Partial AndTotal Tonsillectomy For Pediatric Sleep-Disordered Breathing: The Role Of The Cas-15

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Partial and Total Tonsillectomy for Pediatric Sleep-disordered Breathing: the Role of the CAS-15

A Thesis Submitted to the Yale University School of Medicine

in Partial Fulfillment of the Requirements for the Degree of Doctor of Medicine

by

Jacob Garn Mabey, 2024
THE CLINICAL ASSESSMENT SCORE-15 AS AN ADJUNCT IN THE ASSESSMENT OF SURGICAL OUTCOMES AFTER PARTIAL AND TOTAL TONSILLECTOMY FOR SLEEP-DISORDERED BREATHING IN CHILDREN

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The Clinical Assessment Score-15 (CAS-15) is an office-based tool for assessing the risk of sleep disordered breathing (SDB), a relatively common condition in the pediatric population. Change in CAS-15 following total tonsillectomy (TT) has been shown to have a large effect size, but it is unclear how it varies following partial intracapsular tonsillectomy (PIT). Thus, the objective of the present study is to evaluate the utility of the CAS-15 score in assessing the effectiveness of PIT and how this compares to change after TT. Children ages 2-18 undergoing PIT (N=16) or TT (N=8) with or without adenoidectomy for SDB completed the CAS-15 before surgery and at their post-operative follow-up visit. Participants undergoing PIT did not differ significantly than those undergoing TT with regard to age, sex, BMI percentile, pre-op CAS-15 score or tonsil size, or admission rates following surgery (p>0.05). The median follow-up after surgery was 5.2 (PIT) and 4.4 (TT) weeks. CAS-15 score improved significantly following PIT (42.8±12.3 vs. 9.4±5.6, p<0.0001) and TT (45.5±13.3 vs. 7.9±5.8, p<0.0002). The decrease in CAS-15 for PIT did not differ from TT (33.3±11.8 vs. 37.6±15.0, p>0.49). CAS-15 decreases drastically following PIT and TT, indicating significant improvement of SDB symptoms. Because the change in CAS-15 after PIT was similar to TT, PIT may be preferred due to the decreased morbidity of the procedure. Given the cost, time
required, inconvenience, and other limitations of overnight polysomnography (PSG), which is the gold standard method of diagnosing SDB, CAS-15 may be a suitable replacement or adjunct for the assessment of SDB following PIT in addition to TT.
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Introduction

The Prevalence and Morbidity of Pediatric Sleep-disordered Breathing

Pediatric sleep-disordered breathing (SDB) encompasses a spectrum of conditions ranging from snoring to obstructive sleep apnea (OSA) and is relatively common. OSA, for example, is present in approximately 1–5% of the pediatric population, while snoring is present in roughly 12% of children.1,2 The reported prevalence of OSA, however, is thought to be an underestimate of the true prevalence,3,4 and some studies have reported rates of habitual snoring as high as one third of children.5

Because sleep plays an important role in a child’s health, growth, and development, SDB is associated with substantial morbidity. Pediatric OSA, and SDB in general, has been widely shown to influence cardiovascular health, with studies reporting a relationship with hypertension, ventricular dysfunction, nocturnal cardiac strain, and autonomic dysregulation.2 Obesity and metabolic disorders are also associated with OSA.2,3 These metabolic disorders are thought to be independent of the effects of obesity and include dyslipidemia, insulin resistance, elevated blood glucose levels, and dysfunctional neurohormonal mediators of feeding and satiety like ghrelin and leptin.6 Additionally, while obesity is a known factor in causing OSA, the reverse is also true: OSA can lead to and worsen obesity.6,7

Pediatric SDB can result in a number of neurocognitive deficits. Dozens of studies with a combined population of almost 30,000 pediatric patients have shown that SDB can cause deficits related to memory, learning, language skills, verbal comprehension,
and executive functioning, with meaningful impacts on school performance and academic achievement.\textsuperscript{2} Behavioral problems are also a common sequelae of SDB. Many exhibit oppositional behavior, inattentiveness, and hyperactivity, with some reaching the threshold for attention deficit hyperactivity disorder.\textsuperscript{8} The severity of sleep-related symptoms also appears to coincide with the frequency of behavioral problems. In one study of over 400 patients, those in the highest 15\% of participants based on SDB symptom severity were two-to-three times more likely than the cohort as a whole to exhibit behavioral problems, including aggression, inattentiveness, and social problems.\textsuperscript{9} While the morbidity of SDB is most strongly seen in OSA, even primary snoring and other less severe presentations of SDB can result in behavior and neurocognitive problems.\textsuperscript{4}

Among the most concerning aspects of SDB morbidity are the long-term impacts that can follow children well into adulthood. In a twenty-year follow-up study based on a cohort of adult patients who had confirmed severe OSA as a child—defined as an AHI of 10 or more events per hour—the adults were found to have significantly higher body mass indexes (BMI), fewer academic degrees, and more snoring than adults in the control group.\textsuperscript{10} In this same cohort, patients with increasing apnea-hypopnea index values also trended towards having a higher percentage of cardiovascular comorbidities as adults, though this did not reach significance.

The Risk Factors and Etiology of Pediatric Sleep-disordered Breathing

Risk factors for SDB are wide ranging, with adenotonsillar hypertrophy and obesity being among the most significant in children.\textsuperscript{11,12} Less common causes include a
number of genetic and anatomic abnormalities, like Down syndrome, Pier Robin syndrome, macroglossia, micro- and retrognathia, and neuromuscular disorders.  

Similar to adults, pediatric SDB stems in large part from pharyngeal collapsibility. However, there are notable differences between pediatric and adult patients. Whereas adults generally have collapse in the setting of obesity and increases in neck and parapharyngeal fat, childhood collapse is more related to adenotonsillar hypertrophy and the overlap of the tonsils, adenoids, and soft palate, which is consistent with lymphoid reactivity and growth pattern differences by age. Obesity, while certainly a risk factor in children, is not as strongly associated with SDB in children as it is in adults. An additional difference is that respiratory allergies and conditions like asthma seem to play a larger role in children than in adults. Finally, the sex differences in SDB also vary, with a strong male predominance in adults but parity in prepubertal children.

