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Long-term follow-up of chorda tympani function after middle ear surgery

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Abstract. *Objectives*: The aim of this prospective single center study was to document the incidence of postoperative taste problems after middle ear surgery with long-term follow-up to assess the evolution. Secondary goals were to evaluate the influence of the pathology and the degree of chorda tympani (CT) manipulation on its function.
Methods: We used a questionnaire to prospectively assess subjective changes in taste in 40 patients undergoing middle ear surgery. We calculated chemical taste scores for the operated and contralateral side using a chemical taste test protocol. Intraoperative manipulation of the CT was also documented.
Results: A significant correlation between chemical taste scores on the operated side and the indicated taste was found preoperatively and short-term postoperatively. No correlation was found 3 years after the surgery. A significant correlation between the chemical taste score at the operated side and the degree of CT damage was also found. The chemical taste score on the operated side significantly decreased if the CT was stretched without visible damage in comparison to slightly touched.
Conclusion: Our results showed that a reduction in subjective taste was a relatively frequent yet transient complication after middle ear surgery. Compensatory mechanisms other than (partial) CT recovery co-existed and could explain the loss of correlation between chemical taste tests and subjective taste evaluation long-term postoperatively. Significant changes in chemical taste scores after CT manipulation suggest that surgeons' intraoperative evaluations of CT manipulation and stretching may be a good predictor of postoperative taste reduction.

Introduction

There are five basic taste receptors: sour, bitter, salty, sweet, and umami. Flavour is a more complex sensation than taste and involves tactile, thermal, taste, and odor sensations. Olfactory input is responsible for up to 80% of the sensation of flavor.[1]

Objective taste tests are expensive and not routinely available in clinical practice. Electrogustometry uses a non-physiological stimulus and only tests the sour receptor. Chemical taste tests are assessments with physiological stimuli. Mueller *et al*.[2] established a quick, lateralised, and reliable semi-quantitative chemical taste test based on taste strips. Landis *et al*.[3] implemented a forced multiple choice test that is also standard procedure in olfactory testing, and validated the test in a large cohort of healthy controls. Questionnaires are an easy tool for monitoring subjective taste dysfunctions. A study has shown that people who report a loss of olfaction typically also experience a loss of taste, whereas chemical taste investigations in this study showed that less than 4% had a loss of taste.[1] Patients often confuse taste with flavour when asked to provide a subjective taste assessment, influencing the evaluation of taste with a questionnaire. However, since this is a cheap, fast, and noninvasive method, it is still considered the method of choice to assess chorda tympani (CT) function.[4]

In this study, the taste function in patients undergoing middle ear surgery was prospectively assessed with a taste questionnaire and chemical taste test. The primary goal of this study was to investigate the correlation between subjective taste and chemical taste scores during a 3-year follow-up period. Secondary goals were to postoperatively

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assess the influence of pathology and degree of CT manipulation on its taste function.

Materials and methods

Study population

The taste function in 40 patients who received middle ear surgery was assessed repeatedly before and after surgery from 6 January 2013 until 13 November 2016. Every patient older than 18 years in need of a middle ear operation for the first time was recruited. Previous middle ear surgery on the contralateral ear was not considered to be exclusion criterion. The exclusion criteria were: concomitant autoimmune disease, chemotherapy, radiotherapy, surgery in the head and neck region, and recurrent cholesteatoma during the course of the study. We divided the different pathologies into two groups: non-inflammatory pathology (otosclerosis and "other" group in Tables 1 and 2) and inflammatory pathology (chronic otitis media [COM] with or without cholesteatoma in Table 1).

Table 1

Study population characteristics

N		**Gender**		**Age**		
		Male	Female	18-40	40-60	>60
Total	40	20	20	11	19	10
Cholesteatoma	19	9	10	7	7	5
COM	10	6	4	1	5	4
Otosclerosis	7	3	4	3	4	0
Other †	4	2	2	0	3	1

N=number; COM=chronic otitis media without cholesteatoma.
† See Table 2 for a list of indications.

Assessment of taste function

The analysis of patients' taste function was conducted prospectively using a questionnaire (Addendum 1) and a chemical taste test. The questionnaire was based on the article of Clark *et al*.[1] and assessed taste on a six-level scale ranging from extremely reduced taste to strongly improved taste. The purpose of the questionnaire was to assess changes in subjective taste. A decrease of one, two, or three levels on the six-level subjective taste scale was considered a slight, strong, or extreme decrease in subjective taste, respectively. An improvement of one or two levels on the subjective taste scale was considered a slight or strong improvement of subjective taste.

