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Review Article

Post-tonsillectomy taste dysfunction: Myth or reality?

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Abstract Lingual branches of the glossopharyngeal nerve (CN IX) are at risk of injury during tonsillectomy due to their proximity to the muscle layer of the palatine tonsillar bed. However, it is unclear how often this common surgery leads to taste disturbances. We conducted a literature search using PubMed, Embase, Cochrane Library, Google Scholar, PsychInfo, and Ovid Medline to evaluate the available literature on post-tonsillectomy taste disorders. Studies denoting self-reported dysfunction, as well as those employing quantitative testing, i.e., chemogustometry and electrogustometry, were identified. Case reports were excluded. Of the 8 original articles that met our inclusion criteria, only 5 employed quantitative taste tests. The highest prevalence of self-reported taste disturbances occurred two weeks after surgery (32%). Two studies reported post-operative chemical gustometry scores consistent with hypogeusia. However, in the two studies that compared pre- and post-tonsillectomy test scores, one found no difference and the other found a significant difference only for the left rear of the tongue 14 days post-op. In the two studies that employed electrogustometry, elevated post-operative thresholds were noted, although only one compared pre- and post-operative thresholds. This study found no significant differences. No study employed a normal control group to assess the influences of repeated testing on the sensory measures. Overall, this review indicates that studies on post-tonsillectomy taste disorders are limited and ambiguous. Future research employing appropriate control groups and taste testing procedures are needed to define the prevalence, duration, and nature of post-tonsillectomy taste disorders.

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Introduction

In addition to providing pleasure from eating, drinking, and satisfying hunger, the taste system serves a range of other important physiologic functions. For example, it helps to distinguish nutrients from toxins,[1] provides signals to facilitate nutrient digestion,[2,3] and regulates salt and energy intake.[4] Taste disorders can lead to malnourishment, significant gains or losses in weight, and changes in dietary decisions.[5,6]

To help preserve such functions, this important sensory system exhibits considerable anatomical redundancy. Taste buds are differentially innervated throughout the oral cavity by branches from three different cranial nerves. The chorda tympani branch of the facial nerve (CN VII) innervates the taste buds on the anterior two-thirds of the tongue, whereas the greater superficial petrosal branch of this nerve innervates taste buds on the soft palate. The lingual branches of the glossopharyngeal nerve (CN IX) innervate taste buds on the posterior third of the tongue and the upper epiglottis, and the superior laryngeal branch of the vagus nerve (CN X) innervates taste buds on the lower epiglottis and esophagus.[7,8]

Transient or permanent taste disturbances can occur from a wide variety of causes.[9] These include medications, infections, radiation to the head and neck, exposure to oral irritants (including tobacco), and vitamin deficiencies.[6,10] Among surgeries that can lead to taste dysfunction are middle ear surgery,[11–13] tonsillectomy,[14,15] third molar extraction,[16] microdirect laryngoscopy,[17] and potentially uvulopalatopharyngoplasty.[18] Additionally, diseases like xerostomia, depression, diabetes mellitus, or renal failure have been reported to cause some degree of taste dysfunction.[5,6]

Taste disorders can be clinically classified into qualitative (dysgeusia or phantogeusia) and quantitative (hypogeusia or ageusia) disorders, the latter of which can be measured using standardized testing.[19] Qualitative disorders are more likely to affect quality of life, since they typically manifest as bitter, metallic, salty, or other unpleasant taste sensations. They are a common reason for a referral to specialized chemosensory disorder clinics. Quantitative taste disorders are more rare and more likely to go unnoticed,[20] and must be distinguished from the olfactory disorders that often present as diminished "taste" function. The olfactory receptors are stimulated by the retronasal food vapors, i.e., vapors that enter the olfactory region via the nasal pharynx during deglutition, and are responsible for the majority of "taste" sensations other than those of sweet, sour, bitter, salty, and umami. These include such flavor sensations as chocolate, coffee, licorice, steak sauce, strawberry, lemon, spaghetti sauce, and mint to name a few.[21]

The anatomic relationship of CN IX to the muscle layer of the palatine tonsillar bed is variable and can lead to the injury of the lingual branch of the glossopharyngeal nerve during tonsillectomy.[14,15] CN IX enters the pharynx anterior to the stylopharyngeus muscle by passing between superior and middle pharyngeal constrictors (Fig. 1). The lingual branches of CN IX pass between the superior and middle pharyngeal constrictor muscles, but in some cases can be partially exposed or adherent to the tonsillar capsule due to incomplete coverage of these nerve branches by the pharyngeal constrictor muscles.[15]

