The Journal of Laryngology & Otology (2017), ***131***, *309–315*.

doi:10.1017/S0022215116010008

MAIN ARTICLE

Pre- and post-operative dizziness, tinnitus, and taste disturbances among cochlear implant recipients

K S MIKKELSEN[1], T OVESEN[2,3], C Z SWAN[2,3]

[1]*Department of Otorhinolaryngology, Head and Neck Surgery and Audiology, Rigshospitalet, Copenhagen,* [2]*Department of Otorhinolaryngology and Head and Neck Surgery, Aarhus University Hospital, and* [3]*Institute of Clinical Medicine, Aarhus University, Denmark*

Abstract

Objective: To determine the pre- and post-operative prevalence of dizziness, tinnitus and taste disturbances in adult cochlear implant recipients.

Methods: A questionnaire regarding pre- and post-operative dizziness, tinnitus and taste disturbances was sent to 170 cochlear implant recipients implanted between January 2003 and March 2009. Seventy-seven patients (41 per cent) responded.

Results: Pre-operatively, 20 per cent of the participants experienced dizziness, 52 per cent experienced tinnitus and 3 per cent experienced taste disturbances. Post-operative dizziness developed in 46 per cent of patients and resolved in the majority of these; however, 15 per cent reported dizziness more than six months after implantation. Tinnitus worsened in 25 per cent of patients, whereas 73 per cent reported attenuation or termination of tinnitus. Post-operatively, tinnitus developed in 12 per cent and taste disturbances developed in 17 per cent of the patients.

Conclusion: The high prevalence of dizziness, tinnitus and taste disturbances reported by cochlear implant recipients necessitates that assessment of symptoms related to inner ear and chorda tympani damage are included when evaluating operative results.

Key words: Cochlear Implants; Postoperative Complications; Dizziness; Tinnitus; Taste Disorders; Dysgeusia

Introduction

Cochlear implantation is a beneficial intervention for patients with bilateral profound hearing loss. It has become a routinely performed procedure, with a continuously increasing number of patients receiving a cochlear implant.[1,2] As with all surgical procedures, cochlear implantation carries the risk of a number of complications. In an earlier study, we reported a post-operative rate of complications of 16 per cent, whereof most were minor.[3] However, the study did not evaluate dizziness, tinnitus or taste disturbances in relation to cochlear implantation.

Pre-operative dizziness has been reported in 29–53 per cent of cochlear implant candidates, whereas new post-operative dizziness has been reported in 32–49 per cent of previously unaffected recipients.[4–8] Post-operative dizziness most often resolves spontaneously within weeks; however, some patients experience persisting or delayed-onset dizziness or disequilibrium up to several months after implantation.[6,8,9]

Tinnitus is present in an average of 80 per cent of cochlear implant candidates.[10–12] Following implantation, almost 80 per cent of recipients report termination or attenuation of tinnitus, whereas up to 10 per cent experience aggravation of the symptom. Post-operative tinnitus has not been the main outcome measure in most studies; however, some studies have shown that it develops in more than 10 per cent of cochlear implant recipients.[10,11,13]

In contrast to dizziness and tinnitus, pre-operative taste disturbances are rare in cochlear implant candidates. Post-operative taste disturbances, on the other hand, are common complaints, and have been reported in up to half of cochlear implant recipients; however, the prevalence declines over time.[9,14,15]

As post-operative rates of dizziness, tinnitus and taste disturbances vary considerably, risk assessment and pre-operative counselling is challenging. We therefore sought to determine the pre- and post-operative prevalence of dizziness, tinnitus, and dysgeusia or

Accepted for publication 20 September 2016 First published online 8 February 2017

hypogeusia in a well-defined group of cochlear implant recipients.

