Surgery for Chronic Otitis Media Causes Greater Taste Disturbance Than Surgery for Otosclerosis

yKatarina Berling Holm, zAnna Bornefalk-Hermansson,

y§Johan Knutsson, and yjjMagnus von Unge

Department of Otorhinolaryngology; yCentre for Clinical Research, Uppsala University, Va¨stmanland County Hospital, Va¨stera°s; zUppsala Clinical Research Center, Uppsala University, Uppsala; §Department of Otolaryngology, O¨rebro University Hospital, Sweden.; and jjDepartment of Otorhinolaryngology, Akershus University Hospital and University of Oslo, Oslo, Norway

Address correspondence and reprint requests to Katarina Berling Holm, Department of Otorhinolaryngology, Va¨stmanland County Hospital, 721 89 Va¨stera°s, Sweden; E-mail: katarina.berling.holm@regionvastmanland.se

Funding: This study was funded by The Regional Research Council of Uppsala – O¨ rebro, Sweden, Va¨stmanland County Council Research Foundation, Sweden, and the Centre for Clinical Research, Va¨stera°s, Uppsala University, Sweden.

The authors have no conflict of interest to disclose.

Objectives: Patients with otosclerosis more often complain about postoperative taste disturbance than patients with chronic otitis media, which seems paradoxical. We aim to investigate if and potentially why this seems to be the case, since the chorda tympani nerve (CTN) is thought to be severely traumatized less frequently during surgery in the former than in the latter.

Study Design: Prospective cohort study.

Setting: Department of Otorhinolaryngology at Hospital of Vastmanland, Vasteras, Sweden.

Patients: Sixty-five adults undergoing primary middle ear surgery were included. Thirty-seven were operated on for chronic suppurative otitis media with or without cholesteatoma (CSOM) and 28 for otosclerosis.

Interventions: Middle ear surgery due to otosclerosis or CSOM. Subjective and objective taste measurements and quality of life (QoL) questionnaire.

Main Outcome Measures: Taste was assessed using electrogustometry (EGM) and the filter paper disc (FPD) method before and up to 1 year after surgery. Questionnaires on taste disturbance, including a visual analogue scale (VAS), and QoL were completed before and up to 1 year after surgery.

Results: Subjective taste disturbance anytime during the 1-year follow-up were reported by 62 and 46%, respectively. The difference in EGM 1 week after surgery compared with preoperative EGM was significantly greater among CSOM patients than otosclerosis. One year postoperatively, the difference is non-significant.

Conclusion: Surgery for CSOM causes greater initial and more long-lasting taste disturbances as compared with surgery for otosclerosis. One-year postoperative taste normalizes for both CSOM and otosclerosis patients according to VAS and EGM measurements. No real change in QoL was seen 1-year postoperatively.

Level of evidence: Level 2 evidence is prospective observational research with an experimental design.

Key Words: Chorda tympani nerve—Chronic otitis media—Ear surgery—Electrogustometry—Otosclerosis—Taste.

The chorda tympani nerve (CTN), a branch of the facial nerve, is the most important taste nerve. It runs uncovered through the middle ear. This localization exposes the CTN to pathological processes in the middle ear and to surgical trauma. In chronic suppurative otitis media with or without cholesteatoma (CSOM), the CTN can be exposed to bacterial toxins and enzymes and may be affected by mechanical damage. In middle ear surgery, the CTN is at risk because it can be touched and stretched by surgical instruments, desiccated under the light of the operating microscope, or even severed.

In clinical practice, patients operated on for CSOM seldom complain regarding taste disturbance even though the CTN is sometimes severely traumatized during the surgery. By contrast, patients with otosclerosis seem to complain more often about postoperative taste disturbance. This seems paradoxical because the impression among surgeons is that the CTN is severely traumatized less frequently in patientswith otosclerosis than in those with CSOM (1–13). In theory, patients with CSOM have impaired taste ability because of the pathology before surgery and would be less prone to become affected by taste disturbance after surgery. A few studies reported preoperative taste disturbance in patients with CSOM and other reported, in contrast, functional improvement after surgery for CSOM (5,14,15). Several studies reported morphological changes in the CTN in patients operated for CSOM (16–19).