According to the National Center for Health Statistics, tonsillectomy is one of the most frequently performed surgeries in otolaryngology.[22] The implications of such damage for taste function have not been thoroughly investigated. Numerous lawsuits against surgeons have come forward in multiple countries in relation to tonsillectomy-related taste problems, raising a question about the prevalence and nature of taste changes after this operation.[23–26] This article reviews the extant literature on post-tonsillectomy taste function. Its goal is to provide the reader with an understanding as to what is known about the effect of this common operation on such function and to provide direction for future research in this area.

Materials and methods

A systematic review of literature was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA) statement. Two independent reviewers conducted a search using PubMed Plus, Embase, Cochrane Library, Google Scholar, PsychInfo, and Ovid Medline. All original reports on post-tonsillectomy taste function published in English prior to May 2017 were included, with the exception of single case reports. The search terms included *tonsillectomy* AND *taste* OR *ageusia* OR *hypogeusia* OR *dysgeusia* OR *taste disturbances* OR *tongue sensation* OR *complication*. Our systematic search

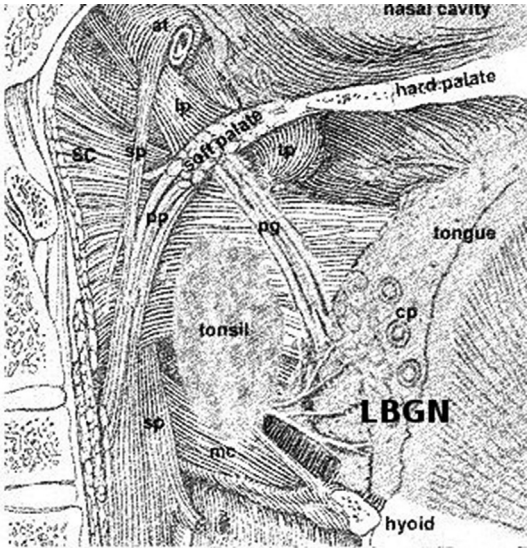

Fig. 1 CN IX anatomic relationship to pharyngeal constrictor muscles[a]. sc — superior pharyngeal constrictor muscle; mc — middle pharyngeal constrictor muscle; sp — stylopharyngeus muscle; pg — palatoglossus muscle or anterior tonsillar pillar; pp — palatopharyngeus muscle or posterior tonsillar pillar; lp — levator veli palatini muscle; tp — tensor veli palatini muscle; cp —circumvallate papillae; at — attachment at the torus tubarius. [a]elements of the drawing were obtained from http://www.wesnorman.com.

involved title-abstract screening followed by full-text screening, with the focus on study design, sample size, and length of follow-up (Fig. 2). Due to methodological diversity of the selected articles and the small number of publications identified during the search, a meaningful meta-analysis could not be performed. The prevalence of post-tonsillectomy taste disturbances was recorded from the patient's perspective, as well as on the basis of quantitative assessment of function [i.e., electrogustometry (EGM) and chemogustometry], when available.

Results

Prior to 2000, the literature on taste dysfunction after tonsillectomy was limited to single case reports. These case reports have been summarized in other publications and are not addressed in this review.[27,28] We identified eight original reports of case series and cohort studies that examined post-tonsillectomy taste function, all from Europe or Japan (Table 1). As summarized in Table 2, the patient-reported rate of taste dysfunction shortly after surgery (4–14 days) varied widely among these studies, ranging from 8.6% to 32%.[29,30] In almost all cases, patients reported symptom resolution within 6 months of surgery. Two studies reported evidence of post-tonsillectomy hypogeusia based on post-operative chemogustometry testing (Table 3).[15,31] Two other studies compared pre- and post-operative test scores and found no significant difference except in one study,[31,32] where the test scores on the left rear of the tongue scores were significantly different 14 days after surgery.[32] Two studies reported elevated post-tonsillectomy EGM threshold values.[15,29] However, only one of these studies performed pre- and post-operative tests, and these thresholds did not differ significantly from one another.[29] Details of these and other studies are listed in Tables 1–3.