The differential diagnosis for enlarged tonsils is broad and includes etiologies such as tonsillar hypertrophy, recurrent tonsilitis, and acute infectious tonsilitis of viral or bacterial origin and its sequelae, though most suppurative complications are unilateral. Malignancies such as squamous cell carcinoma and lymphomas are rare in children but should be on the differential for adults, though a bilateral presentation is less common. In children, the vast majority with bilateral tonsillar enlargement have idiopathic tonsillar hypertrophy.

The Pathophysiology and Cellular Features of Hypertrophic Tonsils

The pathophysiology of adenotonsillar hypertrophy is multifactorial and remains to be entirely elucidated. Some have pointed to immune reactions to environmental
pollution and allergens. In one study that compared 117 children with adenotonsillar hypertrophy to 100 children without, those with hypertrophic tonsils were significantly more likely to have a positive skin-prick test and elevated IgE than the control group. However, a different study found that while tonsil volume was associated with adenoid hypertrophy and an overall hyperstimulated inflammatory response, there was a negative correlation with allergic rhinitis.

At the cellular level, hypertrophic tonsils show a number of important differences from enlarged tonsils secondary to recurrent tonsilitis. Namely, there are increased levels of basophils and apoptosis inhibition, as well as lower levels of T-lymphocytes and the relative absence of Streptococcus pyogenes antibody titers.

Additional studies have shown that hypertrophic tonsils display more innate immune and inflammatory markers, including toll-like receptors (TLRs), tumor necrosis factor alpha (TNF-α), and interferon α, compared to normal tonsils. Histologically, hypertrophic tonsils display lymphoid hyperplasia with an increase in the number of lymphoid follicles and the size of germinal centers.

The Clinical and Laboratory Evaluation of Pediatric Sleep-disordered Breathing SDB in children can present in a number of ways. Parents may report snoring or episodes of apnea that can appear as pauses, choking, labored breathing, or retractions, though many children experience hypopnea instead of complete obstruction. Other nighttime symptoms include restless sleep, mouth breathing, or noisy breathing. During the day, patients with SDB may experience daytime sleepiness, behavioral problems, and problems with inattention or learning. A morning headache or secondary nocturnal enuresis may also point to SDB.
While a full patient history and physical exam is a necessary component of the evaluation for SDB, these methods alone are insufficient. As addressed in the clinical practice guidelines of the American Academy of Pediatrics, the sum of the literature indicates that history alone is no better than chance at determining SDB, with positive and negative predictive values of 65% and 46%, respectively. The addition of a clinical examination also fares poorly, though some features have a high enough specificity to be useful clinically. In one study of 480 6 to 11-year-old children, snoring, daytime sleepiness, and learning problems were all highly specific – though not sensitive – such that in combination they had a specificity of over 95%. A number of adjunct diagnostic measures have been attempted, including radiography, nasal resistance via rhinometry, multiple cardiovascular patterns, nocturnal oximetry, and at-home (“ambulatory”) polysomnography to various degrees of success, though none is sufficiently sensitive or specific to be recommended.

The gold standard for the diagnosis of SDB is nocturnal (overnight) polysomnography, hereafter referred to as “PSG.” For children with suspected SDB based on clinical presentation, an objective assessment by PSG is recommended by the American Academy of Pediatrics. The American Academy of Otolaryngology–Head and Neck Surgery formally recommends PSG only for patients with “obesity, Down syndrome, craniofacial abnormalities, neuromuscular disorders, sickle cell disease, or mucopolysaccharidoses,” though they also recommend advocating for PSG in patients younger than 3 or for whom the benefit of surgery is unclear due to physical exam findings that are inconsistent with the reported severity of SDB symptoms.
PSG involves a number of diagnostic tools and physiologic parameters that are scored according to the *American Academy of Sleep Medicine (AASM) Manual for the Scoring of Sleep and Associated Events*. Some of these diagnostic tools include electroencephalogram (EEG), electrocardiogram (ECG), electromyogram (EMG), electrooculogram, arterial oxygen saturation (SpO2), video, various airflow sensors (e.g., end-tidal PCO2, nasal pressure, thermistor), among others. Apneas and hypopneas are characterized for events lasting at least 2 breaths length with associated respiratory, arousal, and SpO2 changes, even if less than 10 seconds, which is the criteria for adults. The Apnea-hypopnea Index (AHI), which counts the number of events per hour, helps determine both the presence and severity of OSA. The cutoff in pediatric patients is an AHI of 1 with 3 levels of severity: mild (AHI between 1–4.9), moderate (AHI between 5–9.9), and severe (AHI >10).

Although considered the gold standard method, PSG is costly, time-consuming, inconvenient, and unavailable in some practice settings. Even the American Academy of Pediatrics guidelines on OSA admit that PSG may not be practical for all patients with suspected OSA given that the current infrastructure for doing so is insufficient. The COVID-19 pandemic created challenges for sleep laboratories that further hindered the availability of sleep studies for many patients. Much of what occurs in a sleep laboratory has the potential to spread infection, including the aerosolizing nature of continuous positive airway pressure (CPAP), and data from the European Sleep Apnoea Database revealed an 80% decrease in OSA management in the wake of the pandemic.
Furthermore, many children undergo tonsillectomy despite a negative PSG. This may stem from a variety of reasons, including the fact that symptoms of SDB are often readily apparent even though they may not be captured by a single night of PSG (dubbed the “reverse first night effect”) or because there is anatomy (i.e., enlarged tonsils) that is favorable for intervention. Although the first night effect is a possibility, it should be noted that a number of studies have found that there is minimal change in respiratory patterns between several nights of PSG in children and adolescents, and thus a single night of testing should be sufficient.

