Tonsillectomy and Adenoidectomy - Pediatric Clinics of North America

Brandon K. Nguyen, MD[a], Huma A. Quraishi, MD[b,*]

KEYWORDS

• Tonsils • Adenoids • Tonsillitis • Tonsillectomy • Adenoidectomy
• Adenotonsillectomy • Intracapsular tonsillectomy

KEY POINTS

- OSA is the most common indication for adenotonsillectomy.
- PSG is the gold standard for diagnosing OSA.
- Adenotonsillectomy for OSA results in an improvement in obstructive symptoms, behavior, and PSG and QOL measures.
- The Paradise criteria should be used in recommending tonsillectomy for recurrent pharyngitis.
- The indications for adenoidectomy include OSA, chronic otitis media with effusion, and recurrent sinusitis.

INTRODUCTION

Tonsillectomy and adenoidectomy are among the most commonly performed major pediatric operations in the United States, with more than 500,000 procedures performed annually.[1]

This procedure can be performed with or without adenoidectomy. These procedures were traditionally performed for recurrent tonsillitis; however, the vast majority of tonsillectomies are currently performed for obstructive symptoms.[2,3] When performed for appropriate indications, tonsillectomy and adenoidectomy can greatly improve a child's quality of life (QOL) and general health.[4,5] Given the prevalence of these conditions and subsequent surgical procedures, evidence-based recommendations are regularly evaluated and updated.[6] As such, familiarity with these guidelines is

The authors have nothing to disclose and have no financial or commercial conflicts of interest in relation to the preparation of this article.
[a] Department of Otolaryngology–Head and Neck Surgery, Rutgers New Jersey Medical School, 90 Bergen St, Ste 8100, Newark, NJ 07103, USA; [b] Pediatric Otolaryngology, Joseph M. Sanzari Children's Hospital, 30 Prospect Ave. WFAN Bldg 3rd Floor, Hackensack, NJ 07601, USA
* Corresponding author.
E-mail address: huma.quraishi@hmhn.org

Pediatr Clin N Am 69 (2022) 247–259
https://doi.org/10.1016/j.pcl.2021.12.008 **pediatric.theclinics.com**

necessary for pediatric practitioners. This review summarizes the indications, complications, and outcomes for tonsillectomy and adenoidectomy, as well as provides a brief overview of operative techniques.

Anatomy and Physiology

Tonsils and adenoids play an important role in the host defense against invading inhaled or ingested pathogens. These lymphoid structures are arranged in a circular orientation around the naso- and oropharynx called Waldeyer's ring. This ring consists of the nasopharyngeal tonsil known as the adenoids, the tubal tonsils adjacent to the eustachian tube, the palatine tonsils in the oropharynx, and the lingual tonsils at the base of the tongue.

Tonsils are secondary lymphoepithelial organs that initiate the immune response from antigens entering through the nose or the mouth. These tissues are derivatives of the 2nd pharyngeal pouch, typically arise between the 4th and 5th months of gestation, and continue to develop through birth and childhood.[7,8] The greatest immunologic activity for tonsils typically occurs between 3 and 10 years of age and explains the high incidence of obstructive sleep-disordered breathing and recurrent tonsillitis during these ages.[9]

The adenoid pad is situated in the nasopharynx with the apex just inferior to the nasal septum and the base along the posterior nasopharyngeal wall. The adenoid pad develops as a midline structure by the fusion of 2 lateral primordia in the seventh month of gestation and continues to mature until the fifth or sixth year of life and typically involutes by adolescence.[10,11]

The most widely accepted grading scale for tonsil size was proposed by Brodsky in 1989 (**Table 1**). Multiple trials have confirmed the reproducibility of the Brodsky grading scale. Interestingly, much has been made of tonsil size, but multiple studies have shown that size does not correlate with the degree of obstruction clinically.[12,13]

INDICATIONS FOR TONSILLECTOMY

Obstructive Sleep Apnea Syndrome

Obstructive sleep disorder breathing (oSDB) is one of the primary indications for adenotonsillectomy. oSDB is characterized by either abnormality of the respiratory pattern or adequacy of ventilation during sleep. oSDB encompasses a spectrum of obstructive disorders that range from snoring to obstructive sleep apnea (OSA).[14,15] OSAS is characterized by recurrent partial or complete obstruction of the airway during sleep. Even though the prevalence of snoring is high in the pediatric population, estimated to be 8% to 27%, only 1% to 5% of children will have OSAS.[15] Untreated, pediatric OSA can lead to a myriad of morbidities including daytime sleepiness,

Table 1
Brodsky tonsil size classification

Grade	Ratio of Tonsil in Oropharynx
0	Tonsils are entirely within the tonsillar pillar or previously resected
1+	Tonsils occupy <25% of the lateral dimension of the oropharynx, as measured between the anterior tonsillar pillars
2+	Tonsils occupy 26%–50% of the lateral dimension of the oropharynx
3+	Tonsils occupy 51%–75% of the lateral dimension of the oropharynx
4+	Tonsils occupy more than 75% of the lateral dimension of the oropharynx

enuresis, retardation of growth, behavioral and learning issues (hyperactivity, impulsivity, rebelliousness, aggression), and cardiovascular diseases (hypertension, cor pulmonale, ventricular dysfunction).[16]