For the chemical taste test, we used a variant of the validated protocol by Mueller *et al*.[2] developed at the University of Dresden (Smell and Taste clinic; Dresden, Germany). In contrast to Mueller and colleagues, we implemented a forced multiple choice test as suggested by Landis *et al*.[3] We used four different concentrations of sweet (0.4, 0.2, 0.1, 0.05 g/mL saccharose), sour (0.3, 0.165, 0.09, 0.05 g/mL citric acid), salty (0.25, 0.1, 0.04, 0.016 g/mL sodium chloride), and bitter (0.006, 0.0024, 0.0009, 0.0004 g/mL quinine hydrochloride). Distilled water was used as a solvent. A semi-randomised sequence of taste application was determined by the research team in ascending concentration (a total of 32 trials were executed). The strips were wiped on the lateral side of the anterior two-thirds of the extended tongue, alternating between the left and right side. The patients were instructed to leave the tongue out of the mouth so they could not swallow or distribute the taste over the whole mouth with the tongue. They were also asked to rinse their mouths with water every four sweeps. A chemical taste score was calculated for the operated side and control side (maximum of 16). These two scores were combined and referred to as the total chemical taste score (maximum of 32).

The person who executed the chemical taste test was instructed not to ask the patient which ear was operated. Also the patients were asked not to communicate this information during the test. The result of the chemical taste test was not shared with the patient during the course of the study. Finally, the taste and concentration were not known by the person who executed the chemical taste test. The questionnaire was completed 1 day preoperatively

Table 2

Indications for middle ear surgery ("other" group in Table 1)

Pathology	Surgery
Bilateral deafness	Unilateral cochlear implant
Middle ear adenoma	Combined approach tympanoplasty
Ossicular chain discontinuity	Combined approach tympanoplasty
Ossicular chain discontinuity	Endaural tympanoplasty

Table 3
Preoperative subjective taste

	Subjective Taste, No. (%)				
Pathology	Strongly reduced	Slightly reduced	Normal	Slightly better	**Total**
Inflammatory	2 (7)	9 (31)	17 (59)	1 (3)	29
Non-inflammatory			11 (100)		11
Total	2 (5)	9 (23)	28 (70)	1 (2)	40

(T0), and 1 week (T1), 3 weeks (T2), and 3 years (T3) postoperatively. The chemical taste test was performed 1 day preoperatively (T0), 3 weeks (T2), and 3 years (T3) postoperatively.

Intraoperative CT assessment

The surgeon documented the degree of the Chorda Tympani manipulation by means of a questionnaire (Addendum 2). All surgeries were performed by two senior surgeons at the University Hospital Leuven (Leuven, Belgium) with the intention to preserve the CT if possible.

Statistical analysis

The patients were able to withdraw from the study at any time. However, if the patient withdrew after the completion of at least one postoperative questionnaire or taste test, his/her data were used in the analysis. Missing data were taken into account when analysing and interpreting the data. Respectively, 21%, 28%, and 38% of the patients did not participate at T1, T2, or T3. The “Little's Missing Completely At Random” test indicated that the missing data were missing in a completely random fashion ($p = 0.873$).[5] The statistical tests were executed with the IBM SPSS Statistics program (version 24). Because of the small dataset and unequal size of the compared groups, we used non-parametric tests for the statistical analysis. When possible, correlations were analysed using Spearman correlation analysis. Differences between two independent groups were analysed with the Mann-Whitney U test. We considered an alpha level less than 0.05 as significant. The power of the statistical tests was calculated a priori and checked post hoc with GPower (version 3.1); only results with a power level more than 0.8 were noted.

Ethics

This study was conducted according to the guidelines of the committee of medical ethics from the University Hospital of Leuven and the Declaration of Helsinki (S55008).

Results

Preoperative taste

All patients in the non-inflammatory group had a normal subjective taste at T0, and 38% of patients in the inflammatory group had reduced taste preoperatively (Table 3). Patients with inflammatory pathology and a reduction in subjective taste preoperatively, also had a significantly lower chemical taste score than patients who indicated normal or improved subjective taste, with mean chemical taste scores of 19.09 ($n = 11$) and 24.9 ($n = 19$), respectively ($p = 0.023$). The indicated subjective taste of the patient significantly correlated with the total chemical taste score ($r_s = 0.42$, $p = 0.006$; $n = 40$). This correlation was the strongest for the diseased side ($r_s = 0.5$, $p = 0.001$), but was also significant, yet weaker, for the healthy side ($r_s = 0.34$, $p = 0.032$).

