant change in interventricular septum thickness, left ventricular parameters, or left atrial diameter.<sup>16</sup> In addition, Loffredo et al published a study in 2015 of children with OSA and compared to children with primary snoring and healthy controls while evaluating endothelial dysfunction based on oxidative stress. The OSA patients' oxidative stress improved after adenotonsillectomy, demonstrating a possible reduced cardiovascular risk in OSA children.<sup>17</sup>

## Hemorrhage

The risk of postoperative hemorrhage from tonsillectomy is more life-threatening in the pediatric population compared to the adult population. There have been three systematic reviews of the literature evaluating tonsillectomy as a safer alternative to adenotonsillectomy for pediatric OSA patients. Wang et al performed a meta-analysis in 2015 of 10 studies with over 1000 patients and demonstrated no long-term difference in the airway symptoms up to 31 months and a significant improvement in short-term postoperative hemorrhage risk, operative time, and pain relief.<sup>18</sup> Acevedo et al performed a similar systematic review in 2012 that also demonstrated lower postoperative bleeding; however, this finding was not evident in the higher-quality studies that were identified. Also, Acevedo et al did not include sufficient data regarding tonsillar regrowth rates or postoperative sleep-disordered breathing from tonsillectomy.<sup>19</sup> The most recent meta-analysis by Gorman et al in 2017 identified a total of 20 studies, with four of those examining tonsillectomy, and compared

subjective improvement of OSA symptoms with the OSA-18 questionnaire. There was no significant subjective difference in symptom improvement between the two cohorts.<sup>20</sup>

## Neurocognitive outcomes

Song et al published a systematic review evaluating neurocognitive outcomes after pediatric adenotonsillectomy for OSA. They identified 19 prospective studies including 898 patients with an average age of 6 years. Using validated neuropsychological development assessment scores before and after surgery, they were able to demonstrate an increase in IQ scores in preschool-age children in three studies with 274 patients. Over the age of 5 years, the IQ and neurocognitive improvement was not as great, suggesting a possible threshold age when the timeframe for surgical benefit may have lapsed.<sup>21</sup>

## Adult tonsillectomy and OSA

Interestingly, there has been only one systematic review and meta-analysis of tonsillectomy alone for OSA in the adult population. Camacho et al<sup>22</sup> in 2016 identified 17 studies with pre- and postoperative AHI data in adults greater than 18 years of age undergoing tonsillectomy alone for OSA. In 203 patients, they demonstrated an AHI reduction of 65.2% from a mean  $\pm$  standard deviation of  $40.5 \pm 28.9$  events per hour to  $14.1 \pm 17.1$  events per hour. A 7.8% improvement in lowest oxygen saturation was found along with an improvement in Epworth sleepiness scores by 5.5 points. Twelve of the studies included did not describe palate position or Friedman stages; however, all of the patients were described as having hypertrophic, enlarged, grade 2–4 tonsils. Significant predictors of tonsillectomy success were preoperative AHI and BMI. Among patients with an AHI  $<30$  events per hour preoperatively, the success rate, defined as decrease in AHI less than or equal to 50%, was 100% in 25 patients. For patients with a preoperative AHI  $>30$  events per hour, the success rate was 72% and the cure rate was 34%.<sup>22</sup>

## Discussion

Tonsillectomy has been demonstrated to be an effective treatment tool for OSA in both children and adults. While there are hundreds of articles published regarding tonsillectomy, it is difficult to find systematic reviews of tonsillectomy alone, especially for pediatric patients. Tonsillectomy and adenoidectomy are most often performed simultaneously as the primary treatment for OSA in children. Pediatric success and cure is variable based on clinical factors such as tonsil size, palate position, craniofacial abnormalities, comorbid syndromes, and obesity. The literature supports

adenotonsillectomy as the first treatment option for low risk as well as children with Down syndrome and obesity. It is essential, however, when counseling families to mention other treatment options and likelihood for residual disease. Tonsillectomy may also be a surgical consideration to decrease the risk of bleeding and has demonstrated efficacy. Adenoidectomy alone for children less than 2 years of age has also been found in meta-analysis to be an effective and safe treatment option to avoid life-threatening hemorrhage in young patients.<sup>23</sup> While pediatric tonsillectomy requires more research, especially with respect to longer term follow-up, there is a paucity in the adult literature.

There has been one meta-analysis evaluating tonsillectomy as an isolated surgical treatment for adults. One of the most important considerations is patient selection. Of the 17 articles identified, 12 did not describe the palate position and tonsil size, which is essential in patient selection to undergo tonsillectomy alone for OSA. As expected, a patient with mild AHI would be more likely to benefit; however, it is not clear if there is enough literature to support tonsillectomy as a primary surgical modality for adults with OSA considering the recovery and lack of long-term follow-up data.

## Conclusion

Tonsillectomy as an isolated treatment modality is rarely performed in pediatric patients with OSA; however, in combination with adenoidectomy, both have demonstrated efficacy as the primary treatment option for most children. Considering the limited adult data, tonsillectomy alone for OSA has a surprising success rate; yet, more research is required to determine long-term efficacy and need for further treatment.

## Author contributions

All authors met the criteria for authorship established by the International Committee of Medical Journal Editors. Specifically, Lauren K Reckley and Macario Camacho were responsible for substantial contributions to the conception, design, analysis, drafting the work, revising the work, and reviewing of the manuscript. Camilo Fernandez-Salvador assisted with the data gathering and reviewing of the manuscript. Additionally, all authors provided final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring the accuracy and/or integrity of the work.

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