The diagnosis of OSA in children is often made by history and physical examination with a positive predictive value of 50% to 60%.[17] When obtaining a history, parents may describe habitual snoring, restless sleep, mouth breathing, enuresis, diaphoresis, observed apnea, or sleep resistance behaviors. Overnight in-laboratory polysomnography (PSG) is considered "the gold standard" for the diagnosis of pediatric OSA.[17] This study allows for the diagnosis and assessment of disturbances in respiratory and sleep patterns, providing clinicians with objective data for the management of their patients. The apnea-hypopnea index (AHI) is the most commonly used parameter for quantifying the severity of OSA. This index represents the combined number of apneas and hypopneas that occur per hour of sleep. In the pediatric population, an AHI less than 1 is considered normal; > greater than >1 AHI $\leq$5 as mild OSA; > greater than 5 AHI $\leq$10 as moderate OSA; and greater than 10 as severe OSA. The clinical practice guideline from the American Academy of Otolaryngology – Head and Neck Surgery Society (AAO-HNS) recommends PSG in all cases for which the need for tonsillectomy is uncertain or when there is discordance between the physical examination and the reported severity of oSDB.[18] PSG is recommended for children less than 2 years of age as they are at higher risk of having postoperative respiratory complications. Children exhibiting the following should also undergo PSG as they are at risk for having residual OSA postoperatively: obesity, Down syndrome, craniofacial abnormalities, neuromuscular disorders, sickle cell disease, or mucopolysaccharidoses. Tonsillectomy and adenoidectomy is recommended for all children diagnosed with OSA as documented by PSG.[6]

Outcome data regarding adenotonsillectomy have been shown to improve PSG parameters, with a "cure rate" reported between 70% and 90%.[6,16] Disease-specific and global QOL measures have also been shown to be improved.[19] The Childhood Adenotonsillectomy Trial (CHAT), published in 2011, was a randomized controlled trial assessing the health and neurologic outcomes in children with OSA after adenotonsillectomy. This study found that surgery reduced symptoms of OSA and improved behavior, QOL, and polysomnographic findings. However, there was no significant improvement in attention or executive function after adenotonsillectomy.[20] Children with OSA and concurrent enuresis may also derive benefit from adenotonsillectomy. Basha and colleagues reported a marked improvement or resolution of enuresis in most children with OSA who underwent tonsillectomy or adenotonsillectomy.[21] Likewise, a systematic review by Lehmann and colleagues showed complete or partial resolution in a majority of children.[22]

A number of studies have demonstrated that a subset of patients may experience weight gain following tonsillectomy. Increased weight gainwas noted primarily in the first 6 months postoperatively and predominantly in obese children.[20,23–25] However, more recent studies dispute these findings. Kirkham and colleagues and Jensen and colleagues both performed repeat analysis of the initial CHAT study data and reported no undesirable weight gain over a 7 month period following adenotonsillectomy when comparing BMI Z-scores and BMI expressed as a percentage of the 95th percentile, respectively.[26,27]

Recurrent Tonsillitis

Current AAO-HNS guidelines recommend tonsillectomy for patients with recurrent tonsillitis at a frequency of at least 7 episodes in the past year; at least 5 episodes per year for 2 years; or at least 3 episodes per year for 3 years. Each of these episodes

should have documentation of fever greater than 38C (101F), cervical lymphadenopathy, tonsillar exudate, or culture positive for GABHS.[6] These recommendations are based on the Paradise criteria, which are shown in **Table 2**. Tonsillectomy for less severe disease may be recommended in patients with antibiotic allergies or recurrent peritonsillar abscess. .

Outcome data for tonsillectomy in children with recurrent tonsillitis have demonstrated mixed benefits for recurrent pharyngitis episodes postoperatively. Two studies by Paradise and colleagues examined the benefits of tonsillectomy in patients with severe episodes (based on the author's own scoring system) and reported that frequency and severity of throat infections were significantly reduced for 2 years postoperatively.[28] A follow-up study examining patients with less severe cases showed only modest benefit postoperatively.[29] A follow-up Cochrane review of 5 pooled studies corroborated these studies and demonstrated 1 year of benefit as compared with watchful waiting, with severely affected children more likely to benefit.[4] However, improvement in QOL was shown to be significant following tonsillectomy for