In 2002, Tomita and Ohtuka[15] described 11 Japanese cases of post-tonsillectomy taste changes with three cases being attributed to direct or indirect injury to CN IX during tonsillectomy. These cases were identified from a retrospective review of 3583 outpatient visits to their taste disorder clinic, where both electrical and chemical quantitative taste testing was performed. In two of the eleven cases, taste changes were transient (symptoms resolved in 5–7 months). Taste changes in the remaining eight cases were attributed to causes unrelated to tonsillectomy [medication effects ($n = 2$), dietary zinc deficiency ($n = 3$), or unknown causes ($n = 3$)]. The low prevalence noted by these authors (11/3, 583; 0.31%) may reflect to a large degree the types of referrals to their clinic, not the proportion of people who experience altered taste function following tonsillectomy in the general population.

In prospective study published in 2005, Tomofuji et al[29] reported that 3 of 35 (8.6%) tonsillectomy patients complained of taste disturbance 4–6 days after the procedure. This was attributed to pressure on the tongue in two cases (elevated EGM threshold for both the anterior and posterior tongue), and zinc deficiency in one case (normal EGM threshold; Zn/Cu ratio below 0.7).[29] All three patients recovered taste sensation within 1.5 months. Although the EGM values of the 35 patients were nominally higher post-operatively than pre-operatively [respective means (SDs) = 5.5 dB (1.9) & 4.6 dB (1.7)], this small effect was not statistically significant. Moreover, both pre- and post-operative means were within normal limits.

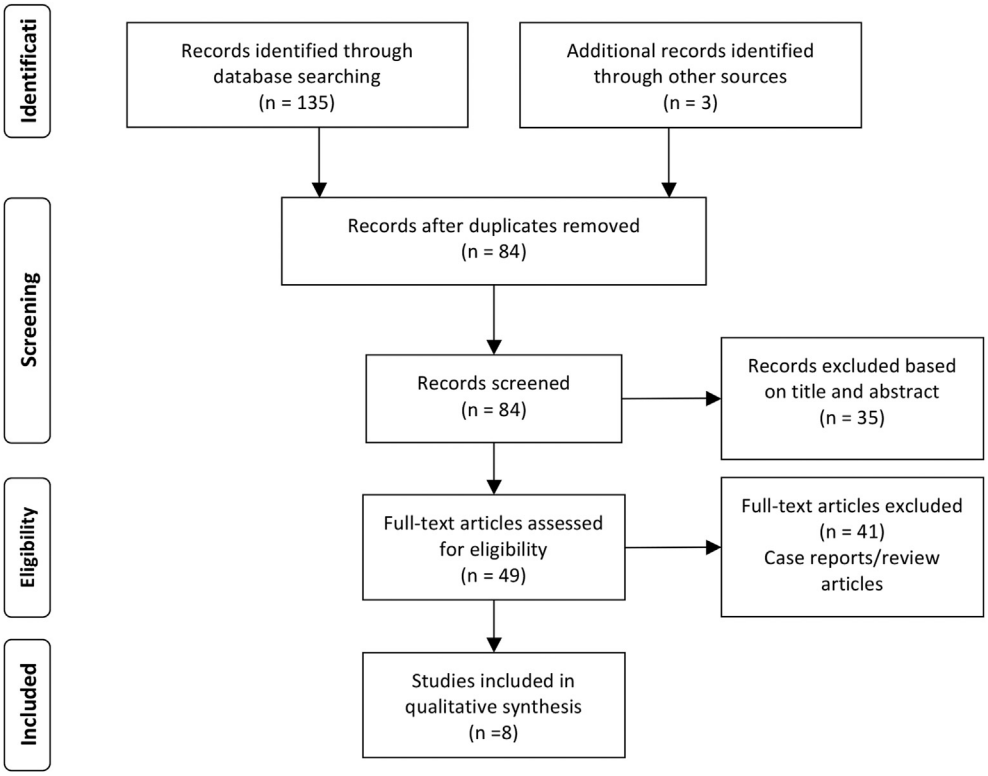

Fig. 2 Flowchart of study selection.

Table 1 Post-tonsillectomy taste disturbances in the literature.

First author (Year)	Ref. no.	Male: Female	Study design	Study method	Taste evaluation method
Tomita (2002)	15	6:5	Case series	Retrospective	Patient survey; Chemical gustometry post-op (filter paper disk method); EGM post-op
Tomofuji (2005)	29	23:12	Case series	Prospective	Patient survey; EGM pre- and post-op
Mueller (2007)	33	23:42	Case series	Prospective	Patient survey; Chemical gustometry (filter paper test strips) pre- and post-op
Smithard (2009)	35	64:36	Case-control	Prospective	Patient survey
Stathas (2010)	32	24:36	Case-control	Prospective	Chemical gustometry (solution application to the tongue) post-op
Windfuhr (2010)	31	40:60	Case series	Retrospective	Chemical gustometry (soaked cotton balls) pre- and post-op
Heiser (2010)	30	n/a	Case series	Prospective	Patient survey post-op
Heiser (2012)	38	n/a	Case series	Prospective	Patient survey post-op

Table 2 Patient-reported post-tonsillectomy taste disturbances.