Materials and methods

A standardised validated questionnaire evaluating dizziness, tinnitus and taste disturbances is not available. We therefore constructed a questionnaire surveying dizziness, tinnitus and taste disturbances pre- and post-operatively, directed specifically at cochlear implant candidates (Appendix 1), taking a possibly limited vocabulary and age into account. The questionnaire was face and content validated. The Central Denmark Region Committees on Biomedical Research Ethics approved the study (National Institutes of Health IORG number: 0005129).

The questionnaire was mailed to 170 consecutively implanted adults at the Department of Otorhinolaryngology and Head and Neck Surgery, Aarhus University Hospital, Denmark, between January 2003 and March 2009. Seventy-seven participants responded (26 males and 51 females), giving us a response rate of 41 per cent. Non-responders did not receive a second questionnaire.

Age at implantation ranged from 19 to 83 years, with a median of 56 years. A median of 45 years (range, 1–78 years) passed from the onset of hearing loss until implantation. A further median of 27 months (range, 4–78 years) passed from the time of implantation to completion of the questionnaire. Two different implant devices were used; 16 patients received a HiRes 90 K (Advanced Bionics, Valencia, California, USA) and 61 patients received a Nucleus Freedom 24 (Cochlear, Sydney, Australia).

TABLE I
HEARING LOSS AETIOLOGY FOR 77 COCHLEAR IMPLANT RECIPIENTS

Hearing loss aetiology	Patients
Congenital	33 (42.9)
– Progressive genetic	20 (26.0)
– Pre-lingual idiopathic	7 (9.1)
– Asphyxia	2 (2.6)
– Mondini deformity	1 (1.3)
– Pendred syndrome	1 (1.3)
– Usher syndrome	1 (1.3)
– Maternal rubella	1 (1.3)
Infectious	14 (18.2)
– Meningitis	8 (10.4)
– Viral infection	1 (1.3)
– Morbilli infection	1 (1.3)
– Neuroborreliosis	1 (1.3)
– Chronic otitis media	3 (3.9)
Idiopathic progressive	9 (11.7)
Head trauma	5 (6.5)
Otosclerosis	4 (5.2)
Idiopathic sudden	3 (3.9)
Noise exposure	3 (3.9)
Ototoxicity	2 (2.6)
Ménière's disease	1 (1.3)
Unknown	3 (3.9)

Data represent numbers and percentages of patients.

Four participants had received an implant in the contralateral ear prior to inclusion in the study, and one patient was re-implanted because of a non-functional electrode.

Demographic data were obtained from surgical and audiological patient files. Hearing loss aetiology is reported in Table I.

All devices were implanted via a transmastoid approach, followed by round window electrode insertion. Electrode position was verified by post-operative X-ray of the temporal bone. Two experienced surgeons performed all implantations. Glucocorticoid was not administered peri-operatively. Implants were activated four weeks after implantation according to standard protocols. Programming of the cochlear implant processor did not include optimisation for tinnitus treatment options.

Results

All statistical analyses were conducted using MatLab version 8.5 software (MathWorks, Boston, Massachusetts, USA). Fisher's exact test was used to evaluate associations between variables. For all statistical analyses, a 5 per cent limit of significance was applied. Categorical variables are presented as frequencies and percentages.

Dizziness

Pre-operative dizziness. Fifteen (19.5 per cent) of 77 patients reported at least 1 incident of dizziness or disequilibrium in the year prior to implantation (Table II). Eleven of the 15 patients suffered from dizziness attacks, 2 experienced constant dizziness, whereas the remaining 2 patients were not able to describe their dizziness.

Post-operative dizziness. Twenty-eight (45.9 per cent) of 61 patients without pre-operative dizziness developed dizziness following implantation (Table II). In 9 participants (14.8 per cent), dizziness persisted until follow up (median of 21 months; range, 7–77 months). Temporal dizziness characteristics are shown in Table III.

Post-operative dizziness was described as rotational or nautical by 14 participants (38.9 per cent), and as a feeling of disequilibrium by 15 (41.7 per cent), whereas the remaining participants were unable to characterise their dizziness (8.3 per cent) or refrained from answering (11.1 per cent). No participant described the dizziness as orthostatic.