Table 2
Paradise criteria for tonsillectomy

Criteria	Definition
Minimum frequency of sore throat episodes	At least 7 episodes in the previous year, at least 5 episodes in each of the previous 2 years, or at least 3 episodes in each of the previous 3 years
Clinical features	Sore throat plus at least one of the following features qualifies as a counting episode: Temperature of >100.9°F (38.3°C) Cervical adenopathy (tender lymph nodes or lymph node size >2 cm) Tonsillar exudate Culture positive for group A β-hemolytic streptococcus
Treatment	Antibiotics administered in the conventional dosage for proved or suspected streptococcal episodes
Documentation	Each episode of throat infection and its qualifying features substantiated by contemporaneous notation in a medical record If the episodes are not fully documented, subsequent observance by the physician of 2 episodes of throat infection with patterns of frequency and clinical features consistent with the initial history
Indications for Adenoidectomy	
History	Four or greater episodes of recurrent purulent rhinorrhea within 12 mo in a child <12 y of age. One episode should be documented by intranasal examination or diagnostic imaging. Persisting symptoms of adenoiditis after 2 courses of antibiotic therapy. One course of antibiotics should be with a B-lactamase stable antibiotic for at least 2 weeks. Sleep disturbance with nasal airway obstruction persisting for at least 3 mo Otitis media with effusion >3 mo or associated with additional sets of tubes. Otitis media with effusion (age 4 or greater)
Physical Exam	Description of uvula, palate, tonsils, nasal airway, cervical lymph nodes. Evaluation of adenoids by mirror, nasal endoscopy, or imaging only as necessary.

all cases of recurrent tonsillitis. In a prospective observational study, clinically significant improvements were seen across all Tonsil and Adenoid Health Status instrument (TAHSI) categories including airway and breathing, recurrent infection, health care utilization, health care costs, eating and swallowing, and behavior at 6 months and 1 year after surgery.[5] Further QOL subsets such as health perception, physical functioning, parental impact, and family impact were found to be significantly improved as well. It is also important to note that general satisfaction with tonsillectomy was reported in 91% of parents and caregivers.[30] While benefits for recurrent pharyngitis episodes may be modest, improvement in QOL indicators has been shown to be significant following tonsillectomy. Clinicians and families should discuss these potential benefits and risks before proceeding with surgery.

Periodic Fever, Aphthous Stomatitis, Pharyngitis, and Cervical Adenitis

PFAPA is a condition that may be confused with recurrent infectious tonsillitis. PFAPA is an acronym for an idiopathic inflammatory syndrome of periodic fevers, adenitis, pharyngitis, and aphthous stomatitis, first described by Marshall in 1987.[31] The hallmark of PFAPA is recurrent high fever that occurs with "clockwork" regularity every 2 to 8 weeks. Greater than 90% of patients will have pharyngitis, 75% will have cervical adenitis and up to 50% will have aphthous stomatitis. Onset is usually before 6 years of age and resolution typically occurs 3 to 5 years after onset.[32] Even though PFAPA is a self-limited condition, there can be a significant disease burden from recurrent episodes. Oral steroids are effective in controlling the symptoms but may result in a shorter interval between episodes. Tonsillectomy has been found to be effective in producing remission in up to 98% of patients with PFAPA.[33–35] Therefore, in children, experiencing an adverse QOL as a result of PFAPA, tonsillectomy is a reasonable option for treatment.

Chronic Tonsillitis

Chronic tonsillitis is defined as sore throat or pharyngitis of at least 3 months' duration accompanied by tonsillar inflammation, often with improvement in symptoms with antibiotics but no resolution. Chronic tonsillitis is relatively uncommon and no evidence-based data is available for outcomes after tonsillectomy. Chronic tonsillitis may also be associated with halitosis. This condition can arise from multiple origins including periodontal disease, glossal debris, gastroesophageal disorders, foreign bodies, and sinusitis. Halitosis can occur when there is stagnation of saliva, build-up of food debris, and accumulation of bacteria, usually retained in the crypts of the tonsils.[36,37] While halitosis is often cited as an indication for surgery, there is currently insufficient evidence to support the use of adenotonsillectomy for management.

Peritonsillar Abscess

Peritonsillar abscess (PTA), also known as quinsy, occurs when a collection of pus fills the space between the tonsillar capsule and the pharyngeal constrictor muscles. Patients present with fever, dysphagia, odynophagia, trismus, and "hot potato" or muffled voice. Physical examination will reveal an erythematous and edematous soft palate withuvular deviation away from the infected side. Initial management consists of incision and drainage or needle aspiration paired with antibiotics and systemic steroids. Tonsillectomy should be considered in patients who have experienced greater than 1 PTA.[6] A low threshold for surgery should be kept for patients who develop PTA with a history of frequent tonsil disease. Quinsy tonsillectomy, in which surgery is performed in the setting of an active infection, is occasionally considered if a child requires general anesthesia for drainage.

Malignancy

Non-Hodgkin lymphoma accounts for the majority of pediatric tonsillar malignancies.[38] A high index of suspicion is appropriate in children who present with rapid unilateral tonsil enlargement, tonsillar asymmetry characterized as greater than 2 grades on the Brodsky scale, or concurrent prominent cervical lymphadenopathy, night sweats, and fevers.[38,39]

SURGICAL TECHNIQUE

History

Tonsillectomy is one of the oldest surgical procedures still in existence. A description of partial removal of the tonsils first appears in texts from ancient India in 1000 BC, with the author exhorting the practitioner to refrain from removing the entire tonsil for fear of fatal hemorrhage. Celsus described a technique for the complete removal of tonsils as early as 50 AD.[40] However, partial tonsillectomy remained the more widely used procedure until the latter part of the 19th century when Ballenger introduced the technique of extracapsular dissection of the tonsil.[40,41]

It was not until the early 20th century, with improvements in anesthesia and hemostasis that total tonsillectomy became widely accepted.