Postoperative change in taste

We compared the patients' subjective taste functions at different postoperative times to T0 (Fig. 1). At T1, T2, and T3, 30% of 23 patients, 38% of 29 patients, and 22% of 27 patients, respectively, reported a reduction in taste compared to T0. A significant correlation was found between the change in subjective taste and change in chemical taste score (operated side score and total score) at T2 compared to T0 (respectively $r_s = 0.57$, $p = 0.002$ and $r_s = 0.46$, $p = 0.017$; $n = 27$). No such correlation was found on the contralateral side. The change in subjective taste and change in chemical taste score on the operated side at T3, compared to T0, did not correlate ($r_s = 0.14$, $p = 0.55$; $n = 21$). In the non-inflammatory group, 66% of six patients reported a reduced taste at T2 compared to T0, whereas in the inflammatory group, 10% of 20 patients reported a

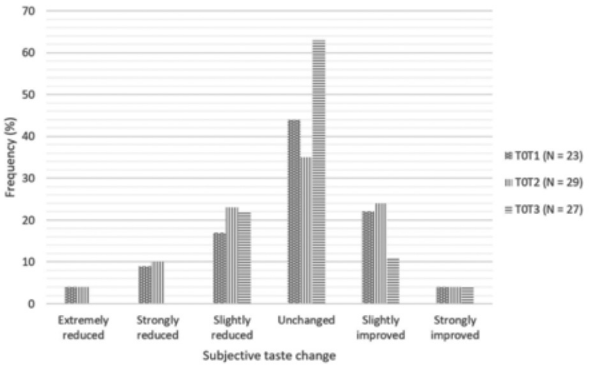

Figure 1

Change in subjective taste on different postoperative times compared to the preoperatively indicated subjective taste. Changes at T1, T2, and T3 compared to T0 are called T0T1, T0T2, and T0T3, respectively. T0=preoperatively; T1=1 week postoperatively; T2=3 weeks postoperatively; T3=3 years postoperatively

reduced taste at T2 compared to T0. None of these patients indicated a reduction in subjective taste at T3 compared to T0.

Fifteen patients underwent a chemical taste test and filled in a questionnaire at T0, T2, and T3 (Fig. 2). All of the chemical taste scores mentioned in this paragraph refer to the difference between the chemical taste scores of the operated and control side at T2 and T3 compared to T0. A change in chemical taste score of more than 3.3 points was considered significant, as suggested by Landis and colleagues.[3] Subsequently, three zones of postoperative change in chemical taste scores can be distinguished in Figure 2A. We distinguished an unchanged chemical taste score (zone 2, 53.4%), a decreased chemical taste score (zone 3, 26.6%), and an increased chemical taste score (zone 1, 20%).

The four patients in zone 3 (Fig. 2A) had a significant decrease in chemical taste score at T2 compared to T0. Of these patients, two reported strongly reduced subjective taste at T2 in comparison to T0 (the CT was stretched), whereas the other two patients reported no change in subjective taste (the CT was slightly manipulated or not documented). The subjective taste and chemical taste scores improved for these patients at T3 compared to T2. The subjective taste ameliorated more than the chemical taste score for patients with follow-up number 2 (Table 4). The three patients in zone 1 (Fig. 2A) had a significant increase in chemical taste score at T3 compared to T0. All of these patients experienced a lower chemical taste score on the diseased side (in comparison to the healthy side) and slightly reduced subjective taste preoperatively. The chemical taste score on the operated side significantly improved after surgery (Table 5).

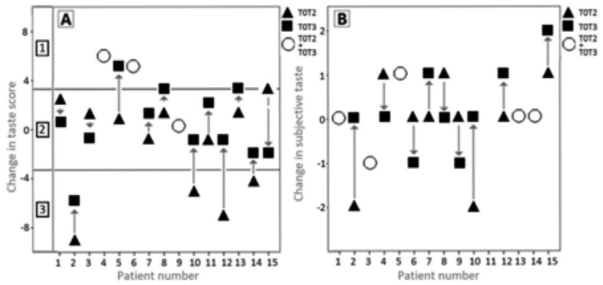

Figure 2

A. Difference between chemical taste scores of the operated and control side at T2 and T3 compared to T0. The chemical taste score of the control side was subtracted from the operated side at T0, T2, and T3. Subsequently, the individual change over time among these scores was plotted. A change in chemical taste score of more than 3.3 points was considered significant. Y-axis: zone 1 (improved chemical taste score), zone 2 (unchanged chemical taste score), and zone 3 (decreased chemical taste score). B. Change in subjective taste at T2 and T3 compared to T0 (T0T2 [triangle] and T0T3 [square], respectively). T0=preoperatively; T2=3 weeks postoperatively; T3=3 years postoperatively. Y-axis: -2=strongly reduced; -1=slightly reduced; 0=unchanged; 1=slightly improved; 2= strongly improved.