Eight of the 15 patients who suffered dizziness prior to implantation also experienced dizziness after implantation; however, dizziness only persisted until follow up for 5 patients.

Three (8.3 per cent) of 36 patients reported aggravation of dizziness upon cochlear implant activation; 2 of the 3 patients also reported dizziness pre-operatively.

No increase in risk of post-operative dizziness was found for patients who experienced symptoms

https://doi.org/10.1017/S0022215116010008 Published online by Cambridge University Press

TABLE II
DIZZINESS, TINNITUS AND TASTE DISTURBANCES FOR 77 PATIENTS BEFORE AND AFTER COCHLEAR IMPLANTATION

Symptom	Yes	No	Not known	Not answered
Dizziness before CI ($n = 77$)	15 (19.5)	61 (79.2)	1 (1.3)	0 (0.0)
Dizziness after CI ($n = 77$)	36 (46.8)	36 (46.8)	3 (3.9)	2 (2.6)
Continued dizziness after CI ($n = 15$)	8 (53.3)	–	–	–
Continued dizziness until follow up ($n = 15$)	5 (33.3)	–	–	–
New dizziness after CI ($n = 61$)	28 (45.9)	–	–	–
New dizziness until follow up ($n = 61$)	9 (14.8)	–	–	–
Dizziness aggravation upon activation ($n = 36$)	3 (8.3)	22 (61.1)	8 (22.2)	3 (8.3)
Tinnitus before CI ($n = 77$)	40 (51.9)	33 (42.9)	3 (3.9)	1 (1.3)
Tinnitus termination after CI ($n = 40$)	13 (32.5)	–	1 (2.5)	–
Tinnitus attenuation after CI ($n = 40$)	16 (40)	–	–	–
Tinnitus aggravation after CI ($n = 40$)	10 (25)	–	–	–
New tinnitus after CI ($n = 33$)	4 (12.1)	26 (78.8)	0 (0.0)	3 (9.1)
Taste disturbances before CI ($n = 77$)	2 (2.6)	71 (92.2)	1 (1.3)	3 (3.1)
New taste disturbances after CI ($n = 71$)	12 (16.9)	52 (73.2)	2 (2.8)	5 (7.0)

Data represent numbers and percentages of patients. CI = cochlear implantation

pre-operatively compared to those without pre-operative dizziness ($p = 0.3$).

Tinnitus

Pre-operative tinnitus. Forty (51.9 per cent) of 77 patients suffered from tinnitus prior to implantation (Table II).

Post-operative tinnitus. Four (12.1 per cent) of the 33 patients without prior tinnitus developed tinnitus following implantation (Table II).

Ten (25 per cent) of the patients affected by pre-operative tinnitus experienced aggravation of existing tinnitus, whereas 16 (40 per cent) reported attenuation, and 13 (32.5 per cent) reported termination of tinnitus in the implanted ear (Table II).

No difference was found for duration of follow up when comparing patients that experienced aggravation of tinnitus following cochlear implantation (median of 42 months; range, 8–67 months) with those in whom tinnitus was attenuated or terminated (median of 30 months; range, 4–78 months) ($p = 0.2$).

Dizziness and tinnitus association

An association was found between pre-operative dizziness and tinnitus ($p < 0.05$), as all patients suffering from pre-operative dizziness also presented with pre-operative tinnitus, whereas only 43 per cent of patients without pre-operative dizziness experienced pre-operative tinnitus. Conversely, patients who did not suffer tinnitus pre-operatively experienced no pre-operative dizziness, whereas 34.3 per cent of patients with pre-operative tinnitus experienced pre-operative dizziness.