Total or extracapsular tonsillectomy is performed by identifying the tonsillar capsule and dissecting in the plane between the tonsillar capsule and the pharyngeal musculature, removing the tonsil in its entirety. Tonsillectomy is most commonly performed with monopolar electrocautery or bipolar radiofrequency ablation (coblation), although other techniques such as cold steel (knife or snare) dissection or harmonic scalpel are also in use.

Complications

Tonsillectomy is generally a safe procedure. It is important, however, to understand and recognize the potential complications related to this surgery. The most common serious complication of tonsillectomy is hemorrhage. Primary bleeding occurs within the first 24 hours of surgery and is rare with an estimated rate of less than 1%. Secondary bleeding usually occurs 7 to 10 days postoperatively at rates between 2% and 4%.[42–44] Older patients (>11 years of age) have been shown to bleed more often after surgery.[45]

Patients can expect to experience sore throat and otalgia postoperatively. Multiple studies have compared the effect of various techniques on postoperative pain with evidence supporting coblation for reduced postoperative pain as well as the time needed to return to normal diet and activity.[46,47] Patients may also experience otalgia—usually during the first postoperative week. This pain occurs via referred pain from the glossopharyngeal nerve rather than via Eustachian tube injury or edema as no relationship has been noted between throat pain, otalgia, and negative middle ear pressures.[48] Ibuprofen and acetaminophen have been shown to be safe and effective for pain control following adenotonsillectomy.[49] Opioids, specifically, codeine which has a black box warning, should be avoided for pediatric patients with OSAS.

Postoperative pain can result in decreased oral intake, leading to dehydration. Following hemorrhage, dehydration is the most common postoperative complication resulting in hospital admission. Admission for dehydration occurs in less than 1% of patients and when needed, admission is usually under 24 hours.[50]

Respiratory compromise should also be monitored following adenotonsillectomy. Complications can be classified as major and minor. Major complications include postoperative pulmonary edema, laryngospasm, and bronchospasm. Minor

complications include apnea exacerbation and hypoxemia with the need for oxygen supplementation. Patients with congenital disorders, cerebral palsy, seizure disorders, prematurity, and age less than 3 years are more likely to have major respiratory complications.[51–53] and should be observed in a monitored setting postoperatively.

Tonsillectomy can be performed safely as a same day procedure.[54] The American Academy of Pediatrics and AAO-HNS suggest that patients with risk factors for postoperative complications be managed in an inpatient setting. These factors focus on patients with decreased respiratory reserve and include obesity, significant comorbidities, severe OSA, or patients younger than 3 years of age.[6,48,55] The AAO-HNS guidelines recommend overnight monitoring for all children under the age of 3 or those who have severe OSA (AHI >10 or oxygen saturation nadir <80%). Inpatient care should include pain control, continuous pulse oximetry, and fluid management with either PO intake or IV fluids.

Intracapsular tonsillectomy

Partial intracapsular tonsillectomy (IT) or tonsillotomy was reintroduced by Koltai in 2002.[56] In this procedure, tonsillar tissue is removed by a microdebrider or bipolar radiofrequency ablation (coblation) from within the tonsillar capsule. The tonsillar capsule and a small rim of residual tonsil tissue serve as a "biological dressing" protecting the neurovascular structures within the underlying muscle. A recent systematic review of pooled data showed that IT was superior to extracapsular total tonsillectomy with respect to postoperative pain, analgesic use, and time to resumption of normal diet and activity. Furthermore, the incidence of postoperative readmission for bleeding or dehydration was significantly decreased with IT.[57] Postoperative secondary bleeding rates have been reported to be less than 1% in 2 large series.[58,59] The disadvantage of IT, however, is that there is a risk of regrowth of the residual tonsil. The reoperation rate has been reported to be less than 1% to 3%.[58–60] Children less than 4 years of age at the time of IT may be at increased risk of regrowth.[61] This data supports the benefits of IT over extracapsular tonsillectomy with an acceptable low risk of reoperation. The AAO-HNS guidelines do not address IT as a treatment for OSA. However, there is a growing body of literature supporting the efficacy of IT in select patients with OSA.[62–64]

ADENOIDECTOMY

Adenoidectomy may be performed with or without tonsillectomy. The most common indication for this procedure is obstructive sleep-disordered breathing and OSA. As with tonsillar hypertrophy, adenoid hypertrophy causes nasopharyngeal narrowing leading to partial or complete obstruction, especially with the loss of neuromuscular tone during sleep. Other indications include chronic or recurrent otitis media with effusion (cOME), chronic rhinorrhea, nasal obstruction, sinusitis, and chronic adenoiditis.