In the field of otosurgery, different opinions prevail about the best way to handle the CTN, but the matter is rarely addressed in the literature. The aims of the present study were to investigate to what extent patients with CSOM experience nerve malfunction before surgery, to what extent manipulations of the CTN during surgery impair nerve function, and whether nerve function recovers with time. It was examined whether the CTN status upon tympanotomy might predict the postoperative outcome of taste function and whether there are age or sex differences regarding postoperative taste disturbance. A further aim of the study was to investigate to what extent postoperative malfunction of the CTN affects quality of life (QoL).

MATERIALS AND METHODS

Patients

Seventy-five patients undergoing primary middle ear surgery for CSOM or for otosclerosis, at the Ear, Nose and Throat department of Va¨stmanland County Hospital Va¨stera°s, Sweden, were included from November 2009 through April 2016. Ten patients were excluded because of loss to follow-up, the need for revision surgery during the study period or an inability to comprehend the questionnaires. The final study population comprised 65 patients.

At inclusion, each participant signed an informed consent form and was given a study identification number. All collected study data were anonymized. The patients' taste was measured using two methods: electrogustometry (EGM) and the filter paper disc (FPD)method.Before surgery, the patientscompleted a symptom

questionnaire about taste disturbance and a validated QoL questionnaire, the Short Form36 Health Survey (SF-36). The surgeon recorded the status of the CTN and the extent of CTN traumatization during surgery. Taste measurements were performed, and the symptom questionnaire completed again at 1 week, 6 weeks, 6 months, and 1 year after surgery. The QoL questionnaire was repeated at 1 year postoperatively.

Electrogustometry

EGM was performed using the Rion TR-06 electrogustometer (Sensonics Inc., Haddon Heights, NJ). Taste buds at the surface of the tongue were stimulated for 2 seconds with calibrated electrical currents, delivered by a metal probe with a flat circular contact surface, 5mmin diameter. The lateral sides of the tongue were stimulated at about 2 cmfromits tip; both sides of the tongue were assessed independently of each other. The current level was increased stepwise from 4 to 400mA and the current readings were converted into a logarithmic dB scale in which 4mA corresponds to 6 dB and 400mA to 34 dB. Steps of 2 dB were used. The lower the value in dB, the more sensitive the taste. The participants' perception of a sensation was indicated by pressing a button. The threshold value was defined as the lowest current level that twice elicited a positive response, interspersed with a current at one level below the threshold level that did not elicit a response. The participants were blinded with regard to the stimulation time and levels.

Filter Paper Disc Method

The FPD method was used to test the ability to recognize four flavors: sweet; salty; sour; and bitter. Circular FPDs with a diameter of 5mm were soaked in a solution of one of the four

flavors, each at five different concentrations. One disc at a time was placed at the lateral side of the tongue, about 2 cm from its tip. The lowest concentration level was applied first and was followed by the next higher level until the participant indicated perception of the correct flavor. This method was used to establish a threshold for each of the four flavors for each patient. The scoring system ranged from 1 to 6, where 1 represented the lowest threshold, 5 the highest measurable threshold and 6 represented an un-measurably high threshold, i.e., that no flavor was perceived even at the highest concentration. The scores for all four flavors were summed to produce a total score for each side. The total score could vary from 4 to 24, where a score of 4 is equivalent to maximum taste ability and a score of 24 is equivalent to no ability to perceive flavors. The Central Pharmacy in Stockholm, Sweden prepared the solutions. The concentrations used in the study (substance to create this taste) were as follows; salty (sodium chloride) 0.5, 2.5, 5, 10, and 25%; sweet (sucrose) 0.5, 2.5, 10, 20, and 50%; sour (citric acid) 0.1, 1, 2, 5, and 10%; and bitter (quinine hydrochloride) 0.05, 0.25, 0.5, 1, and 2.5%.