No relationship was found between development of post-operative tinnitus and dizziness ($p = 0.3$). Three (75 per cent) of four patients who suffered new-onset tinnitus also experienced new-onset dizziness. Nine (35 per cent) of 26 patients without pre- or post-operative tinnitus developed post-operative dizziness.

Pre-operative tinnitus was not associated with post-operative dizziness ($p = 0.3$). In addition, pre-operative dizziness showed no association with the aggravation of tinnitus ($p = 0.7$) or new tinnitus following implantation ($p = 1.0$).

Taste disturbance

Pre-operative taste disturbances. Two (2.6 per cent) of 77 patients complained of taste disturbances prior to implantation; 1 suffered hypogeusia and 1 suffered dysgeusia (Table II).

TABLE III
TIME TO APPEARANCE AND REMISSION OF NEW-ONSET DIZZINESS IN 28 PATIENTS FOLLOWING COCHLEAR IMPLANTATION

Time to resolution	Onset of new dizziness						
	Immediate	Within days	Within weeks	Within months	Not known	Not answered	Total
1 day	4 (14.3)	2 (7.1)	0 (0.0)	1 (3.6)	0 (0.0)	–	7 (25.0)
Few days	4 (14.3)	4 (14.3)	1 (3.6)	0 (0.0)	0 (0.0)	1 (3.6)	10 (35.7)
Weeks	5 (17.9)	0 (0.0)	1 (3.6)	0 (0.0)	0 (0.0)	–	6 (21.4)
Months	2 (7.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	–	2 (7.1)
Not known	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (7.1)	–	2 (7.1)
Not answered	1 (3.6)	–	–	–	–	–	1 (3.6)
Total	16 (57.1)	6 (21.4)	2 (7.1)	1 (3.6)	2 (7.1)	1 (3.6)	28 (100)

Data represent numbers and percentages of patients. Seven patients reported dizziness at follow up, but did not report the symptom as lasting for more than a matter of weeks in a previous section of the questionnaire.

https://doi.org/10.1017/S0022215116010008 Published online by Cambridge University Press

Post-operative taste disturbances. Twelve (16.9 per cent) of 71 patients developed taste disturbances following implantation; 8 patients complained of hypogeusia and 4 complained of dysgeusia. No participants reported complete loss of taste (ageusia).

Discussion

When performing cochlear implantation, structures in the middle and inner ear, such as the chorda tympani, cochlea and vestibular organs, are at risk of being injured. Symptoms related to damage of these structures can be debilitating, and must be taken into consideration when planning the procedure. In this study, we present the prevalence and incidence of dizziness, tinnitus and taste disturbances prior to and following cochlear implantation in a well-defined group of cochlear implant recipients, based on patient feedback. Although data were obtained using a non-standardised questionnaire, our findings contribute new and useful information regarding complications related to cochlear implantation.

Dizziness was experienced by one in five of the participants in the year prior to surgery. This is somewhat lower than the incidence reported by others (26–53 per cent); the incongruence might be due to differences in the aetiology of the study populations.[5,16,17] It is noteworthy that the prevalence of pre-operative dizziness among cochlear implant recipients in the present study is comparable to that expected in a healthy background population.[18]

A relationship was found between pre-operative dizziness and tinnitus, as all patients with pre-operative dizziness also reported pre-operative tinnitus. The relationship could not be explained by hearing loss aetiology; however, it may indicate that conditions believed to affect the cochlea exclusively might also impair vestibular function.

Approximately one-third of patients who experienced pre-operative dizziness reported relief from dizziness after cochlear implantation, which is in accordance with the findings of previous studies (11–28 per cent).[8,9,19,20] It has been suggested that diminished dizziness after implantation could be due to the promotion of spatial orientation, electrical stimulation of the vestibular nerve, and the mechanical or electrical influence of a persisting vestibular lesion.[19,21] Patients suffering pre-operative dizziness were not at greater risk of experiencing post-operative dizziness than patients without pre-operative dizziness. The finding is in accordance with previous studies;[22,23] however, it conflicts with a study by Fina *et al*.[8] In our study, pre-operative tinnitus did not present as a risk factor for post-operative dizziness, a finding not previously reported.