PSG is not routinely recommended following tonsillectomy. However, for patients with severe OSA prior to surgery, it is recommended to assess the need for further treatment. For patients with persistent OSA, the American Academy of Otolaryngology–Head and Neck Surgery also recommends PSG following surgery, as well as drug-induced sleep endoscopy (DISE) and other diagnostic and therapeutic options depending on the degree of symptoms.

Cost-effectiveness of PSG
The cost of a PSG for patients is highly variable depending on the institution but can be quite high. Because the number of tonsillectomies performed after a negative PSG was as high as 40% in one study of 1 to 3 year-olds, which the authors surmised may be due to the low-risk nature of the procedure and the desire of parents and surgeons to alleviate the patients’ symptoms, routine pre-operative PSG may not be cost-effective. In that study, the cost of a tonsillectomy with adenoidectomy was ~17x the cost of a PSG. Given that 40% of patients with negative PSG results still underwent the procedure, 30 negative PSGs would have to be completed in order to account for
the cost of a single operation. Consequently, the authors\textsuperscript{34} proposed stratifying patients into low- and high-risk categories, with only those in the low-risk category being referred for PSG, as a negative result might actually prevent an unnecessary surgery. A different study found that the mean cost of a PSG was $793.57, whereas the surgery cost was around $1000 if performed in an ambulatory center and over $5000 if performed at the hospital.\textsuperscript{35} Thus, PSG may represent a significant portion of the overall cost in some circumstance. In this same cohort, patients who underwent PSG prior to surgery had an average cost of over $400 more than the additional cost of the sleep study alone, likely due to increases in the number of admitted children after surgery.

\textbf{Clinical Questionnaires Used in the Evaluation of Pediatric Sleep-disordered Breathing}

As discussed above, patient history and physical exam findings alone perform poorly in correctly identifying patients with SDB. Some clinicians have attempted to develop standardized questionnaires to address this shortcoming. One such tool is the Pediatric Sleep Questionnaire (PSQ).\textsuperscript{36} Developed with a cohort of 54 patients aged 2–18 with a positive PSG (defined in the study as an AHI > 5), the PSQ is a 22-item questionnaire with question subgroups related to snoring, sleepiness, and behavior. The original validation study found that the PSQ had a sensitivity of 0.85 and a specificity of 0.878. A later study found that the PSQ might be most useful in determining which patients would likely not have a positive PSG—as evidenced by a lack of daytime mouth breathing and habitual snoring—and therefore might be spared testing. An additional questionnaire used to diagnose SDB is the Brouillette score.\textsuperscript{37} Published in 1984, the Brouillette score consists of only three questions: difficulty in breathing during sleep,
stops in breathing during sleep, and snoring. A weighted score of > 3.5 was diagnostic of OSA that would benefit from a tonsillectomy and adenoidectomy.

Additional questionnaires have also been used to determine the quality of life (QOL) impacts of SDB symptoms on patients’ lives. These are not primarily for diagnosing the condition but rather can assist clinicians in determining the current disease burden and improvement following surgery. For example, the OSA-18 is a SDB-specific QOL survey that includes 18 items across 5 domains: sleep disturbances, physical suffering, emotional distress, daytime problems, and caregiver concerns. Each item is scored from 1 to 7 depending on the frequency of the problem over the past 4 weeks, yielding a total score of 126. Using this number, one can assess the disease-specific severity as having a small (<60), moderate (60–80), or large (>80) impact. A summary score (mean) can then be calculated for the entire questionnaire and for each of the 5 domains, which gives the baseline score. The questionnaire is repeated no sooner than 4 weeks after the initial completion to determine the change in QOL. A change score ranging from -7.0 to 7.0 is calculated, where positive numbers indicate an improvement in symptoms, and negative numbers suggest a worsening of QOL. The change scores can also be stratified in small, moderate, and large changes, with changes in the OSA-18 of 0.5, 1.0, and 1.5, respectively.

Another QOL survey used is the Pediatric Quality of Life Inventory Version 4.0 (PedsQL 4.0). This 23-item questionnaire covers domains related to physical health, psychosocial health, emotional functioning, social functioning, and school functioning. Although not specific for patients with SDB, some studies have used this questionnaire
in their assessment of patients, as all domains have the potential to be affected by SDB. In one cohort of 86 tonsillectomy and adenoidectomy patients where each participant completed the PSQ, OSA-18, and PedsQL 4.0 prior to and after surgery, the OSA-18 was the most predictive of improvement following surgery, followed by the PSQ and PedsQL 4.0.\textsuperscript{41}

**The Clinical Assessment Score-15**
The Clinical Assessment Score-15 (CAS-15) (Table 1) was developed as an office-based tool for assessing the risk of pediatric sleep-disordered breathing.\textsuperscript{40} The Clinical Assessment Score originally consisted of 30 items but was reduced to 15 in order to provide the greatest predictive utility and reliability. The 15 items in the questionnaire cover 4 domains: nighttime symptoms, daytime symptoms, symptoms related to the hypertrophy of Waldeyer’s ring, and physical exam findings. Scores range from 0 to 77, where a cutoff score ≥ 32 indicates an AHI >2 on PSG with a sensitivity of 77.3% and specificity of 60.7%.\textsuperscript{40} A score of ≥ 32 was chosen as it yielded the highest sensitivity while maintaining a minimum specificity of 60%, with an area under the receiver operating characteristic (ROC) curve value of 0.77. Although an AHI of 1 is diagnostic of OSA in pediatric patients, the authors\textsuperscript{40,42} used an AHI of 2 when creating a cutoff score because it has been used as the cutoff for determining which patients qualify for surgery.\textsuperscript{43} While not a perfect substitute, the CAS-15 has nonetheless shown good reliability, internal consistency,\textsuperscript{40} and generalizability.\textsuperscript{42}

The cohort in which the CAS-15 was validated\textsuperscript{40} included 100 children between the ages of 2–12 that had experienced symptoms of SDB for at least 3 months, of whom 94 completed a PSG and 60 underwent surgery. The exclusion criteria including a broad
range of conditions that might influence SDB: Down syndrome; craniofacial abnormalities; sickle cell disease; psychiatric and neurocognitive disorders; prior tonsil, adenoid, palate, or pharyngeal surgery; and mucopolysaccharide storage disorder.

