International Tinnitus Journal, Vol. 8, No. 1, 20–26 (2002)

Tinnitus in Childhood

Gottfried Aust

Center for Deaf Children, Berlin-Neukoelln, Germany

Abstract: All of 1,420 children seen for clarification of a hearing disorder or to follow up for known difficulty in hearing were questioned as to whether they experienced tinnitus. The interview was carried out after a hearing test was conducted, which was based on play audiometry or normal pure-tone threshold audiometry, depending on the age of the child. When being interviewed, 102 children reported that tinnitus had appeared or was still present. Seventy-five children (73.5%) demonstrated difficulty in hearing in one or both ears, whereas 27 children (26.5%) had normal hearing in both ears. The most frequently obtained information (29.4%) was the progression of an existing hearing loss. Meningitis is an important cause of hearing loss and of tinnitus and could be identified in 20% of our patients. We also considered as a cause of tinnitus skull or brain trauma, acute hearing loss, and stapes surgery. However, the mechanisms of tinnitus development were not immediately clear in a large proportion of the children studied: Problems included central sensory perception (14.7%) and emotional factors (11.8%). No additional information that might lead to an understanding of the hearing loss was available for 14.7% of the patients studied. Tinnitus is a frequent symptom in childhood and, because children seldom complain about their tinnitus, such hearing problems that they report must always be taken seriously. The diagnosis should exclude metabolic disturbances, possible damage to the sensory level of the central nervous system, and circulatory disturbances. In addition, the physician should always consider emotional problems and disturbances of perception.

Key Words: children; hearing loss; meningitis; psychic factors; tinnitus

The number of patients who suffer from tinnitus has risen clearly within the last decades, and the frequency of tinnitus in children has increased. However, children often have difficulty in naming and describing their symptoms. Their complaints are minimized or not taken seriously by adults, particularly those of more sensitive children. This is often the case when tinnitus does not appear to be connected with any illness or other problems. However, often to the astonishment of adults, when asked specifically, children describe the exact symptoms that prove the existence of tinnitus. The aim of our study was to analyze the appearance, characteristics, and frequency of tinnitus in children.

PATIENTS

We questioned as to whether they had tinnitus 1,420 children seen for clarification of a hearing disorder or to follow up known hardness of hearing. The interview was carried out after the hearing test, which was based on play audiometry or normal pure-tone threshold audiometry, depending on the age of the child. Supplementary tests included those of otoacoustic emissions, auditory evoked potentials, and impedance audiometry. Vestibular examination with electronystagmographic recording and posturography was performed in some children.

RESULTS

A total of 102 children, their parents, or the people who had referred them to us said at the interview that tinnitus had appeared or was still present. The age of these children ranged between 5.1 and 16.9 years (mean age, 10.4 ± 3.9 years). That age distribution is represented in Figure 1. One-half of the children were female, and one-half were male. Seventy-five (73.5%) showed hardness of hearing on one or both sides, and 27 (26.4%) had normal hearing in both ears. The hardness of hearing was sensory in 69 of the 75 children (92.0%) and was combined in 6 (8.0%). Table 1 shows the audiological findings in examined children with respect to

Reprint requests: Priv.-Doz. Dr. G. Aust, Beratungsstelle für Hörbehinderte, Paster-Behrens-Strasse 81, D-12359 Berlin, Germany. Phone: +49 30 21963300; Fax: +49 30 21963301; E-mail: gottfriedaust@t-online.de

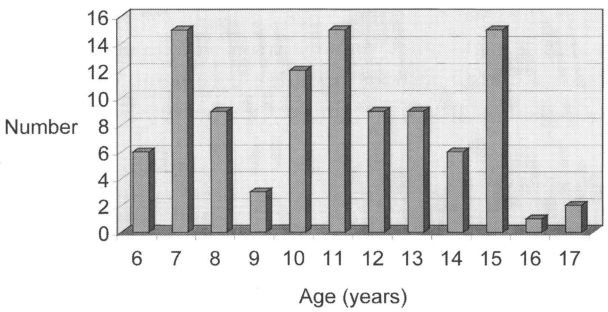

Figure 1. Age distribution in 102 children with tinnitus.

various levels of hearing loss in the right and left ears. A clear frequency or intensity determination and the measuring of masking curves were not possible except in a few cases. Twenty-four children (23.5%) reported vertiginous complaints in addition to their tinnitus.