Almost half of the participants in our study experienced initiation of dizziness following implantation. The majority of patients who developed dizziness following surgery reported symptoms indicative of dizziness of vestibular origin, which is in agreement with previous findings (90 per cent).[24] Dizziness occurred within days after implantation in almost 80 per cent of affected patients, and lasted for several days in more than half of patients, whereas approximately one-third experienced symptoms for weeks to months. Thus, most of the patients who developed post-operative dizziness only suffered a brief period of dizziness after implantation, consistent with previous studies.[6–8,24] Several studies have reported dizziness following cochlear implantation, with prevalence ranging from 0 to 64 per cent; however, comparison is difficult because of variations in aim, study design, method, definition of dizziness, implantation technique, electrode type and study sample.[16,17,25] In particular, differences in follow-up duration may account for a substantial portion of the observed variation, as follow-up periods vary from a few months to several years. Fifteen per cent of our patients reported new post-operative dizziness lasting more than six months after implantation, a finding also reported in previous studies with long follow up (1–37 per cent).[6,9,19,26]

In a review comprising 18 studies, the prevalence of pre-operative tinnitus was 80 per cent (range, 65–100 per cent),[10] which corresponds to the findings of recent studies, wherein prevalence ranges from 63 to 78 per cent.[10–13] In our study, half of the participants reported pre-operative tinnitus. The incongruence might be a result of differences in the definition of tinnitus, patient demographics (i.e. aetiology and disease severity) and study design.

Tinnitus was perceived as attenuated following implantation in a substantial proportion of participants, and ceased in one-third of the patients in our study. Previous studies have reported results supporting our findings, although with considerable variability.[10–13] In contrast to the favourable effect of cochlear implantation on tinnitus, 25 per cent of the patients with pre-existing tinnitus in our study complained of aggravation following implantation, whereas previous studies have reported worsening of tinnitus in less than 13 per cent of cochlear implant recipients.[10–12]

Tinnitus developed following implantation in approximately one-tenth of participants in our study. Only a few studies have previously addressed this side effect, with incidences ranging from 2 to 33 per cent.[11,13,27] The questionnaire we used did not clarify on which ear the patient had tinnitus, and it did not include characterisation of the perceived tinnitus. New background environmental sounds, apparent for the first time following activation of the cochlear implant, could falsely have been categorised or subjectively perceived as tinnitus, as proposed by others.[28] Prospective patient interviews to avoid misclassification of tinnitus should be included in future studies, bearing in mind the diverse characteristics of the condition.[29] The necessity of utilising standard tinnitus questionnaires, which include change in any direction in symptom perception (i.e. aggravation, attenuation, termination, and unchanged or new tinnitus), and long follow-up periods to assess alterations in tinnitus after implantation, is acknowledged.

Only a few patients complained of pre-operative taste disturbances, as reported in previous studies (0–1 per

https://doi.org/10.1017/S0022215116010008 Published online by Cambridge University Press

cent).[9,14,15] In contrast, post-operative taste disturbances occurred in almost one-fifth of participants in the present study. Post-operative taste disturbances were reported in up to half of cochlear implant recipients immediately after implantation in one study; however, the symptom was present in less than one-fifth of recipients at long-term follow up.[14] Other studies have reported post-operative taste disorders at long-term follow up in approximately 5 per cent of recipients.[9,15] This suggests that although taste disturbances are a frequent complication in cochlear implantation, symptoms are often transient and resolve during the first post-operative year, as in most surgical procedures in which the middle ear is entered.[30]

The present study was conducted using a postal questionnaire to evaluate complications often not sufficiently addressed during routine post-operative outpatient consultation. A response rate of a little less than half is acceptable; however, it implicates selection bias, inducing a risk of over- or under-estimation of complications. Although the questionnaire had been face validated among a group of recipients before the study commenced, some recipients may have had difficulties interpreting the questions. In addition, other studies on dizziness, tinnitus and dysgeusia in relation to cochlear implantation have utilised different questionnaires, both validated and non-validated, which makes comparison of the results difficult. This emphasises the need for a validated questionnaire or standardised interview when assessing cochlear implantation complications.