English language literacy was also required, as the CAS-15 was only available in English. In 2020, a second study to assess the generalizability of the CAS-15 was published.\textsuperscript{42} Using the same inclusion and exclusion criteria, the authors enrolled 530 participants across 13 sites (including 1 in Saudi Arabia). The more expansive enrollment lead to the inclusion of more females, fewer children with overweight or obesity, and a higher racial diversity.

In the original validation study,\textsuperscript{40} using an AHI > 5 instead of AHI > 2 as the cutoff for patients did not improve the correlation between a change in CAS-15 score and a change in mean OSA-18 score, mean PedsQL 4.0 score, Child Behavior Checklist (CBCL) score, or PSG AHI. Using this higher cutoff also did not affect the area under the curve values for the ROC analysis. The mean change in CAS-15 after surgical intervention (in this study, adenoidectomy and total tonsillectomy) was 32.7 for patients with a pre-operative PSG diagnostic for OSA.\textsuperscript{40} The change in CAS-15 score correlated moderately-to-strongly with various quality-of-life and PSG measures after surgery. The correlation was strongest with a change in OSA-18 score ($r = 0.65$), followed by the initial parameter values for PSG AHI ($r = 0.50$), CBCL score ($r = 0.34$) and PedsQL 4.0 score ($r = -0.32$). A change in CAS-15 did not correlate with a change in PSG AHI, CBCL score, and PedsQL 4.0 score. In a later study designed to establish the generalizability of the CAS-15,\textsuperscript{42} the
change in CAS-15 (-30.5) and area under the ROC curve (0.7115) were both similar, and correlation with the baseline PSG AHI was weaker but still significant ($r = 0.41$).

**The History of the Tonsillectomy**

For children with SDB caused by adenotonsillar hypertrophy, tonsillectomy with or without adenoidectomy is the first-line surgical approach\(^2,44\) and has been shown to improve clinical symptoms.\(^43\) Tonsillectomies are one of the most common procedures performed by otolaryngologists and rank among the most frequently performed of all surgeries across the country, with over 250,000 being done annually in children younger than 15 years of age.\(^44\) The procedure has been practiced for centuries with techniques ranging from the removal of inflamed tonsillar tissue via blunt dissection in the first century A.D. to scalpel excision and later the development of snares, guillotines, precursors of the tonsillotome, and now electrocautery, which is the most widely used method.\(^45\)

Despite its long history, the tonsillectomy was relatively uncommon until the early twentieth century. Around this time, the focal theory of infection—which held that the mouth, nose, and throat were entry points for infections that could spread to the rest of the body—became popular among the scientific community.\(^46\) Reports in the scientific literature espousing the benefits of the tonsillectomy in light of this theory subsequently become more frequent. As described by the medical historian Gerald Grob, the tonsils and adenoids were seen as “portals of entry for infections” that could be easily accessed and removed with what was believed to be little risk or negative consequence.\(^47\) The tonsillectomy and adenoidectomy ultimately became the most common procedure in the United States between 1915 and the 1960s, persisting in
popularity long after focal theory of infection lost favor. Of note, Dr. R. Garn Mabey, Sr., a former general surgeon and my grandfather, told me on a number of occasions that his father routinely removed patients’ tonsils in the 1930s as a family medicine doctor in rural Idaho. The number of the tonsillectomies declined in the 1970s and 1980s before later increasing in the early twenty-first century, where it now holds prominence largely due to its benefits for improving airway obstruction and sleep-disordered breathing.

**Different Tonsillectomy methods**

The palatine tonsils are lymphoid tissue that make up part of Waldeyer’s ring along with the adenoids, lingual tonsils, and tubal tonsils. Enveloped by a fibrous capsule, the palatine tonsils are located between the anterior and posterior tonsillar pillars, which are the palatoglossus and palatopharyngeus muscles, respectively. The tonsils are also surrounded by the superior constrictor muscle laterally and the glossopharyngeal nerve (cranial nerve IX) inferiorly in the tonsillar bed.

Traditionally, tonsillectomy has referred to the complete removal of the palatine tonsil and capsule. The American Academy of Otolaryngology–Head and Neck Surgery describes it as “a surgical procedure performed with or without adenoidectomy that completely removes the tonsil, including its capsule, by dissecting the peritonsillar space between the tonsil capsule and the muscular wall.” This technique is now known as a total tonsillectomy (TT). A newer evolving technique consists of removing tonsillar tissue while leaving the tonsil capsule intact, known as the partial intracapsular tonsillectomy (PIT). With this method, tonsillar tissue is debulked, but a small amount of tonsil tissue and the tonsillar capsule are left as a barrier to exposure of the pharyngeal muscles. The
most common methods used to debulk the tonsils in a PIT are via coblation devices and microdebriders, though others use suction electrocautery or carbon dioxide lasers.

**Perioperative Differences Between Partial and Total Tonsillectomies**

The discussion of partial tonsillectomies was notably absent from the updated clinical practice guidelines for tonsillectomy in 2019 given the lack of long-term data. Acknowledging the paucity of long-term follow-up, PIT demonstrates similar outcomes to TT for the treatment of OSA with a number of reported benefits in the perioperative period. Post-operative hemorrhage is perhaps the most significant cause of perioperative morbidity following tonsillectomy, and multiple reviews of the literature have pointed to improvements in bleeding rates for PIT. This may be because the larger caliber blood vessels and pharyngeal muscles near the capsule are preferentially spared in a PIT. Specifically, one meta-analysis of randomized control trials found a 40% decrease in primary hemorrhage and a 79% decrease in secondary hemorrhage for PIT compared to TT. Another meta-analysis of 699 patients undergoing PIT and 635 undergoing TT found no difference in primary hemorrhage but a significant decrease in secondary hemorrhage (0.7% PIT vs 2.0% TT, p=0.04).