Symptom Questionnaire

The participants completed a symptom questionnaire to record symptoms before and after surgery. The participants were asked to indicate the type of disturbances experienced, such as: loss of taste; metallic taste sensation; numbness; tingling; or ‘‘other types’’ of disturbance. For other types, space was provided for the patient to describe the disturbance(s) in his or her own words. The participant also indicated the severity of the disturbance on a visual analog scale (VAS) from 1 (no disturbance) to 100 (maximum disturbance).

Quality of Life Questionnaire (SF-36)

The SF-36 is a QoL questionnaire for general health, and is the questionnaire most frequently used in otorhinolaryngology. It has a scoring system from 0 (no disability) to 100 (maximum disability) that comprises questions in eight domains: physical function; role limitations due to physical problems; role limitations due to emotional problems; energy/fatigue; emotional well-being; social function; pain; and general health (20,21).

Surgeon's Form

The surgeon recorded the status of the CTN immediately upon elevation of the tympanomeatal flap by indicating the presence or absence of CTN atrophy, dislocation, and adherence involving the CTN. Next, the surgeon recorded any incidental surgical trauma to the CTN during surgery as: untouched; touched, and stretched only; visually injured; severed or shrunk because of desiccation under the light from the operating microscope.

Statistical Methods

Patient characteristics were tabulated by diagnosis using median with range (for age) or interquartile range (IQR) due to skewness of the distributions. Categorical variables were expressed as frequencies and percentages.

The two primary objectives were the difference in taste disturbance after surgery between the two diagnoses, at 1 week after the operation and at 1 year. Taste disturbance was measured as the difference in EGM before the operation and 1 week or 1 year afterwards, respectively. With an overall significance level of 0.05, these two-sided t tests were individually considered significant if the p-value from the test was less than 0.025

(Bonferroni correction for multiple testing).

All secondary analyses were of a descriptive nature via individual value plots and no testing was performed. Focus was on subjective (as measured by symptoms yes/no) and objective (as measured by EGM) taste disturbance, sex, preoperative CTN abnormalities, and trauma afflicted to the CTN during surgery.

Ethics

The study was performed in accordance with Swedish ethical legislation and with approval from Regionala etikpro¨vningsna ¨mnden, Uppsala, Sweden (dnr 2007/250).

RESULTS

The study population of 65 adults is described in Table 1 and comprised 36 (55%) women and 29 (45%) men. The median age was 45 years (range, 17–74); 37 (57%) patients had CSOM and 28 (43%) had otosclerosis. Only four patients (6%), all of which were women, reported preoperative taste disturbance: one had CSOM and three had otosclerosis. Two of the three patients with otosclerosis had higher EGM scores than the patients with otosclerosis that did not report taste disturbance before the surgery (see Fig. 1). The EGM values did not differ markedly between either CSOM and otosclerosis nor between men and women.

Thirty-six participants (55%) reported taste disturbances after surgery. The frequency (percentage) of participants reporting taste disturbance were as follows (not in table): 32 (89%) sensitivity disturbance; 30 (83%) taste disturbance; 28 (78%) numbness; 27 (75%) loss of taste; 23 (64%) metallic taste sensation; and 13 (36%) tingling.

Six (17%) participants reported other types of disturbances, which were described as: bad taste; poison; salty; sour; and ‘‘ghost taste,’’ i.e., bitter or sweet taste between meals.
As can be seen in Table 1, the percentage of selfreported symptoms was higher for the CSOM patients throughout the follow-up, but levels off towards the 1-year checkup. VAS was more stable, but the variation was larger for CSOM up to 6 months. At 1 year, the taste disturbance as measured by VAS had vanished for both diagnoses. EGM showed higher values for CSOM than for otosclerosis, with the same pattern of an initial increase that had leveled off at the end of the year.
The reference values for the never operated ear were low and quite stable. The pattern for FPD was not as clear-cut as the other three measures but showed more taste disturbance among CSOM patients. The reference values here were similar to the values for the operated ear, indicating that FPD perhaps is not a valid measure here. There was no real change in QoL 1 year after surgery as compared with before, which is in line with the normalization of the other measures.
Table 2 presents the result from the tests of the primary hypotheses of a difference between the diagnoses regarding objective taste disturbance 1 week and 1 year after surgery. The mean difference in EGM 1 week after surgery compared with the preoperative EGM was 7.2 dB (standard deviation, SD, 12.9) for CSOM and 0.9 dB (SD 6.7) for otosclerosis. The difference of 6.3 dB (95% confidence interval, CI, 1.3–11.2) was significantly different from zero (p¼0.014); the taste disturbance as measured by EGM was greater among patients with