First author (Year)	Ref. no.	Reported post-op symptoms	Post-op follow-up	Prevalence
Tomita (2002)	15	Dysgeusia, hypogeusia	4–7 months	n/a (11 cases)
Tomofuji (2005)	29	Hypogeusia, decreased tongue sensation	4–6 days	8.6% (3 of 35)
			8 days–1.5 months	0 (0 of 35)
Mueller (2007)	33	"Transient" dysgeusia	"days"	23% (15 of 65)
Smithard (2009)	35	"Altered taste sensation"	1 day	11% (11 of 100)
			3 months	0 (0 of 11)
Windfuhr (2010)	31	Dysgeusia	4 days	29% (29 of 100)
			14 days	13% (13 of 100)
			21 days	6% (6 of 100)
			3 months	0 (0 of 100)
Heiser (2010)	30	Dysgeusia, hypogeusia	14 days	32% (60 of 188)
		Dysgeusia, hypogeusia	6 months	8.3% (15 of 181)
Heiser (2012)	38	Dysgeusia, hypogeusia	32 $\pm$ 10 months	0.1% (2 of 15)

In 2007, Mueller et al[33] had 65 German or Swiss tonsillectomy patients self-assess their taste function before and after tonsillectomy on a scale that ranged from no taste (0) to excellent taste (10). Of these 65 patients, 32 were tested with chemical gustometry (filter paper strips) on the left and right sides of the anterior and posterior tongue before and after surgery. No pre-post differences in the taste strip test scores were found (32 trials in front and back of the tongue; respective pre-post posterior means = 23.7 & 24.8 and pre-post anterior means = 27.1 & 27.8). Although the taste mean scores were lower in the back than in the front of the tongue ($p = 0.001$), such front-back differences are well established in the general population.[34] The self-assessed taste ratings were lower post-op relative to pre-op ratings, and 15 of the 65 patients (23%), some of whom were interviewed over the telephone, reported experiencing transient dysgeusia "days" after surgery. This study is limited by inconsistent length of follow-up and no differentiation between the basic taste qualities.

In 2009, Smithard et al[35] administered a questionnaire on the day prior to discharge to 104 tonsillectomy patients and 43 appendectomy patients (controls) that inquired about altered post-surgical tongue sensations. The patients were from a district general hospital in England. These investigators found that 28 of the tonsillectomy patients (28%) had aberrant tongue sensations one day after surgery, with 11 (11%) reporting altered taste. The authors contacted 23 of the 28 symptomatic patients 3 months after surgery. Only one patient had persistent tongue paresthesia. The median time for return to normal tongue sensation was two weeks. This study was limited by the lack of actual taste testing and, like earlier studies, the fact that self-reports of taste dysfunction are often unreliable.[20] Additionally, since only patients who reported altered tongue sensation one day after surgery were contacted, those with a possible delayed onset of symptoms would not have been sampled.

That same year, Stathas et al[31] assessed the taste function of 60 Greek patients prior to and 1-, 15- and 30-days after tonsillectomy. They evaluated chemical taste sensation employing a procedure modified from that of Doty et al.[36] The standard procedure (six 15 μl trials × 4

Table 3 Chemical gustometry and EGM in post-tonsillectomy taste studies.

First author (Year)	Ref. no.	Post-op follow-up	Chemical gustometry results	EGM results
Tomita (2002)	15	4–7 months	Positive for hypogeusia, ageusia	Increased threshold values post-op
Tomofuji (2005)	29	1 week	Not performed	Increased threshold values post-op, no significant difference[b]
Mueller (2007)	33	2–5.5 months	No significant difference[a]	Not performed
Stathas (2010)	32	1 day	Positive for hypogeusia ($n = 54$)	Not performed
		0.5 months	Positive for hypogeusia ($n = 2$)	Not performed
		1 month	Positive for hypogeusia ($n = 1$)	Not performed
Windfuhr (2010)	31	4 days	No significant difference[a]	Not performed
		14 days	Significantly different only for left rare tongue[a]	Not performed