Given the central location of the adenoids in the upper respiratory tract and the proximity to the eustachian tube, adenoid hypertrophy was hypothesized to cause physical obstruction of the Eustachian tubes and nasal cavity thereby preventing mucus drainage and leading to infection. Interestingly, studies have demonstrated that adenoidectomy reduces chronic OME symptoms regardless of the size of the adenoid pad.[65,66] Multiple studies have examined the bacterial load of the adenoid pad and found that the adenoid pad serves as a reservoir for bacteria to form biofilms rather than causing mechanical obstruction of the Eustachian tube.[67,68]

In 2014, Wallace and colleagues reported that adenoidectomy reduced OME and improved hearing as compared with either myringotomy or observation.[69] Further systematic reviews demonstrated that adenoidectomy reduced the number of days

experienced with OME over a 12 month period and also decreased the rate of repeat tympanostomy tube placement in children greater than 4 years of age.[68,70] As a result of these studies, adenoidectomy is recommended by the AAO-HNS for children over 4 years of age with chronic OME or in children receiving their second set of tubes.

Pediatric recurrent rhinosinusitis is also thought to be related to adenoid biofilm formation. A study by Brietzke found a correlation of sinonasal-symptom scores with quantitative bacteriologic findings in the adenoid core and not with adenoid size.[71] Additionally, Coticchia and colleagues compared adenoid tissue removed for chronic rhinosinusitis versus oSDB and found a statistically significantly larger biofilm surface area in the tissue from the rhinosinusitis patients.[72] These authors concluded that recurrent sinusitis despite medical therapy is due to biofilms, and adenoidectomy is the best therapeutic option to mechanically disrupt and eradicate the biofilms. The AAO-HNS guidelines recommend adenoidectomy in children less than 12 years of age with at least 4 episodes of recurrent purulent rhinorrhea in 12 months with at least one episode documented by intranasal examination or diagnostic imaging.

Chronic adenoiditis involves adenoid inflammation with resultant nasal obstruction, snoring, mouth breathing, and persistent purulent rhinitis unresponsive to antibiotics. These symptoms are similar to the manifestations of adenoid hypertrophy and can easily lead to confusion between the 2 conditions. As with rhinosinusitis and cOME, the etiology of chronic adenoiditis stems from biofilm formation. No controlled trials have been established to help guide management. Adenoidectomy, however, can disrupt the biofilm and address the local obstruction and may be offered to patients who have failed medical management.

Surgical Technique

Adenoidectomy can be completed by a variety of techniques. Traditional excision is completed via loop adenoid curettes. The use of this technique is declining; however, as more clinicians have transitioned to microdebridement and electrosurgical devices. Electrocautery adenoidectomy provides the benefits of greater precision while also minimizing blood loss and reducing surgical time. Of note, it is important to understand that the adenoid is not an encapsulated structure like the tonsils, but rather fronds of tissue.[73] Thus, adenoidectomy never results in complete removal and tissue regrowth becomes a potential concern with regrowth rates reported between 1% and 9% and revision required in approximately 3% of cases.[74,75]

Complications

In general, adenoidectomy is well tolerated with low rates of complications. Velopharyngeal insufficiency (VPI) is a rare complication associated with adenoidectomy and manifests as hypernasal speech and nasal regurgitation. VPI has a reported incidence of 1 in 1500 and is more likely to occur in patients with hypotonia or submucosal cleft palate.[76,77] Nasopharyngeal stenosis or eustachian tube scarring may also occur as a result of excessive excision or electrocautery of the tonsillar pillars or posterior pharyngeal wall. Compared with tonsillectomy, adenoidectomy complications are infrequent and the procedure is associated with minmal postoperative pain, dehydration, postoperative bleeding, as well as shorter hospital stays, and lower cost.

SUMMARY

This article provides a brief overview of the indications, surgical techniques, and outcomes for adenoidectomy and tonsillectomy. Tonsillectomy should be performed in

children with recurrent tonsillitis meeting the Paradise criteria, with oSDB or OSA, and in some cases of PTA, PFAPA, or concern for malignancy. Adenoidectomy is indicated in children with chronic otitis media with effusion, recurrent rhinosinusitis, and chronic adenoiditis.

CLINICS CARE POINTS

- Adenotonsillectomy has been shown to be effective in treating OSA with improvement in symptoms, behavior, and PSG and QOL measures postoperatively.
- Tonsillectomy for recurrent pharyngitis has modest benefits and in some cases, is no better than watchful waiting.
- Adentonsillectomy can be safely performed as an outpatient procedure in children greater than 3 years of age; children with significant comorbidities and severe OSA should be observed overnight postoperatively.
- Adenoidectomy is recommended in children greater than 4 years of age with chronic otitis media with effusion.
- Adenoidectomy is recommended for the treatment of recurrent sinusitis in children less than 12 years of age.