- **Cochlear implantation is increasingly being performed; middle- and inner-ear structures risk injury during implantation**
- **In this study, post-operative dizziness developed in 46 per cent of previously unaffected implantees**
- **This dizziness ceased within weeks in most recipients, but persisted for over six months in 15 per cent**
- **Pre-operative tinnitus occurred in 52 per cent, but most patients (73 per cent) experienced attenuation or termination after implantation**
- **Taste disturbances developed in 17 per cent after implantation**
- **Thorough dizziness, tinnitus and taste disturbance assessments are required for evaluating cochlear implantation outcome**

A long-term follow-up period is necessary to detect delayed or persisting dizziness, and to determine the long-term effects on tinnitus and taste disturbances following implantation; however, the long lapse from implantation to follow up has its costs. The biggest drawback seems to be the considerable risk of recall bias leading to misclassification, which could be reduced if follow up was performed prospectively at regular intervals.

Conclusion

Based on our results, we conclude that dizziness and tinnitus are common symptoms in cochlear implant recipients, both before and after implantation. Post-operative dizziness often develops shortly after cochlear implantation and fades within weeks, but symptoms persist for months in some patients. In a subgroup of patients, tinnitus arises following implantation, whilst some patients experience aggravation of pre-existing tinnitus. However, the majority of patients with tinnitus prior to cochlear implantation experience a beneficial effect of the procedure. Disturbances of taste sensation occur in a significant proportion of cochlear implant recipients.

Given the high prevalence of dizziness, tinnitus and taste disturbances in cochlear implant recipients, a thorough assessment of symptoms should be performed, both at the pre-operative consultation and at all routine post-operative consultations, and when evaluating operative results.

References

1 Bond M, Mealing S, Anderson R, Elston J, Weiner G, Taylor RS *et al*. The effectiveness and cost-effectiveness of cochlear implants for severe to profound deafness in children and adults: a systematic review and economic model. *Health Technol Assess* 2009;**13**:1–330
2 Berrettini S, Baggiani A, Bruschini L, Cassandro E, Cuda D, Filipo R *et al*. Systematic review of the literature on the clinical effectiveness of the cochlear implant procedure in adult patients. *Acta Otorhinolaryngol Ital* 2011;**31**:299–310
3 Ovesen T, Johansen LV. Post-operative problems and complications in 313 consecutive cochlear implantations. *J Laryngol Otol* 2009;**123**:492–6
4 Krause E, Louza JP, Wechtenbruch J, Hempel JM, Rader T, Gurkov R. Incidence and quality of vertigo symptoms after cochlear implantation. *J Laryngol Otol* 2009;**123**:278–82
5 Krause E, Louza JP, Hempel JM, Wechtenbruch J, Rader T, Gurkov R. Prevalence and characteristics of preoperative balance disorders in cochlear implant candidates. *Ann Otol Rhinol Laryngol* 2008;**117**:764–8
6 Kubo T, Yamamoto K, Iwaki T, Doi K, Tamura M. Different forms of dizziness occurring after cochlear implant. *Eur Arch Otorhinolaryngol* 2001;**258**:9–12
7 Enticott JC, Tari S, Koh SM, Dowell RC, O'Leary SJ. Cochlear implant and vestibular function. *Otol Neurotol* 2006;**27**:824–30
8 Fina M, Skinner M, Goebel JA, Piccirillo JF, Neely JG, Black O. Vestibular dysfunction after cochlear implantation. *Otol Neurotol* 2003;**24**:234–42; discussion 242
9 Wagner JH, Basta D, Wagner F, Seidl RO, Ernst A, Todt I. Vestibular and taste disorders after bilateral cochlear implantation. *Eur Arch Otorhinolaryngol* 2010;**267**:1849–54
10 Baguley DM, Atlas MD. Cochlear implants and tinnitus. *Prog Brain Res* 2007;**166**:347–55
11 Pan T, Tyler RS, Ji H, Coelho C, Gehringer AK, Gogel SA. Changes in the tinnitus handicap questionnaire after cochlear implantation. *Am J Audiol* 2009;**18**:144–51
12 Amoodi HA, Mick PT, Shipp DB, Friesen LM, Nedzelski JM, Chen JM *et al*. The effects of unilateral cochlear implantation on the tinnitus handicap inventory and the influence on quality of life. *Laryngoscope* 2011;**121**:1536–40
13 Kompis M, Pelizzone M, Dillier N, Allum J, DeMin N, Senn P. Tinnitus before and 6 months after cochlear implantation. *Audiol Neurootol* 2012;**17**:161–8