[a] Pre- and post-operative gustometry testing results compared.
[b] Pre- and post-operative EGM testing results compared.

tastants × 4 tongue regions = 96 trials) was changed by decreasing the number of trials per stimulus to 1 trial each and adding three different stimulus volumes (15 μl, 30 μl, 60 μl). Thus, the total number of trials was reduced to 48 (3 trials × 4 tastants × 4 tongue regions = 48 trials). One day after surgery the ability to identify the taste qualities was found to be low on the posterior tongue (area supplied by CN IX), particularly for the sour- and bitter-tasting stimuli. For example, for the 15 μlsolution, 90% of tested subjects (54 of 60) failed to correctly identify the stimulus on that day. On the subsequent test occasions, performance improved, with 95% or more of the trials being correct by 30 days. It is conceivable that some aberration of perception beyond loss was present on post-operative day 1 (e.g., a taste quality confusion).[37] If ageusia alone was present, a given subject would be expected, by chance alone, to correctly identify about one-fourth of the trials (25%) or to fail ~75% of the trials. This would translate to ~75% of subjects failing the task, not 90%.[33]

In 2010, Windfuhr et al[31] published a retrospective study of 100 German or Swiss post-tonsillectomy patients and described patient-reported taste changes in 29 patients four days after surgery. Chemical taste testing was performed before surgery as well as 4 and 14 days after surgery on both sides of the tongue using soaked cotton balls. In all 29 reported cases of taste disturbance, the symptoms resolved within 3 months of the procedure. The difference in taste function before and after surgery for all patients was statistically significant only on the left side of the rear tongue and only 14 days after tonsillectomy, which was attributed to the improvement in sweet sensation between day 4 and day 14 after tonsillectomy. The authors suggested that wound healing scored by a physician 4, 14 and 21 days after the operation led to the return of normal taste function. They also commented on the possibility of the measurement bias due to their use of non-standardized taste assessment methods.

A prospective German study by Heiser et al published in 2010 surveyed 188 patients following tonsillectomy.[30] Of 188 patients surveyed 2 weeks after surgery, 32% (60 patients) reported taste disturbances. This decreased to 8.3% six months after surgery (15 of 181 surveyed patients). In most cases, when questioned about the presence of a "strange taste," the participants reported presence of a metallic or bitter taste at the posterior tongue (area innervated by the lingual branches of CN IX). No quantitative taste function testing was performed in this study.

In a follow-up study published two years later, Heiser and colleagues interviewed 15 subjects who reported taste disturbances two weeks after tonsillectomy when surveyed in 2010 [follow-up of (32 ± 10) months after tonsillectomy] and found that two patients (0.9%) still experienced taste dysfunction, although their symptoms had changed in character over time.[38] Unfortunately, as in their earlier work, quantitative taste tests were not performed. Although the study attempted to provide long-term follow-up information on post-tonsillectomy taste distortion, only 8% of the subjects from their original study in 2010 (15 patients of 188) were surveyed.

Since 2012, no studies have been published on the influences of tonsillectomy on taste function. Nonetheless, numerous book chapters, informational papers, online blogs, lawsuits against surgeons and articles in the popular press have brought this problem to the attention of both, otolaryngologists and the general public.[20,23–26,39–41]

Discussion

Taste dysfunction has been previously described as one of the rare complications of tonsillectomy, although, as noted in this review, the prevalence and nature of such dysfunction is enigmatic. Relatively few studies have quantitatively assessed such function before and after tonsillectomy, despite reports suggesting that, in some cases, post-tonsillectomy taste disturbances may be severe enough to produce long-term dietary alterations that result in weight changes and decrease quality of life.[42,43] It should not be overlooked, however, that adult tonsillectomy is a rather traumatic experience for some patients, and can produce considerable post-operative swelling as well as pain during swallowing and mastication. This in itself can lead to decreased oral intake, and sub-optimal ability to appreciate the flavor of foods. Some patients may perseverate in

their belief that they cannot taste as a result of such factors even though return of normal function has occurred.

The eight studies identified in this literature review[15,29–33,35,38] reported a rate of transient taste dysfunction following tonsillectomy as high as 29%–32% (Table 2). Unfortunately, these metrics were not always supported by psychophysical testing (EGM or chemical gustometry), with only five studies providing quantitative taste testing and even fewer reporting on the difference between pre- and post-operative test results. Each study utilized different psychophysical testing methods, complicating the comparison of results. Additionally, some authors did not make a distinction between quantitative and qualitative taste disturbances when reporting symptoms.