REFERENCES

1. Bohr C, Shermetaro C. Tonsillectomy and Adenoidectomy. In: StatPearls. StatPearls Publishing; 2021. Available at: http://www.ncbi.nlm.nih.gov/books/NBK536942/. Accessed September 14, 2021.
2. Erickson BK, Larson DR, St Sauver JL, et al. Changes in incidence and indications of tonsillectomy and adenotonsillectomy, 1970-2005. Otolaryngol Head Neck Surg 2009;140(6):894–901.
3. Patel HH, Straight CE, Lehman EB, et al. Indications for tonsillectomy: a 10 year retrospective review. Int J Pediatr Otorhinolaryngol 2014;78(12):2151–5.
4. Burton MJ, Glasziou PP, Chong LY, et al. Tonsillectomy or adenotonsillectomy versus non-surgical treatment for chronic/recurrent acute tonsillitis. Cochrane Database Syst Rev 2014;11. https://doi.org/10.1002/14651858.CD001802.pub3.
5. Goldstein NA, Stewart MG, Witsell DL, et al. Quality of life after tonsillectomy in children with recurrent tonsillitis. Otolaryngol Head Neck Surg 2008;138(1 Suppl):S9–16.
6. Mitchell RB, Archer SM, Ishman SL, et al. Clinical practice guideline: tonsillectomy in children (update). Otolaryngol Head Neck Surg 2019;160(1_suppl):S1–42.
7. Isaacson G, Parikh T. Developmental anatomy of the tonsil and its implications for intracapsular tonsillectomy. Int J Pediatr Otorhinolaryngol 2008;72(1):89–96.
8. Goeringer GC, Vidić B. The embryogenesis and anatomy of Waldeyer's ring. Otolaryngol Clin North Am 1987;20(2):207–17.
9. Arambula A, Brown JR, Neff L. Anatomy and physiology of the palatine tonsils, adenoids, and lingual tonsils. World J Otorhinolaryngol Head Neck Surg 2021;7(3):155–60.
10. Jaw TS, Sheu RS, Liu GC, et al. Development of adenoids: a study by measurement with MR images. Kaohsiung J Med Sci 1999;15(1):12–8.
11. Handelman CS, Osborne G. Growth of the nasopharynx and adenoid development from one to eighteen years. Angle Orthodontist 1976;46(3):243–59.

12. Cahali MB, de Paula Soares CF, da Silva Dantas DA, et al. Tonsil volume, tonsil grade and obstructive sleep apnea: is there any meaningful correlation? Clinics (Sao Paulo) 2011;66(8):1347–51.
13. Marcus CL, Fernandes Do Prado LB, Lutz J, et al. Developmental changes in upper airway dynamics. J Appl Physiol (1985) 2004;97(1):98–108.
14. Dehlink E, Tan H-L. Update on paediatric obstructive sleep apnoea. J Thorac Dis 2016;8(2):224–35.
15. SAVINI S, CIORBA A, BIANCHINI C, et al. Assessment of obstructive sleep apnoea (OSA) in children: an update. Acta Otorhinolaryngol Ital 2019;39(5):289–97.
16. Marcus CL, Brooks LJ, Ward SD, et al. Diagnosis and Management of Childhood Obstructive Sleep Apnea Syndrome. Pediatrics 2012;130(3):e714–55.
17. Brietzke SE, Katz ES, Roberson DW. Can history and physical examination reliably diagnose pediatric obstructive sleep apnea/hypopnea syndrome? A systematic review of the literature. Otolaryngol Head Neck Surg 2004;131(6):827–32.
18. Liu H, Feng X, Sun Y, et al. Modified adenoid grading system for evaluating adenoid size in children: a prospective validation study. Eur Arch Otorhinolaryngol 2021;278(6):2147–53.
19. Stewart MG, Glaze DG, Friedman EM, et al. Quality of life and sleep study findings after adenotonsillectomy in children with obstructive sleep apnea. Arch Otolaryngol Head Neck Surg 2005;131(4):308–14.
20. Redline S, Amin R, Beebe D, et al. The Childhood Adenotonsillectomy Trial (CHAT): Rationale, Design, and Challenges of a Randomized Controlled Trial Evaluating a Standard Surgical Procedure in a Pediatric Population. Sleep 2011;34(11):1509–17.
21. Basha S, Bialowas C, Ende K, et al. Effectiveness of adenotonsillectomy in the resolution of nocturnal enuresis secondary to obstructive sleep apnea. Laryngoscope 2005;115(6):1101–3.
22. Lehmann KJ, Nelson R, MacLellan D, et al. The role of adenotonsillectomy in the treatment of primary nocturnal enuresis in children: A systematic review. J Pediatr Urol 2018;14(1):53.e1-8.
23. Lewis TL, Johnson RF, Choi J, et al. Weight gain after adenotonsillectomy: a case control study. Otolaryngol Head Neck Surg 2015;152(4):734–9.
24. AlAbdullah ZA, Alali K, Al Jabr I. Clinical assessment of weight gain in pediatric patients post-tonsillectomy: a retrospective study. Cureus 2020;12(12):e12005.
25. Barr GS, Osborne J. Weight gain in children following tonsillectomy. J Laryngol Otol 1988;102(7):595–7.
26. Kirkham EM, Leis AM, Chervin RD. Weight gain in children after adenotonsillectomy: undesirable weight gain or catch-up growth? Sleep Med 2021;85:147–9.
27. Jensen AM, Herrmann BW, Mitchell RB, et al. Growth After Adenotonsillectomy for Obstructive Sleep Apnea: Revisited. Laryngoscope 2021. https://doi.org/10.1002/lary.29863.
28. Paradise JL, Bluestone CD, Bachman RZ, et al. Efficacy of Tonsillectomy for Recurrent Throat Infection in Severely Affected Children. N Engl J Med 1984;310(11):674–83.
29. Paradise JL, Bluestone CD, Colborn DK, et al. Tonsillectomy and adenotonsillectomy for recurrent throat infection in moderately affected children. Pediatrics 2002;110(1 Pt 1):7–15.
30. Wolfensberger M, Haury JA, Linder T. Parent satisfaction 1 year after adenotonsillectomy of their children. Int J Pediatr Otorhinolaryngol 2000;56(3):199–205.