In addition to lower postoperative bleeding rates, the majority of studies show fewer days of analgesic use and a decreased time to normal diet and activities for patients receiving PIT compared to TT. In one meta-analysis of over 30 studies that included 19 randomized control trials, patients undergoing PIT had on average 2.7 fewer days of analgesia, lower pain at days 3-5 and beyond 7 days, a return to normal diet that was 3 days earlier, and a 62% decrease in the odds of readmission. A recent study that compared PIT to TT in patients with trisomy 21 also found similar trends for analgesic
use, pain, hospital admission duration, return to oral intake, and overall perioperative complications. Notably, they also found no difference in rates of OSA reoccurrence or tonsil regrowth at a mean follow-up of around 2 years.

However, some studies show no differences in each of above mentioned perioperative domains. The heterogeneity in outcomes may be due to the variation in the surgical methods (i.e., the instrumentation used, amount of tonsil that is left, etc.) or in the reporting measures used. For example, one review that reported outcomes by surgical type found that the length of time before returning to normal diet and activity was lower with PIT than TT when coblation or cold dissection was used but not when electrocautery was used. Less pain was also seen with the use of radiofrequency and laser techniques for PIT, which are less commonly used than coblation devices or microdebriders.

Some outcomes – including quality of life measures and behavioral outcomes – are similar between groups regardless of the technique used. Disease-specific QOL, for example, has been evaluated in 4 studies consisting of 540 pediatric patients, but the comparison was limited due to the heterogeneity of the QOL measures used. Rates of recurrent tonsil infection after surgery may also be similar between the two procedures. Although the data are limited, 2 studies suggest that rates of throat infections in the years following PIT may not be different than in patients who underwent TT. In one cohort of 174 PIT patients and 219 TT patients, 8.1% and 5.4%, respectively, had recurrent tonsillitis in the year following surgery, which was not statistically different.
In a different study that surveyed 48 TT and 43 PIT patients at 6 years after surgery, there was no difference in the incidence of tonsillitis or other ENT surgeries.\textsuperscript{61}

Other outcome areas, namely mortality after tonsillectomy, have an unknown difference between partial and total tonsillectomies. A recent retrospective study of over 500,000 children undergoing tonsillectomy found an unadjusted mortality rate of roughly 7 deaths per 100,000 procedures,\textsuperscript{62} but this did not differentiate between procedure types.\textsuperscript{63} Of note, the risk of mortality was not increased with the presence of SDB but rather with chronic conditions including neuromuscular, congenital and genetic disorders.

The most pronounced area in which PIT performs worse than TT is tonsil regrowth following the procedure, as some of the tonsil and the capsule remain. The incidence of regrowth varies widely between studies. Published rates of range from 0 to 10\% at one year post-operatively, though a meta-analysis of the data shows a roughly 4\% average rate.\textsuperscript{54} The risk appears to be highest in the youngest patients, particularly among those younger than two\textsuperscript{64} or five\textsuperscript{65} years old. In a retrospective review of 3141 patients who underwent PIT, reoperation for the recurrence of enlarged tonsils was seen in 12.2\% of patients under 2 but only 0.5\% in those over 5 years old.\textsuperscript{64} The presence of acute tonsillitis or upper respiratory allergies also appears to be related to regrowth.\textsuperscript{64,65} This is consistent with an increase in severe lymphocyte and neutrophil infiltration seen on histology of regrown tonsils.\textsuperscript{64} A Cochrane Library systemic review of data for PIT versus TT found no difference in the recurrence of SDB due to tonsil
regrowth in the short (0-6 months), medium (7-12 months), and long term (3-24 months), though they rated the quality of evidence as “very low.”

The Cost-effectiveness of PIT Compared to TT
Based on the available literature, PIT appears to be less costly and require fewer resources than TT. In one retrospective review of 289 PIT patients and 289 TT patients, those in the PIT group had shorter operative times, spent less time in the postanesthesia care unit, required inpatient or intensive care unit admission less frequently, had fewer readmissions, and visited the emergency department fewer times after surgery, all while having similar rates of postoperative bleeding and reoperation for tonsil regrowth.

Assuming a similar effectiveness for treating SDB, PIT would be more cost-effective. When looking at a number of studies on the topic jointly, the evidence suggests that caregivers may be able to return to work sooner following PIT relative to TT, which would further reduce the indirect costs of the procedure. However, when using a purely economic model based on Medicare cost values and a limited number of postoperative interventions, including the management of hemorrhage and reoperation, TT is more cost-effective unless PIT has an OSA reoccurrence rate of less than 3%.

Statement of Purpose
To date, it is unclear how the CAS-15 changes following partial intracapsular tonsillectomy (PIT) compared to total tonsillectomy (TT), as previous studies have only reported change after TT. Thus, the primary aim of the present study is to evaluate the utility of the CAS-15 score in assessing the effectiveness of PIT and how this compares to
change after TT. The secondary aim is to assess how the change in CAS-15 varies between those who do or do not have obesity.

Methods
Student Contributions
The study team included Jacob Mabey (author); Candice Kremer, MD (otolaryngology resident); Emily Savoca, MD (otolaryngology resident); Sarah Maurrasse, MD (otolaryngology faculty); and Michael Weinstock, MD (otolaryngology faculty and principal investigator). This author conducted the data collection (chart review), maintained the study database, completed the statistical analyses and led the manuscript writing. Drs. Kremer and Savoca assisted with survey collection (CAS-15), research design and manuscript development. Dr. Maurrasse helped with participant enrollment, survey collection, and research design. Dr. Weinstock, who led and developed the study, participated in all aspects of the study.

Ethical Statement
All aspects of this study, including the involvement of human subjects, were conducted according to international standards. This study was approved by the Institutional Review Board at Yale University (IRB ID 2000029104).