Table 4

Characteristics of patients with reduced chemical taste scores postoperatively (Fig. 2A, zone 3)

Patient number	Pathology	CT[§]	Subjective taste (T0)
2	Cholesteatoma	2	Normal
10	Cholesteatoma	2	Normal
12	COM	/	Strongly reduced
14	COM	1	Normal

COM=chronic otitis media without cholesteatoma; CT=chorda tympani. § 1=slight manipulation; 2=traction without visible damage; /=unknown

Table 5

Characteristics of patients with improved chemical taste scores postoperatively (Fig. 2A, zone 1)

Patient number	Pathology	CT[§]	Subjective taste (T0)
4	Cholesteatoma	1	Slightly reduced
5	COM	/	Slightly reduced
6	COM	0	Slightly reduced

COM=chronic otitis media without cholesteatoma; CT=chorda tympani. § 0=No visualisation; 1=slight manipulation; /=unknown

CT manipulation

CT manipulation was recorded for 31 patients (Addendum 2). The CT was mostly slightly touched or stretched without visible damage (71% of the recordings, resp. n = 12 and n = 10). The CT was not visualised during one operation, not touched during one operation, visibly damaged during three operations, and transected in four cases. The chemical taste score on the operated side was reduced by an average of 0.33 points (T2 compared to T0) when the CT was slightly touched and 4.33 points when the CT was stretched without visible damage (n = 9 and n = 6, respectively; p = 0.042). No change in chemical taste score was found on the contralateral side in these patients. The change in chemical taste score on the operated side (T3 compared to T0) did not significantly differ when the CT was slightly touched or stretched (-0.83 points, n = 5 and -1.0 points, n = 4, respectively; p = 0.8). A total of 63% of the patients indicated subjective taste reduction at T2 compared to T0 (n = 8) when the CT was stretched without visible damage, and 33% of the patients indicated subjective taste reduction at T2 compared to T0 (n = 9) when the CT was slightly touched. Due to missing data, no conclusions could be drawn for patients with transection of the CT.

Discussion

Both chemical taste testing and taste questionnaires are subjective evaluations. Pure objective tests to assess taste do not currently exist in daily clinical practice. These two modalities also evaluate taste on different levels. The questionnaire basically evaluated how flavour is experienced in the whole mouth, whereas the chemical taste test examined four basic tastes on the anterior two-thirds of the tongue. We also did not evaluate the sense of smell as an influencing factor. Therefore, our results should be carefully interpreted with regard to the missing data.

Our results showed that a postoperative reduction in subjective taste was a relatively frequent yet transient complication of middle ear surgery. Mcmanus and colleagues[6] reported that a reduction of subjective taste occurs in 15-22% of patients after middle ear surgery. This number was higher in our study population (30% at T1 and 38% at T2) due to the different definitions of reduction in subjective taste and different assessment techniques of taste.

Goyal and colleagues[7] included 84 patients with unilateral chronic inflammatory disease in their study. The chemical taste score on the diseased side was significantly lower preoperatively than that on the control side (p < 0.0001). The authors found that patients with chronic inflammatory middle ear disease were less likely to report symptoms after manipulation of the CT because of this preoperative inflammatory dysfunction. Ciofalo *et al.*[8] tested the taste function in patients with COM (n = 30) and otosclerosis (n = 30) with a chemical taste test. The non-inflammatory group had a more severe reduction in chemical taste score and needed more time to recover. The inflammatory group showed a minimally operative-induced decrease in chemical taste scores mainly because the chemical taste scores were already reduced preoperatively.

Our findings supported these conclusions; 38% of 29 patients with chronic inflammatory middle ear disease preoperatively reported a reduction in subjective taste. These patients also had a significantly lower chemical taste score compared to patients who indicated a normal subjective taste. Postoperatively decreased subjective taste was also less prevalent in the group with chronic inflammatory disease (10%) compared to 66% in the non-inflammatory group at T2.