CSOM than patients with otosclerosis. One year after surgery, the mean was −0.6 dB (SD 9.7) for CSOM and −0.3 dB (SD 6.3) for otosclerosis, with a difference of −0.3 dB (95% CI, −4.3–3.7). This is not significantly different from zero (p¼0.877) and hence we cannot conclude that there was a difference 1 year after the operation.

The variation among CSOM patients regarding the degree of taste disturbance 1 week after surgery was higher than for otosclerosis patients (Table 2, Fig. 2 top panel). Exclusion of patients with severe trauma afflicted to the CTN during surgery from the analysis did not alter the higher variability. The higher variability together with the greater taste disturbance was similar for different patient ages (see Fig. 3). One year after surgery, both the taste disturbance and its variability were similar between the diagnoses (Table 2, Fig. 2 bottom panel).

Taste disturbances after 1 week, both objective as measured by EGM and subjective, showed great variability within the different categories (sex; diagnosis; abnormality of, or severe trauma to the CTN). The concordance between objective taste disturbance at 1 week and subjective taste disturbance anytime during follow-up was low, which may be due to disturbances appearing before or after 1 week for some patients and that experienced taste disturbance may be of a positive nature. There were no obvious differences between men and women. Taste disturbance was, however, greater for patients with normal CTN. The concordance between subjective and objective taste disturbance was greater for otosclerosis women with normal CTN and without severe

trauma, as compared with the same group with CSOM, but this is not generalizable due to the few observations.

DISCUSSION

The effect of surgical trauma to the CTN and whether different degrees of traumatization or severing of the CTN produce symptoms is seldom discussed among surgeons. One opinion among some surgeons is that a complete severing of the CTN during tympanotomy causes fewer symptoms than leaving the nerve severely traumatized (6,8,9). Rice reported that cutting or preserving the CTN made little difference to postoperative symptoms (22). The current attitude seems to favor preservation of the CTN (7,11–13). In the present study, all four incidents in which the CTN was severed completely occurred in the CSOM group. This is not unexpected, since in CSOM the CTN is often involved in the pathology and surgery involves dissection of the CTN. Surprisingly, only two of these patients reported symptoms at 1 year after the surgery and one had normal EMG and FPD scores. One possible explanation is that, provided that the two nerve endings are in close proximity after the CTN is severed, regrowth of nerve fibers may eventually restitute nerve function (23). In a previous study, we found histological signs of nerve regeneration (sprouting) in CTNs from ears with CSOM (16). The fact that taste is mediated via three different nerves may also explain why loss of function of one nerve may be asymptomatic. The CTN exerts a central suppressive mechanism on the glossopharyngeal nerve (24). When the CTN becomes impaired or completely nonfunctional

there is a release of this suppression, which may compensate for loss of CTN function (5,8).

The effects of taste disturbance upon QoL have seldom been addressed in the literature. To our knowledge, only one paper has evaluated the effects of taste disturbance on QoL in relation to surgery for otosclerosis (25). A weakness of our use of the SF-36 in the present study is that the postoperative hearing gain and possible relief of other aural symptoms may have confounded the results (26,27).