https://doi.org/10.1017/S0022215116010008 Published online by Cambridge University Press

14 Lloyd S, Meerton L, Di Cuffa R, Lavy J, Graham J. Taste change following cochlear implantation. *Cochlear Implants Int* 2007;**8**:203–10
15 Hansen S, Anthonsen K, Stangerup SE, Jensen JH, Thomsen J, Caye-Thomasen P. Unexpected findings and surgical complications in 505 consecutive cochlear implantations: a proposal for reporting consensus. *Acta Otolaryngol* 2010;**130**:540–9
16 Filipo R, Patrizi M, La Gamma R, D'Elia C, La Rosa G, Barbara M. Vestibular impairment and cochlear implantation. *Acta Otolaryngol* 2006;**126**:1266–74
17 Todt I, Basta D, Ernst A. Does the surgical approach in cochlear implantation influence the occurrence of postoperative vertigo? *Otolaryngol Head Neck Surg* 2008;**138**:8–12
18 Neuhauser HK, Lempert T. Vertigo: epidemiologic aspects. *Semin Neurol* 2009;**29**:473–81
19 Shoman N, Ngo R, Archibald J, Pijl S, Chan S, Westerberg BD. Prevalence of new-onset vestibular symptoms following cochlear implantation. *J Otolaryngol Head Neck Surg* 2008;**37**:388–94
20 Katsiari E, Balatsouras DG, Sengas J, Riga M, Korres GS, Xenelis J. Influence of cochlear implantation on the vestibular function. *Eur Arch Otorhinolaryngol* 2013;**270**:489–95
21 Buchman CA, Joy J, Hodges A, Telischi FF, Balkany TJ. Vestibular effects of cochlear implantation. *Laryngoscope* 2004;**114**:1–22
22 Krause E, Wechtenbruch J, Rader T, Gurkov R. Influence of cochlear implantation on sacculus function. *Otolaryngol Head Neck Surg* 2009;**140**:108–13
23 Steenerson RL, Cronin GW, Gary LB. Vertigo after cochlear implantation. *Otol Neurotol* 2001;**22**:842–3
24 Krause E, Louza JP, Wechtenbruch J, Hempel JM, Rader T, Gurkov R. Incidence and quality of vertigo symptoms after cochlear implantation. *J Laryngol Otol* 2009;**123**:278–82
25 Jutila T, Aalto H, Hirvonen TP. Cochlear implantation rarely alters horizontal vestibulo-ocular reflex in motorized head impulse test. *Otol Neurotol* 2013;**34**:48–52
26 Jeppesen J, Faber CE. Surgical complications following cochlear implantation in adults based on a proposed reporting consensus. *Acta Otolaryngol* 2013;**133**:1012–21
27 Olze H, Szczepek AJ, Haupt H, Zirke N, Graebel S, Mazurek B. The impact of cochlear implantation on tinnitus, stress and quality of life in postlingually deafened patients. *Audiol Neurootol* 2012;**17**:2–11
28 Bovo R, Ciorba A, Martini A. Tinnitus and cochlear implants. *Auris Nasus Larynx* 2011;**38**:14–20
29 Stouffer JL, Tyler RS. Characterization of tinnitus by tinnitus patients. *J Speech Hear Disord* 1990;**55**:439–53
30 McManus LJ, Stringer MD, Dawes PJ. Iatrogenic injury of the chorda tympani: a systematic review. *J Laryngol Otol* 2012; **126**:8–14