One of the potential causes of post-tonsillectomy hypogeusia and dysgeusia is direct or indirect injury to CN IX from ligation or stretching of the nerve, or from scarring of the nerve during post-operative healing.[15,27,44,45] The lingual branches of CN IX are at risk of injury during tonsillectomy due to anatomic variation of its relationship to superior constrictor muscles of the palatine tonsillar bed (Fig. 1). In a study of 83 cadaver dissections, Ohtsuka et al[46] reported that only in 23.4% of cases they passed at a distance beneath the styloglossus muscle and were at a low risk of injury during tonsillectomy. In 55.1% of cases, these branches of CN IX were only partially protected by the muscle fibers of the stylopharyngeus, palatopharyngeus and superior pharyngeal constrictors. In 21.5% of cases, the lingual branches of CN IX were directly adherent to the tonsillar capsule due to incomplete coverage of the tonsillar fossa by the pharyngeal constrictor muscles, placing it at higher risk of injury.

More recently, a study by Hill et al[47] reported that in 138 reviewed tonsillectomy operative reports in a pediatric subset of patients, twenty-eight cases (20.3%) had at least one lingual branch of CN IX exposed at the end of surgery. Nine cases (9.5%) had bilateral nerve exposure. Interestingly, the authors found statistically significant predilection for the visualization of the left glossopharyngeal nerve (24 of 37 nerves exposed on the left *vs.* 13 of 37 on the right). This study further highlights the vulnerability of the glossopharyngeal nerve branches during tonsillectomy.

Although the nature of qualitative taste disturbances such as dysgeusia and phantogeusia is not completely understood, several investigators have proposed that alterations in the normally redundant and parallel afferent signals to the brain can lead to dysgeusia or phantogeusia symptoms. Such taste anomalies can result from the damage to any one of the cranial nerves responsible for taste sensation (CN VII, CN IX or CN X), with the increase in the response to the stimuli from the other cranial nerves supplying taste.[12,48] Prior reports of middle ear surgery complications have shown that damage to the chorda tympani can result in not only decreased taste, but also in taste phantoms, notably metallic, bitter or salty sensations.[49,50] Studies by Bartoshuk et al[6] Lehman et al[48] and Halpern et al[50] support the theory of increased CN IX responses in the presence of anesthesia to the chorda tympani nerve, reflecting physiologic compensation to minimize the loss of taste sensation from this branch of CN VII. In post-tonsillectomy dysgeusia cases reported in the past, elevation of EGM threshold in the posterior tongue has been observed.[14,27,28] This correlated with the patient reports of unpleasant or bitter taste, which could be explained by the increase in the response to the stimuli delivered to the uninjured areas of the tongue.

Conclusion

Due to small sample sizes, variable lengths of follow-up, lack of uniformity in study design and assessment methods, and the fact that many patients fail to recognize deficits in their taste sensation until it is tested,[20] the available literature does not provide enough information to estimate the prevalence, duration and nature of post-tonsillectomy taste disorders. Case reports suggest that taste disturbances can persist in some patients 18–24 months after surgery.[15,27,28,46] Clearly, long-term studies are needed to determine whether dysfunction can remain even longer and whether, like tinnitus and some other problems, patients develop strategies to ignore an ongoing sensation. Overall, the studies reviewed in this article suggest that taste disturbances should be included as a potential risk in the pre-operative counseling of patients prior to tonsillectomy. Future studies are needed to provide more information on the prevalence of long-term taste dysfunction following tonsillectomy and the mechanisms to aid patients in coping with them when they occur.