CSOM patients experience both negative and positive changes in taste sensitivity according to these data, whereas otosclerosis patients may be prone to negative disturbances, if any. This may be the reason for the perception that otosclerosis patients complain more often. The results of this study show that the taste disturbance after surgery is greater for patients with CSOM than for patients with otosclerosis, and that disturbances remain for longer time in CSOM patients. They also show, however, that taste function normalizes after 1 year. These results were primarily supported by EGM and VAS. The binary variable symptoms yes/no were more in line with EGM and VAS than FPD but seems to be a better indicator for patients with otosclerosis than with CSOM.

The inflammatory nature of CSOM makes it more difficult to avoid trauma to the CTN during surgery. The nerve is when necessary cleared from disease during surgery and may thus be touched, stretched, severed, or desiccated. This is likely the explanation for both the higher occurrence and longer persistence of taste disturbance

among CSOM patients. The inflammation of the middle ear does, however, not seem to have caused any noticeable difference between the diagnoses regarding taste disturbance before surgery, according to all measures. The variation among CSOM patients in the amount of taste disturbance was higher than for otosclerosis patients.

A weakness with symptom assessment is the lack of a validated questionnaire. A new questionnaire was developed for this study and the results indicate a need for a revised version of the patient form. The higher variability in the data for CSOM can be due to the use of, e.g., perioperative antibiotics or steroids, which can give a negative taste disturbance. Removal of mucoid exudate, desquamated epithelium, or granulation tissue during surgery may affect taste sensitivity in a positive direction for CSOM patients. Subjective symptom assessment should therefore be a variable with three categories rather than two; no taste disturbance/less sensitive taste/more sensitive taste. In future work, the data collecting procedure would also benefit from addressing other variables that affect taste such as coexisting diseases and current medication.

This data set is too limited in size to enable modeling of how likely and for how long an individual patient can be expected to experience taste disturbance after surgery for CSOM or otosclerosis. It does, however, give an insight into the vast individual variation and to relevant explanatory factors important in designing a comprehensive study that could be the foundation to a multivariable prognostic model.

CONCLUSIONS

Surgery for CSOM causes greater initial and more long-lasting taste disturbance as compared with surgery for otosclerosis.

However, at 1 year after surgery, the taste disturbance as measured by VAS had vanished for both diagnoses, and as for EGM there was no remaining significant difference. Simultaneously, there was no real change in QoL as compared with before surgery. Thus, both the taste disturbance and its variability were similar between the diagnoses.

Acknowledgments: The authors wish to thank the staff members at the Ear, Nose, and Throat department at Va¨stmanlands Hospital Va¨stera°s and particularly Monika Stroka, Mona Bergstro ¨m, Lina Hejneborg, and Eva Johansson for their assistance in the inclusion of patients and collection of data.

REFERENCES

1. Gopalan P, Kumar M, Gupta D, Phillipps JJ. A study of chorda tympani nerve injury and related symptoms following middle-ear surgery. J Laryngol Otol 2005;119:189–92.

2. Sano M, Ito K, Suzukawa K, Kaga K, Yamasoba T. Influence of chronic middle ear disease on gustatory function: an electrogustometric study. Otol Neurotol 2006;28:44–7.

3. Miuchi S, Sakagami M, Tsuzuki K, Noguchi K, Mishiro Y, Katsura H. Taste disturbance after stapes surgery – clinical and experimental study. Acta Otolaryngol Suppl 2009;129:71–8.

4. Sakagami M, Sone M, Tsuji K, Fukazawa K, Mishiro Y. Rate of recovery of taste function after preservation of chorda tympani nerve in middle ear surgery with special reference to type of disease. Ann Otol Rhinol Laryngol 2003;112:52–6.