The patients more frequently reported a decrease in subjective taste at T2 when the CT was stretched in comparison to a slight manipulation. This resulted in a significant difference in chemical taste scores at T2. No significant change in chemical taste scores was found at T3 between these groups. These results show that a surgeon's intraoperative evaluation of CT manipulation and stretching could predict postoperative taste disturbances. A larger study that includes more surgeries with different extents of CT manipulation is needed to help validate these findings. It would also be interesting to determine if the use of a CT retractor in stapedectomy would decrease or improve the chemical taste score in comparison to standard techniques.[9] Güneri *et al.*[10] found that there is less manipulation of the CT during endoscopic stapedotomy compared with microscopic stapedotomy. Thus, it would also be interesting to evaluate CT function after stapedotomy with both techniques.

The preoperatively indicated subjective taste of the patient significantly correlated with the total chemical taste score. The change in chemical taste scores on the operated side significantly correlated with the change in subjective taste at T2 compared to T0. This correlation was not found for the chemical taste score on the contralateral side. The change in chemical taste score on the operated side did not correlate with the change in subjective taste at T3 compared to T0. As an illustration, patient number 2 (Fig. 2, Table 4) underwent a combined approach tympanoplasty for cholesteatoma. He experienced a strong reduction in subjective taste after CT stretching. His chemical taste score on the operated side decreased by 75% (from 12 to 3) at T2, whereas the chemical taste score on the contralateral side remained unchanged. He experienced normal subjective taste 3 years after surgery (T3), yet his chemical taste score on the operated side was still 25% lower than his preoperative score, whereas his chemical taste score on the contralateral side improved by 33% (from 10 to 13). Although he indicated a normal subjective taste 3 years after the surgery, the CT function on the operated side only partially recovered.

These results suggest that other compensatory mechanisms together with partial CT recovery co-exist. Different mechanisms are described in the literature to explain subjective taste recovery (even in the absence of complete improvement of CT function), namely compensation of other nerves and subjective adjustment.

The afferent inputs of the seventh and ninth cranial nerves have been shown to inhibit each other centrally. Consequently, a loss of CT function can lead to an increase of taste sensitivity by the glossopharyngeal nerve.[11] Alternative taste pathways, such as taste sensation through the greater superficial petrosal nerve, are also recruited.[6] Cross-innervation and compensation of the contralateral CT and ipsilateral glossopharyngeal nerve have also been suggested.[12] Mcmanus *et al*.[6] suggested that central adaptation to taste dysfunction occurs over time; however, it is uncertain whether the patient stops noticing the deficit or just stops complaining about it.

These mechanisms could explain why the prevalence of subjective taste dysfunction is lower than that of CT damage documented with chemical taste tests. Finally, Saito *et al*.[1] showed with a questionnaire-based study that taste function recovered faster after sectioning the CT in contrast to stretching, probably due to the compensatory mechanisms described above. Our population was too small to confirm these findings.

Conclusion

Our results confirmed that a reduction in subjective taste is a relatively frequent yet transient complication after middle ear surgery. A significant correlation between chemical taste scores on the operated side and the indicated subjective taste was found preoperatively and short-term postoperatively. No correlation was found long-term postoperatively (3 years after the surgery), suggesting that compensatory mechanisms other than partial CT recovery co-exist. A significant difference between chemical taste scores on the operated side was found when the CT was slightly touched or stretched, suggesting that a surgeon's intraoperative evaluation of CT manipulation and stretching could be a good predictor of postoperative taste reduction.

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Addendum 1: Taste questionnaire

Indicate the most appropriate

How would you describe your taste?

No taste	Strongly reduced	Slightly reduced	Normal	Slightly improved	Strongly improved

Have you, in the last 2 weeks, experienced taste when there was nothing in the mouth?	Yes	No
If yes, which taste?		
Have you, in the last 2 weeks, experienced a numbness or tingling on the tongue?	Yes	No
If yes, where?	Left	Right
Have you, in the last 2 weeks, experienced a pain on the tongue?	Yes	No
If yes, where?	Left	Right
Have you, in the last 2 weeks, experienced a burning sensation on the tongue or in the mouth?	Yes	No
If yes, where?	Left	Right

Addendum 2: Surgical trauma to the CT

CT contact during the procedure:
- No visualisation
- Visualisation but no touching
- Slightly touched
- Stretched but no visible damage
- Visibly dried/frayed at the end of the surgery
- Completely sectioned

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