Human Subjects Research
All participants in this study are part of a vulnerable population because they are children. The CAS-15 is a tool specifically designed for children, necessitating this study population. Given that children cannot consent for themselves, we obtained parental permission for enrollment in the study. The parent who was informed about the study and consented their child to participate was also the parent consenting for surgery. As
with surgery, the decision regarding study participation was respected. As mentioned above, the use of children as subjects was approved by the Yale Institutional Review Board.

Methods Description
Participant Recruitment
Study participants were recruited from patients scheduled for PIT or TT with or without adenoidectomy at Yale Medicine between November 2020 and December 2021. All participants were age 2–18 at the time of surgery with a diagnosis of sleep disordered breathing. Exclusion criteria included concurrent surgery on the neck or upper aerodigestive tract other than tonsillectomy or adenoidectomy; history of Down syndrome, other genetic disorder or craniofacial syndrome; history of cleft palate with or without repair; neuromuscular disease or neurologic disorder; previous tonsil or adenoid surgery; or immunodeficiency. The study was approved by the Institutional Review Board at the Yale University, and informed consent was obtained from the legal guardian of all participants.

Measures
The CAS-15 is a 15-question office tool used to assess the risk of SDB in children (Table 1). The assessment includes parent/guardian report of 7 nighttime symptoms (e.g., snoring, pauses), daytime hyperactivity, and 2 clinical features related to adenotonsillar hypertrophy, as well as 5 items identified by the surgeon during physical examination (e.g., tonsil size, hyponasal voice). The patients’ parent or guardian completed the CAS-15 prior to surgery and again at the post-surgical follow-up appointment. The operative surgeon also completed the assessment at both time
points. Patients enrolled in the study that did not return to complete the post-operative CAS-15 were not included in the final analysis (N=3).

Table 1

Clinical Assessment Score for Pediatric Sleep-Disordered Breathing\textsuperscript{40}

<table>
<thead>
<tr>
<th>Clinical Feature</th>
<th>Frequency or Severity of Symptom or Physical Finding Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nighttime symptoms</strong></td>
<td>4 to 6 nights per</td>
</tr>
<tr>
<td>Snoring</td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Pauses</td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Duration of pauses</td>
<td>≥15 seconds</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Retractions</td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Gasping</td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>4 to 6 nights per week</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td><strong>Choking</strong></td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Sleeps with neck extended</strong></td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td><strong>Daytime symptom</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Hyperactivity</strong></td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Hypertrophy of Waldeyer’s ring</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mouth breathing</strong></td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>6</td>
</tr>
<tr>
<td><strong>Chronic rhinorrhea</strong></td>
<td>Every night</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Physical examination</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mouth breathing</strong></td>
<td>Present</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Hyponasal voice</td>
<td>Present</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adenoid facies</th>
<th>Severe</th>
<th>Mild</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height of hard palate</th>
<th>High placed</th>
<th>Moderate elevation</th>
<th>Low placed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tonsil size*</th>
<th>4+</th>
<th>3+</th>
<th>2+</th>
<th>0-1+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

*Item scored for the larger of the tonsils

Participant age, sex, BMI, comorbidities, history of prior ENT surgery, results of prior PSG (if performed), peri- and post-operative complications, and dates of surgery and CAS-15 completion were obtained by chart review using Epic (Verona, Wisconsin, USA). Obesity was defined as being greater than or equal to the 95th percentile for BMI based on age and sex.

**Surgical procedure and pre-operative planning**

All procedures were completed by one of two pediatric otolaryngologists at a tertiary academic children’s hospital. All patients were undergoing tonsillectomy and adenoidectomy for SDB or OSA. The decision to undergo IT or TT was jointly made by the surgeon, family members, and when applicable patients. Surgeon 1 completed 62.5% of TT and 68.8% of PIT.
The procedure for TT was standardized between both providers, utilizing electrocautery. The procedure for IT differed between providers only in utilization of microdebrider by one and coblator (ArthoCare Company, Sunnyvale, CA, USA) by the other. Tonsils were shaved down at least past the anterior and posterior tonsillar pillars in both cases.

**Statistical Methods**

The primary outcome was the change in CAS-15 following surgery, which was determined using a two-tailed paired t-test. The secondary outcome was the difference in CAS-15 change scores between PIT and TT, which was determined using a two-tailed unpaired t-test for unequal variances. Differences in participant characteristics between the two intervention groups were also evaluated with a two-tailed unpaired t-test for unequal variances. Although only 3 patients were lost to follow-up, an additional comparison of pre-operative data between completers and non-completers was performed using a two-tailed unpaired t-test for unequal variances.

**Results**

**Participant Characteristics**

Participant characteristics can be found in Table 2. Participants were 6.7±3.9 (mean±standard deviation) years of age at the time of surgery, with a range of 2.6–12.7 years in the PIT group and 2.1–16.3 years in the TT group. Fifty-four percent were female, 45.9% were Hispanic, and 11 had obesity. The median follow-up time after surgery was 5.2 weeks (PIT group) and 4.4 weeks (TT group). 16 of the patients received PIT, 8 received TT, and all but 1 patient also underwent an adenoidectomy at the time of surgery. One patient in the PIT group underwent a bilateral myringotomy with
tympanostomy tube placement, and one participant in the TT group also received a direct laryngoscopy and bronchoscopy. Participants did not differ by group with regard to age, sex, follow-up time after surgery, BMI percentile, pre-operative tonsil size or pre-operative CAS-15 score, or admission rates after surgery for observation (p>0.05). The most common comorbidity among patients was asthma (N=3), followed by atopic dermatitis, allergic rhinitis, and dysphagia (all N=2). Epistaxis was the most common complication after surgery (N=4). Other complications included emesis (N=2), with one patient requiring treatment in the emergency department, tongue swelling (N=1), and halitosis (N=1).