31. Marshall GS, Edwards KM, Butler J, et al. Syndrome of periodic fever, pharyngitis, and aphthous stomatitis. J Pediatr 1987;110(1):43–6.
32. Batu ED. Periodic fever, aphthous stomatitis, pharyngitis, and cervical adenitis (PFAPA) syndrome: main features and an algorithm for clinical practice. Rheumatol Int 2019;39(6):957–70.
33. Licameli G, Lawton M, Kenna M, et al. Long-term surgical outcomes of adenotonsillectomy for PFAPA syndrome. Arch Otolaryngol Head Neck Surg 2012;138(10):902–6.
34. Lantto U, Koivunen P, Tapiainen T, et al. Long-Term Outcome of Classic and Incomplete PFAPA (Periodic Fever, Aphthous Stomatitis, Pharyngitis, and Adenitis) Syndrome after Tonsillectomy. J Pediatr 2016;179:172–7.e1.
35. Erdogan F, Kulak K, Öztürk O, et al. Surgery vs medical treatment in the management of PFAPA syndrome: a comparative trial. Paediatr Int Child Health 2016;36(4):270–4.
36. Madhushankari GS, Yamunadevi A, Selvamani M, et al. Halitosis – An overview: Part-I – Classification, etiology, and pathophysiology of halitosis. J Pharm Bioallied Sci 2015;7(Suppl 2):S339–43.
37. Kapoor U, Sharma G, Juneja M, et al. Halitosis: Current concepts on etiology, diagnosis and management. Eur J Dent 2016;10(2):292–300.
38. Adil EA, Medina G, Cunningham MJ. Pediatric tonsil cancer: a national and institutional perspective. J Pediatr 2018;197:255–61.e1.
39. Berkowitz RG, Mahadevan M. Unilateral tonsillar enlargement and tonsillar lymphoma in children. Ann Otol Rhinol Laryngol 1999;108(9):876–9.
40. Grob GN. The rise and decline of tonsillectomy in twentieth-century America. J Hist Med Allied Sci 2007;62(4):383–421.
41. Verma R, Verma RR, Verma RR. Tonsillectomy-comparative study of various techniques and changing trend. Indian J Otolaryngol Head Neck Surg 2017;69(4):549–58.
42. Krishna P, Lee D. Post-tonsillectomy bleeding: a meta-analysis. Laryngoscope 2001;111(8):1358–61.
43. Wall JJ, Tay K-Y. Postoperative Tonsillectomy Hemorrhage. Emerg Med Clin North Am 2018;36(2):415–26.
44. Dhaduk N, Rodgers A, Govindan A, et al. Post-Tonsillectomy Bleeding: A National Perspective. Ann Otol Rhinol Laryngol 2021;130(8):941–7.
45. Myssiorek D, Alvi A. Post-tonsillectomy hemorrhage: an assessment of risk factors. Int J Pediatr Otorhinolaryngol 1996;37(1):35–43.
46. Vieira L, Nissen L, Sela G, et al. Reducing postoperative pain from tonsillectomy using monopolar electrocautery by cooling the oropharynx. Int Arch Otorhinolaryngol 2014;18(2):155–8.
47. Omrani M, Barati B, Omidifar N, et al. Coblation versus traditional tonsillectomy: A double blind randomized controlled trial. J Res Med Sci 2012;17(1):45–50.
48. Randall DA. Current Indications for Tonsillectomy and Adenoidectomy. J Am Board Fam Med 2020;33(6):1025–30.
49. Diercks GR, Comins J, Bennett K, et al. Comparison of ibuprofen vs acetaminophen and severe bleeding risk after pediatric tonsillectomy: a noninferiority randomized clinical trial. JAMA Otolaryngol Head Neck Surg 2019;145(6):494–500.
50. Randall DA, Hoffer ME. Complications of tonsillectomy and adenoidectomy. Otolaryngol Head Neck Surg 1998;118(1):61–8.
51. Biavati MJ, Manning SC, Phillips DL. Predictive Factors for Respiratory Complications After Tonsillectomy and Adenoidectomy in Children. Arch Otolaryngol Head Neck Surg 1997;123(5):517–21.