Appendix 1. Dizziness, tinnitus and taste disturbances questionnaire

1. Did you experience vertigo within a year prior to cochlear implant surgery?

   ☐ Yes
   ☐ No
   ☐ Don't know

2. If yes, was vertigo experienced…

   ☐ Constantly
   ☐ In attacks
   ☐ Don't know

3. Did you experience vertigo after cochlear implant surgery?

   ☐ Yes – Please proceed to question 4
   ☐ No – Please proceed to question 9

4. When did vertigo develop in relation to the surgical procedure?

   ☐ Immediately following surgery
   ☐ Several days after surgery
   ☐ Several weeks after surgery
   ☐ Several months after surgery
   ☐ Don't know

5. How long did the sensation of vertigo last?

   ☐ One day
   ☐ A few days
   ☐ Weeks
   ☐ Months
   ☐ Don't know

6. If you experienced vertigo, was there an aggravation of vertigo when the cochlear implant was activated?

   ☐ Yes
   ☐ No
   ☐ Don't know

7. Do you still experience vertigo?

   ☐ Yes
   ☐ No

8. How would you best describe the vertigo you experience/experienced?

   ☐ Shimmering/blackening of the eyes when I get up from horizontal to standing position
   ☐ I experience attacks of vertigo (carousel-like sensation)
   ☐ I experience attacks of vertigo (the floor is swaying under me)
   ☐ I experience constant vertigo (carousel or swaying sensation)
   ☐ I experience a feeling of unbalance
   ☐ Don't know

9. Did you experience taste disturbances prior to cochlear implant surgery?

   ☐ Yes
   ☐ No
   ☐ Don't know

10. If yes, how would you describe these?

    ☐ Weakening of taste
    ☐ Change of taste
    ☐ Complete loss of taste
    ☐ Don't know

https://doi.org/10.1017/S0022215116010008 Published online by Cambridge University Press

11. Did you experience (newly occurred) taste disturbances after cochlear implant surgery?

    ☐ Yes
    ☐ No
    ☐ Don't know

12. If yes, what kind of taste disturbances?

    ☐ Weakening of taste
    ☐ Change of taste
    ☐ Complete loss of taste
    ☐ Don't know

13. Did you experience tinnitus prior to cochlear implant surgery?

    ☐ Yes – Please proceed to question 15
    ☐ No – Please proceed to question 14
    ☐ Don't know

14. If no, did tinnitus develop after cochlear implant surgery?

    ☐ Yes
    ☐ No

15. If yes, in what way, if any, was the sensation of tinnitus altered following cochlear implant surgery?

    ☐ Aggravated
    ☐ Improved
    ☐ Disappeared

Address for correspondence:
Dr Kasper Sandager Mikkelsen,
Department of Otorhinolaryngology,
Head and Neck Surgery and Audiology,
Rigshospitalet,
Blegdamsvej 9,
DK-2100 Copenhagen, Denmark

Fax: +45 35 45 26 29
E-mail: kasper.mikkelsen@hotmail.com

Dr K S Mikkelsen takes responsibility for the integrity of the content of the paper
Competing interests: None declared

https://doi.org/10.1017/S0022215116010008 Published online by Cambridge University Press