**Table 2**

**Participant characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All participant (N=24)</th>
<th>Partial Intracapsular Tonsillectomy (N=16)</th>
<th>Total Extracapsular Tonsillectomy (N=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>6.7±3.9</td>
<td>6.7±2.8</td>
<td>6.6±5.7</td>
</tr>
<tr>
<td>Sex, no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>11 (45.8)</td>
<td>7 (43.8)</td>
<td>4 (50.0)</td>
</tr>
<tr>
<td>Female</td>
<td>13 (54.2)</td>
<td>9 (56.3)</td>
<td>4 (50.0)</td>
</tr>
<tr>
<td>Race, no. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>5 (20.8)</td>
<td>3 (18.8)</td>
<td>2 (25.0)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>11 (45.9)</td>
<td>3 (18.8)</td>
<td>3 (37.5)</td>
</tr>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td>Group 3</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>White</td>
<td>6 (25.0)</td>
<td>8 (50.0)</td>
<td>3 (37.5)</td>
</tr>
<tr>
<td>Other/mixed</td>
<td>2 (8.3 )</td>
<td>2 (2.5 )</td>
<td>0 (0)</td>
</tr>
<tr>
<td>BMI, kg/m2</td>
<td>20.7±5.4</td>
<td>20.2±5.2</td>
<td>21.8±6.0</td>
</tr>
<tr>
<td>BMI percentile</td>
<td>72.8±34.2</td>
<td>70.6±37.8</td>
<td>77.1±27.2</td>
</tr>
<tr>
<td>Patients with obesity, no. (%)</td>
<td>10 (41.7)</td>
<td>7 (43.8)</td>
<td>3 (37.5)</td>
</tr>
<tr>
<td>Median follow-up, weeks</td>
<td>4.9</td>
<td>5.2</td>
<td>4.4</td>
</tr>
<tr>
<td>Pre-Op CAS-15</td>
<td>43.7±12.4</td>
<td>42.8±12.3</td>
<td>45.5±13.3</td>
</tr>
<tr>
<td>Tonsil Size</td>
<td>3.1±0.6</td>
<td>3.1±0.5</td>
<td>3.1±0.8</td>
</tr>
<tr>
<td>Admission after surgery, no. (%)</td>
<td>8 (33.3)</td>
<td>5 (31.3)</td>
<td>3 (37.5)</td>
</tr>
</tbody>
</table>

All values are presented as mean±SD except where indicated

Participants that were lost to follow-up (N=3) did not differ from those who completed the study with respect to age, sex, or BMI percentile (p>0.05). They did, however, have lower pre-operative CAS-15 scores (31.6 vs. 43.7, p<0.001).

**CAS-15 Scores following Partial Intracapsular or Total Tonsillectomy**

Surgery led to significant improvement in the CAS-15 score for both the PIT (42.8±12.3 vs. 9.4±5.6, p<1e-7) and TT (45.5±13.3 vs. 7.9±5.8, p<0.0002) groups (Table 3). The mean decrease in CAS-15 for PIT did not differ from TT (33.3±11.8 vs. 37.6±15.0, p>0.49).

In a subgroup analysis based on BMI, the 11 participants with obesity had a 32.5±11.5 decrease in CAS-15 score following surgery, which was not different than those who did not have obesity (36.6±14.0, p=0.44; Table 3). This trend held true for both the PIT and TT groups.
### Table 3

**Change in CAS-15 scores from before to after surgery**

<table>
<thead>
<tr>
<th></th>
<th>Partial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
</tr>
<tr>
<td>participant (N=24)</td>
<td>(N=16)</td>
</tr>
<tr>
<td>Before surgery</td>
<td>43.7±12.4</td>
</tr>
<tr>
<td>After surgery</td>
<td>8.9±5.6</td>
</tr>
<tr>
<td>Change in score</td>
<td>34.8±12.8</td>
</tr>
<tr>
<td>Significance</td>
<td>p&lt;1e-11</td>
</tr>
</tbody>
</table>

All values are presented as mean±SD.

Only 4 patients, 3 from the PIT group and 1 from the TT group, had a pre-operative PSG (Table 4). All four patients met the criteria for OSA based on an AHI ≥ 1 (13.1±9.8) and a pre-operative CAS-15 score ≥32 (42.5±9.0).

### Table 4

**Nocturnal Polysomnography Results for Select Patients**

<table>
<thead>
<tr>
<th>Surgery Group</th>
<th>PIT</th>
<th>PIT</th>
<th>PIT</th>
<th>TT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>7</td>
<td>7</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>Pre-Op CAS-15</td>
<td>Post-Op CAS-15</td>
<td>Change in CAS-15</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>---------------</td>
<td>----------------</td>
<td>------------------</td>
<td></td>
</tr>
<tr>
<td>BMI Percentile</td>
<td>99</td>
<td>99</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>AHI</td>
<td>14.5</td>
<td>26.2</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>SpO2 Nadir</td>
<td>80</td>
<td>70</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>Pre-Op CAS-15</td>
<td>32</td>
<td>42</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Post-Op CAS-15</td>
<td>3</td>
<td>16</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

PIT, Partial Intracapsular Tonsillectomy; TT, Total Tonsillectomy; CAS-15, Clinical Assessment Score-15; AHI, Apnea-hypopnea Index; SpO2, oxygen saturation

**Discussion**

The present study evaluated changes in CAS-15, an office-based questionnaire to assess SBD, following PIT and TT. Individuals in both groups experienced a large decrease in CAS-15 after surgery, indicating a substantial improvement in their symptoms. These results are consistent with and provide additional support for numerous reports that have shown PIT and TT to be effective treatments for SDB as determined by PSG.