References

1. Yarmolinsky DA, Zuker CS, Ryba NJ. Common sense about taste: from mammals to insects. *Cell*. 2009;139:234–244.
2. McLaughlin S, Margolskee RF. The sense of taste. *Am Sci*. 1994; 82:538–545.
3. Woschnagg H, Stollberger C, Finsterer J. Loss of taste is loss of weight. *Lancet*. 2002;359:891.
4. Shin YK, Martin B, Kim W, et al. Ghrelin is produced in taste cells and ghrelin receptor null mice show reduced taste responsivity to salty (NaCl) and sour (citric acid) tastants. *PLoS One*. 2010;5. e12729.
5. Schiffman SS, Graham BG. Taste and smell perception affect appetite and immunity in the elderly. *Eur J Clin Nutr*. 2000; 54(suppl 3):S54–S63.
6. Bartoshuk LM, Catalanotto F, Hoffman H, Logan H, Snyder DJ. Taste damage (otitis media, tonsillectomy and head and neck cancer), oral sensations and BMI. *Physiol Behav*. 2012;107: 516–526.
7. Lewis D, Dandy WE. The course of the nerve fibers transmitting sensation of taste. *Arch Surg*. 1930;21:249–288.
8. Zahm DS, Munger BL. The innervation of the primate fungiform papilla—development, distribution and changes following selective ablation. *Brain Res*. 1985;356:147–186.
9. Bromley SM, Doty RL. Clinical disorders affecting taste: an update. In: Doty RL, ed. *Handbook of Olfaction and Gustation*. 3rd ed. Hoboken, N.J.: John Wiley & Sons; 2015:887–910.
10. Landis BN, Lacroix JS. Postoperative/posttraumatic gustatory dysfunction. *Adv Otorhinolaryngol*. 2006;63:242–254.
11. Saito T, Manabe Y, Shibamori Y, et al. Long-term follow-up results of electrogustometry and subjective taste disorder after middle ear surgery. *Laryngoscope*. 2001;111:2064–2070.
12. Yanagisawa K, Bartoshuk LM, Catalanotto FA, Karrer TA, Kveton JF. Anesthesia of the chorda tympani nerve and taste phantoms. *Physiol Behav*. 1998;63:329–335.
13. Catalanotto FA, Bartoshuk LM, Östrum KM, Gent JF, Fast K. Effects of anesthesia of the facial nerve on taste. *Chem Senses*. 1993;18:461–470.