5. Huang CC, Lin CD, Wang CY, Chen JH, Shiao YT, Tsai MH. Gustatory changes in patients with chronic otitis media, before and after middle-ear surgery. J Laryngol Otol 2012;126: 470–474.
6. House HP. Early and late complications of stapes surgery. Arch Otolaryngol 1963;78:606–13.
7. 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;111:2064–70.
8. Nin T, Sakagami M, Sone Okunaka M, Muto T, Mishiro Y, Fukazawa K. Taste function after section of chorda tympani nerve in middle ear surgery. Auris Nasus Larynx 2005;33:13–7.
9. Kenway B, Kasbekar A, Donnelly N, Axon P. The effect of early division of the chorda tympani on gustatory function. Ear Nose Throat J 2011;11:221–5.
10. Berteretche MV, Eloit C, Dumas H, et al. Taste deficits after middle ear surgery for otosclerosis: taste somatosensory interactions. Eur J Oral Sci 2008;116:394–404.
11. Mahendran S, Hogg R, Robinson JM. To divide or manipulate the chorda tympani in stapedotomy. Eur Arch Otorhinolaryngol 2005;262:482–7.
12. Yeo SB, Loy AH. Chorda tympani trauma – how much does it affect taste? Singapore Med J 1997;38:329–31.
13. Guder E, Bo¨ttcher A, Pau HW, Just T. Taste function after stapes surgery. Auris Nasus Larynx 2012;39:562–6.
14. Krishna A, Babu SV, Mohiyuddin SMA, Naseeruddin K. Gustatory function in chronic otitis media (mucosal type) before and after tympanoplasty. Eur Arch Otorhinolaryngol 2017;274: 95–99.
15. Saito T, Ito T, Ito Y, Yamada T, Okamoto M, Manabe Y. Gustatory dysfunction and decreased number of fungiform taste buds in

patients with chronic otitis media with cholesteatoma. Ann Otol Rhinol Laryngol 2016;125:704–9.
16. Berling K, Mannstro¨m P, Ulfendahl M, Danckwardt-Lilliestro¨m N, von Unge M. The chorda tympani degenerate during chronic otitis media: an electron microscopy study. Acta Otolaryngol 2015;135: 1–7.
17. Gedikli O, Dogru H, Aydin G, Tuz M, Uygur K, Sari A. Histopathological changes of chorda tympani in chronic otitis media. Laryngoscope 2001;111:724–7.
18. Uygur K, Bayramoglu I, Nazikoglu A, Yilmaz M, Bayazit Y, Muftuoglu S. Ultrastructural analysis of the chorda tympani nerve in chronic suppurative otitis media. Otol Neurtol 2005;26: 1118–1121.
19. Teker AM, Gedikli O, Altun H, Korkut AY, Ahishali B. Chorda tympani nerve analysis with electron microscopy in chronic suppurative otitis media. Acta Otolaryngol 2010;130:859–64.
20. Sullivan M, Karlsson J, Ware JR Jr. The Swedish SF-36 health survey – I. Evaluation of data quality, scaling assumptions, reliability and construct validity across general populations in Sweden. Soc Sci Med 1995;41:1349–58.
21. Jo¨rnga°rden A, Wettergren L, von Essen L. Measuring health-related quality of life in adolescent and young adults: Swedish normative data for the SF-36 and the HADS, and the influence of age, gender, and method of administration. Health Qual Life Outcomes 2006;4:91.
22. Rice JC. The chorda tympani in stapedectomy. J Laryngol Otol 1963;77:943–4.
23. Saito T, Shibamori Y, Manabe Y. Incidence of regeneration of the chorda tympani nerve after middle ear surgery. Ann Otol Rhinol Laryngol 2002;111:357–63.
24. Kveton JF, Bartoshuk LM. The effect of unilateral chorda tympani

damage on taste. Laryngoscope 1994;104:1027–31.
25. Berling Holm K, Knutsson J, Stro¨mba¨ck K, et al. Taste disturbance after stapes surgery: an evaluation of frequency, severity, duration, and quality-of –life. Acta Otolaryngol 2017;137:39–43.
26. Subramaniam K, Eikelboom RH, Marino R, Atlas MD, Rajan GP. Patient's quality of life and hearing outcomes after stapes surgery. Clin Otolaryngol 2006;31:273–9.
27. Morzaria S, Westerberg BD, Anzarut A. Quality of life following ear surgery measured by the 36-item Short Form Health Survey and the Glasgow Benefit Inventory. J Otolaryngol 2003;32:323–7.