Most notably, we found that the decrease in CAS-15 between PIT and TT was not statistically significant. This suggests that both operations provide similar improvements to SDB. Recent reviews have indicated that both procedures are equally effective, though PIT may have additional perioperative benefits. Patients experience lower postoperative bleeding rates, which is a common complication and significant source of morbidity after surgery, and other postoperative complications following PIT compared to TT. PIT also shows less pain after surgery, two to three fewer days of
analgesic use\textsuperscript{55,56} and a decreased time to normal diet\textsuperscript{54,55,58} and activities\textsuperscript{54,55,58,59} by one to four days. Although more data is needed, the reduced morbidity of PIT compared to TT might also make the procedure more cost-effective\textsuperscript{66}, with cost savings ranging from less post-operative health care utilization to fewer lost days of work for caregivers.\textsuperscript{54} However, other analyses suggest that PIT is only more cost-effective when OSA reoccurrence after surgery is less than 3\%.\textsuperscript{72} While tonsillar regrowth is a potential drawback to PIT, reports suggest the occurrence is low,\textsuperscript{56,58} though longer term data is needed to assess the true extent of the problem.\textsuperscript{54} In one retrospective cohort study of 315 children who received PIT or TT, Tipirneni and colleagues\textsuperscript{73} found that only 5\% of children experienced regrowth following PIT, and this was limited to children less than 4 years of age.

The mean decrease in CAS-15 following PIT and TT was similar to the change reported by Goldstein and colleagues.\textsuperscript{40,42} While the CAS-15 has been validated and found to be generalizable, the authors only measured the change in CAS-15 for patients undergoing TT. Thus, our results indicate that the CAS-15 may also be a useful resource for assessing improvements in SDB following PIT. While PSG is considered to be the gold standard for evaluating improvements after PIT, its challenges are well documented. Unlike overnight PSG, the CAS-15 is convenient, inexpensive, easily accessible, and potentially more representative of the patient’s symptoms. It has also been shown to be more cost-effective than PSG despite having less predictive accuracy.\textsuperscript{35} Given the drawbacks and resource-demanding nature of PSG, as well as the poor diagnostic accuracy of unstructured clinical assessments,\textsuperscript{74} the CAS-15 may be the preferred
method to assess improvements in SDB following surgery with PSG reserved for those whose post-operative CAS-15 suggests minimal change.

**Additional Areas of Research**

Based on our findings, the CAS-15 appears to be an effective method of detecting an improvement in SDB symptoms following PIT and is not significantly different than for TT. Given that the original validation of the CAS-15 by Goldstein and colleagues\(^{40}\) used pre-operative PSG for their cohort, a reasonable next step would be to confirm our findings in a patient population where all participants receive a PSG prior to either PIT or TT. A post-operative PSG would also have been ideal for study purposes, so future studies looking at the CAS-15 in PIT might consider doing both a pre- and post-operative PSG, preferably more than 6 months following surgery. However, it is worth mentioning that the original CAS-15 validation paper\(^{40}\) found no correlation \((r = 0.07, p = 0.728)\) between a change in CAS-15 after surgery and a change in PSG parameters and thus would likely have been unrevealing in the present study.

Given the push towards cost-effectiveness and value-based care, future areas of research should more closely examine the respective costs and value for a number of potential diagnostic and treatment combinations. Cost-effectiveness has already been assessed in smaller cohorts from a small number of institutions with regard to PIT compared to TT,\(^{54,66}\) as well as in smaller groups comparing CAS-15 to PSG.\(^{34}\) Unfortunately, single-institution cost analyses may lack generalizability, though obtaining costs among a broad group of institutions would likely prove challenging due to an overall lack of price transparency in the medical industry. More robust cost analyses include examining the costs of PIT with either PSG or the CAS-15 and the costs
of TT with either PSG or the CAS-15, including both direct costs and indirect costs related to surgical complications and PSG. It would also be useful to obtain cost-effectiveness data that compares the cost of medications with close follow-up to either PIT or TT.

**Conclusion**

In summary, our results add to the current body of literature that supports PIT as an effective treatment for SDB in children with adenotonsillar hypertrophy. Additionally, given the similarity in outcome between TT and PIT and the body of literature supporting reduced morbidity after PIT, the latter procedure may be preferrable. Because CAS-15 successfully detects improvements in SDB after PIT in addition to TT, physicians may consider using this office-based tool in lieu of PSG for the post-operative assessment of routine cases given the cost, inconvenience, and often limited availability of PSG.

**Challenges and Limitations**

Notable limitations of the present study are the small sample size and lack of randomization. Further, the lack of long-term follow-up limited our ability to detect differences in the improvements to sleep disordered breathing beyond the initial post-operative period. For example, in a clinical trial of over 450 patients where half were randomized to undergo tonsillectomy for SDB, 79% had a normalization of PSG findings at 7 months, whereas the CAS-15 data in our study indicate that 100% of patients would have had a normalization of PSG based on a score of <32. This suggests that the response we observed in the immediate postoperative period (<6 weeks on average in
our study) may not have been durable for all patients. However, our results were consistent with those found by Goldstein and colleagues, who had a mean follow-up of around 8 months. Our study's size and short follow-up also limit our ability to detect tonsil regrowth. As discussed in the introduction, rates of tonsil regrowth are roughly 4% or less. With our sample sizes of 16 and 8 for PIT and TT, respectively, any regrowth in either group would have resulted in a higher percentage than expected and would likely have been falsely elevated. Thus, our study was not equipped to answer all long-term questions related to the differences between partial and total tonsillectomies.

An additional limitation of this study is the lack of consistent PSG data in both surgical groups. Only 1 patient in the TT group and 3 patients in the PIT group had a pre-operative PSG. Consequently, it is unclear to how well the CAS-15 correlates with PSG findings, including the AHI or nadir SpO2, in patients undergoing PIT based on our data.

**Dissemination**

The above work has been disseminated through two wide-reaching formats. First, the abstract and initial data for the project were presented as an oral presentation at the American Society of Pediatric Otolaryngology section of the Combined Otolaryngology Spring Meeting in 2022. The meeting took place in Dallas, Texas, and is the largest yearly gathering of pediatric otolaryngologists. Second, this work was published in the September-October 2022 issue of the *American Journal of Otolaryngology – Head and Neck Medicine and Surgery.*
References


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