14. Windfuhr JP, Schlöndorff G, Sesterhenn AM, Kremer B. From the expert's office: localized neural lesions following tonsillectomy. *Eur Arch Otorhinolaryngol*. 2009;266:1621—1640.
15. Tomita H, Ohtuka K. Taste disturbance after tonsillectomy. *Acta Otolaryngol Suppl*. 2002:164—172.
16. Klasser GD, Utsman R, Epstein JB. Taste change associated with a dental procedure: case report and review of the literature. *J Can Dent Assoc*. 2008;74:455—461.
17. Gaut A, Williams M. Lingual nerve injury during suspension microlaryngoscopy. *Arch Otolaryngol Head Neck Surg*. 2000; 126:669—671.
18. Rombaux P, Hamoir M, Bertrand B, Aubert G, Liistro G, Rodenstein D. Postoperative pain and side effects after uvulopalatopharyngoplasty, laser-assisted uvulopalatoplasty, and radiofrequency tissue volume reduction in primary snoring. *Laryngoscope*. 2003;113:2169—2173.
19. Snyder DJ, Sims CA, Bartoshuk LM. Psychophysical measures of human oral sensation. In: Doty RL, ed. *Handbook of Olfaction and Gustation*. 3rd, ed. Hoboken: John Wiley & Sons; 2015:751—773.
20. Soter A, Kim J, Jackman A, Tourbier I, Kaul A, Doty RL. Accuracy of self-report in detecting taste dysfunction. *Laryngoscope*. 2008;118:611—617.
21. Burdach KJ, Doty RL. The effects of mouth movements, swallowing, and spitting on retronasal odor perception. *Physiol Behav*. 1987;41:353—356.
22. Hall MJ, Schwartzman A, Zhang J, Liu X. Ambulatory surgery data from hospitals and ambulatory surgery centers: United States, 2010. *Natl Health Stat Report*. 2017:1—15.
23. Windfuhr JP. Malpractice claims and unintentional outcome of tonsil surgery and other standard procedures in otorhinolaryngology. *GMS Curr Top Otorhinolaryngol Head Neck Surg*. 2013;12. Doc08.
24. Simonsen AR, Duncavage JA, Becker SS. A review of malpractice cases after tonsillectomy and adenoidectomy. *Int J Pediatr Otorhinolaryngol*. 2010;74:977—979.
25. Wienke A. Impairment of taste perception and extent of patient education in tonsillectomy. *Laryngorhinootologie*. 1992; 71:487—488.
26. Perrino A, Gessini L. Permanent disorders of taste after tonsillectomy. Medicolegal considerations. *Clin Otorinolaringoiatr*. 1961;13:624—629.
27. Collet S, Eloy P, Rombaux P, Bertrand B. Taste disorders after tonsillectomy: case report and literature review. *Ann Otol Rhinol Laryngol*. 2005;114:233—236.
28. Randall DA. Taste impairment following tonsillectomy and adenoidectomy: an unusual complication. *Ear Nose Throat J*. 2010;89:E15—E18.
29. Tomofuji S, Sakagami M, Kushida K, Terada T, Mori H, Kakibuchi M. Taste disturbance after tonsillectomy and laryngomicrosurgery. *Auris Nasus Larynx*. 2005;32:381—386.
30. Heiser C, Landis BN, Giger R, et al. Taste disturbance following tonsillectomy—a prospective study. *Laryngoscope*. 2010;120: 2119—2124.
31. Windfuhr JP, Sack F, Sesterhenn AM, Landis BN, Chen YS. Post-tonsillectomy taste disorders. *Eur Arch Otorhinolaryngol*. 2010;267:289—293.
32. Stathas T, Mallis A, Naxakis S, et al. Taste function evaluation after tonsillectomy: a prospective study of 60 patients. *Eur Arch Otorhinolaryngol*. 2010;267:1403—1407.
33. Mueller CA, Khatib S, Landis BN, Temmel AF, Hummel T. Gustatory function after tonsillectomy. *Arch Otolaryngol Head Neck Surg*. 2007;133:668—671.
34. Doty RL, Heidt JM, MacGillivray MR, et al. Influences of age, tongue region, and chorda tympani nerve sectioning on signal detection measures of lingual taste sensitivity. *Physiol Behav*. 2016;155:202—207.
35. Smithard A, Cullen C, Thirlwall AS, Aldren C. Tonsillectomy may cause altered tongue sensation in adult patients. *J Laryngol Otol*. 2009;123:545—549.
36. Doty RL, Haxel BR. Objective assessment of terbinafine-induced taste loss. *Laryngoscope*. 2005;115:2035—2037.
37. Doty RL, Chen JH, Overend J. Taste quality confusions: influences of age, smoking, PTC taster status, and other subject characteristics. *Perception*. 2017;46:257—267.
38. Heiser C, Landis BN, Giger R, et al. Taste disorders after tonsillectomy: a long-term follow-up. *Laryngoscope*. 2012;122: 1265—1266.
39. Petrozzello D. Post-tonsillectomy taste disorders rare but present. In: *ENTtoday*. Hoboken: John Wiley & Sons; 2012:1—4.
40. Blogger "Joon", Loss of taste after tonsillectomy: Everything Tastes Just Terrible, 2013 January 24. https://happybabyusa.org/2013/01/24/loss-of-taste-after-tonsillectomy.
41. Tooke G. *Sense of Taste after Tonsillectomy*; 2012 February 16. http://tonsillectomyrecovery.com/sense-of-taste-after-tonsillectomy.
42. Beck CN. Glossopharyngeus and tonsillectomy (author's transl). *Laryngol Rhinol Otol (Stuttg)*. 1979;58:463—465.
43. Goins MR, Pitovski DZ. Posttonsillectomy taste distortion: a significant complication. *Laryngoscope*. 2004;114:1206—1213.
44. Arnhold-Schneider M, Bernemann D. Incidence of taste disorders following tonsillectomy. *HNO*. 1987;35:195—198.
45. Sakuma A, Kobayashi Y, Takahashi F, et al. Taste disorders after tonsillectomy. *Jpn J Tonsil*. 1990;29:99—103.
46. Ohtsuka K, Tomita H, Murakami G. Anatomy of the tonsillar bed: topographical relationship between the palatine tonsil and the lingual branch of the glossopharyngeal nerve. *Acta Otolaryngol Suppl*. 2002:99—109.
47. Hill CA, Thimmappa V, Smith MC, Chen EY. Incidence of visualization of the glossopharyngeal nerve after pediatric tonsillectomy. *Otolaryngol Head Neck Surg*. 2016;154: 532—534.
48. Lehman CD, Bartoshuk LM, Catalanotto FC, Kveton JF, Lowlicht RA. Effect of anesthesia of the chorda tympani nerve on taste perception in humans. *Physiol Behav*. 1995;57: 943—951.
49. Bull TR. Taste and the chorda tympani. *J Laryngol Otol*. 1965; 79:479—493.
50. Halpern BP, Nelson LM. Bulbar gustatory responses to anterior and to posterior tongue stimulation in the rat. *Am J Physiol*. 1965;209:105—110.

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