52. Richmond KH, Wetmore RF, Baranak CC. Postoperative complications following tonsillectomy and adenoidectomy–who is at risk? Int J Pediatr Otorhinolaryngol 1987;13(2):117–24.
53. Marrugo Pardo G, Romero Moreno LF, Beltrán Erazo P, et al. Respiratory Complications of Adenotonsillectomy for Obstructive Sleep Apnea in the Pediatric Population. Sleep Disord 2018;2018:1968985.
54. Amoils M, Chang KW, Saynina O, et al. Postoperative Complications in Pediatric Tonsillectomy and Adenoidectomy in Ambulatory vs Inpatient Settings. JAMA Otolaryngol Head Neck Surg 2016;142(4):344–50.
55. Werle AH, Nicklaus PJ, Kirse DJ, et al. A retrospective study of tonsillectomy in the under 2-year-old child: indications, perioperative management, and complications. Int J Pediatr Otorhinolaryngol 2003;67(5):453–60.
56. Koltai PJ, Solares CA, Mascha EJ, et al. Intracapsular partial tonsillectomy for tonsillar hypertrophy in children. Laryngoscope 2002;112(8 Pt 2 Suppl 100):17–9.
57. Lee HS, Yoon HY, Jin HJ, et al. The safety and efficacy of powered intracapsular tonsillectomy in children: A meta-analysis. Laryngoscope 2018;128(3):732–44.
58. Soaper AL, Richardson ZL, Chen JL, et al. Pediatric tonsillectomy: A short-term and long-term comparison of intracapsular versus extracapsular techniques. Int J Pediatr Otorhinolaryngol 2020;133:109970.
59. Amin N, Bhargava E, Prentice JG, et al. Coblation intracapsular tonsillectomy in children: A prospective study of 1257 consecutive cases with long-term follow-up. Clin Otolaryngol 2021. https://doi.org/10.1111/coa.13790.
60. Sorin A, Bent JP, April MM, et al. Complications of microdebrider-assisted powered intracapsular tonsillectomy and adenoidectomy. Laryngoscope 2004;114(2):297–300.
61. Sagheer SH, Kolb CM, Crippen MM, et al. Predictive Pediatric Characteristics for Revision Tonsillectomy After Intracapsular Tonsillectomy. Otolaryngol Head Neck Surg 2021. https://doi.org/10.1177/01945998211034454. 1945998211034454.
62. Chang DT, Zemek A, Koltai PJ. Comparison of treatment outcomes between intracapsular and total tonsillectomy for pediatric obstructive sleep apnea. Int J Pediatr Otorhinolaryngol 2016;91:15–8.
63. Mukhatiyar P, Nandalike K, Cohen HW, et al. Intracapsular and Extracapsular Tonsillectomy and Adenoidectomy in Pediatric Obstructive Sleep Apnea. JAMA Otolaryngol Head Neck Surg 2016;142(1):25–31.
64. Mostovych N, Holmes L, Ruszkay N, et al. Effectiveness of Powered Intracapsular Tonsillectomy in Children With Severe Obstructive Sleep Apnea. JAMA Otolaryngol Head Neck Surg 2016;142(2):150–6.
65. Saafan ME, Ibrahim WS, Tomoum MO. Role of adenoid biofilm in chronic otitis media with effusion in children. Eur Arch Otorhinolaryngol 2013;270(9):2417–25.
66. Bayazian G, Sayyahfar S, Safdarian M, et al. Is there any association between adenoid biofilm and upper airway infections in pediatric patients? Turk Pediatri Ars 2018;53(2):71–7.
67. Boonacker CW, Rovers MM, Browning GG, et al. Adenoidectomy with or without Grommets for Children with Otitis Media: An Individual Patient Data Meta-Analysis. Health Technol Assess 2014;18(5):1–118.
68. van den Aardweg MT, Schilder AG, Herkert E, et al. Adenoidectomy for otitis media in children. Cochrane Database Syst Rev 2010;1:CD007810.
69. Wallace IF, Berkman ND, Lohr KN, et al. Surgical treatments for otitis media with effusion: a systematic review. Pediatrics 2014;133(2):296–311.

70. Mikals SJ, Brigger MT. Adenoidectomy as an Adjuvant to Primary Tympanostomy Tube Placement: A Systematic Review and Meta-analysis. JAMA Otolaryngol Head Neck Surg 2014;140(2):95–101.
71. Brietzke SE, Shin JJ, Choi S, et al. Clinical Consensus Statement: Pediatric Chronic Rhinosinusitis. Otolaryngol Head Neck Surg 2014;151(4):542–53.
72. Coticchia J, Zuliani G, Coleman C, et al. Biofilm surface area in the pediatric nasopharynx: Chronic rhinosinusitis vs obstructive sleep apnea. Arch Otolaryngol Head Neck Surg 2007;133(2):110–4.
73. Dearking AC, Lahr BD, Kuchena A, et al. Factors associated with revision adenoidectomy. Otolaryngol Head Neck Surg 2012;146(6):984–90.
74. Babademez MA, Gul F, Muz E, et al. Impact of partial and total tonsillectomy on adenoid regrowth. Laryngoscope 2017;127(3):753–6.
75. Lesinskas E, Drigotas M. The incidence of adenoidal regrowth after adenoidectomy and its effect on persistent nasal symptoms. Eur Arch Otorhinolaryngol 2009;266(4):469–73.
76. Hubbard BA, Rice GB, Muzaffar AR. Adenoid involvement in velopharyngeal closure in children with cleft palate. Can J Plast Surg 2010;18(4):135–8.
77. Donnelly MJ. Hypernasality following adenoid removal. Ir J Med Sci 1994;163(5):225–7.