The frequent appearance of tinnitus in connection with the deterioration of an existing sensorineural hearing loss was striking in the patients in our group. The deterioration did not happen in a way similar to that in acute hearing loss but more slowly. It was so distinctive, however, that children, along with their parents, noticed the deterioration in their hearing. The parents could not offer reasons for this deterioration, as there was no sign of medical illness.

The second most frequent cause of tinnitus was postmeningitis conditions. In many of the children examined in our center, meningitis was the cause of acquired hearing disorders. In a large number of them, the hearing fluctuated after a long period of meningitis, in which tinnitus might have been present simultaneously. Vertiginous complaints also appeared frequently in this stage. The audiometric picture can be very different and varies between normal hearing and various levels of deafness.

Tinnitus also is found frequently in children with problems of sensory perception. In most such cases, the hearing thresholds are in the normal ranges. In affected children, cerebral damage with lesions of central processing structures must originate from head trauma at a very early age, from oxygen deficiency during birth, from infections, and the like. We did not receive any further information from 15 children. Affected children's environment was another source of important data. In 12, we found that symptoms were caused by problems in the parental home and in their social environment or by the pressure of high performance requirements. In four children, the condition appeared after skull or brain trauma and, in three, the condition appeared after acoustic trauma. One child had acute hearing loss, and one developed tinnitus after stapes surgery (Table 2).

We compared the information of children with normal hearing and of those with existing hardness of hearing. Of 27 children with normal hearing, 7 (25.9%) showed problems with central sensory perception, and 7 (25.9%) exhibited psychological problems. In 1 child (3.8%), the tinnitus occurred after sudden hearing loss. Detailed information could not be ascertained for 12 children (44.4%). Of 69 children with hardness of hearing, 8 (11.6%) displayed problems with central sensory perception, 5 (7.3%) demonstrated psychological factors and 30 (43.5%) showed deterioration of an existing hearing loss; no details could be obtained from 3 children (4.3%; Table 3).

The characteristics of tinnitus are shown in Table 4. Wheezing or beeping and murmur are the most fre-

Table 1. Audiological Findings in 102 Children with Tinnitus

	Right Ear	Left Ear
Normal hearing	33	39
Mild hearing loss	12	12
Moderate hearing loss	6	12
Profound hearing loss	3	6
Near-deafness	18	3
Total deafness	30	30

Table 2. Information Obtained from Patient History

	No. of Patients	Percentage
Deterioration of existing hearing loss	30	29.4
After meningitis	21	20.6
Problems with central sensory perception	15	14.7
No information	15	14.7
Psychological factors	12	11.8
Head trauma	4	3.9
Acoustic trauma	3	2.9
After acute hearing loss	1	1.0
After stapes surgery	1	1.0

Table 3. Information Obtained from the History of 27 Children with Normal Hearing and 69 Children with Hearing Loss

	Normal Hearing n = 27 (%)	Hearing Loss n = 69 (%)
Problems with central sensory perception	7 (25.9)	8 (11.6)
Psychological factors	7 (25.9)	5 (7.3)
Sudden hearing loss or deterioration	1 (3.8)	30 (43.5)
No information	12 (44.4)	3 (4.3)

Table 4. Characteristics of Tinnitus in 102 Children

Quality	No. of Patients
Wheezing, peeping	60
Murmur	24
Buzzing	6
Echo of noises	6
Tone	4
Roaring	3
Chirping	3
Beating	2

quent sensations characterized by the children questioned. Some children claimed difficulty in hearing and wanted hearing aids, although their hearing was normal. The appearance of tinnitus could also be seen in 36 children in certain situations (Table 5). In this group, tinnitus was present in 15 children who were under pressure, in 9 in the evening, in 3 in the morning, in 5 after school, in 3 while under stress, and in 1 during noise.

CASE REPORTS

Patient 1

Seven-year-old patient 1 was introduced to us a few weeks after she suffered a case of bacterial meningitis because she complained of tinnitus and could no longer hear well. The hearing test showed residual hearing on the right side; on the left side, it revealed moderate sensorineural hearing loss with a mild hearing loss in the low and high frequencies. The tinnitus was characterized partly as roaring and partly as a low tone. The vestibular examination showed profound functional loss of the right labyrinth, with spontaneous nystagmus to the left; the function of the left labyrinth was normal.

Table 5. Incidence and Frequency of Tinnitus

Characteristic	No. of Patients
Continuous	18
Intermittent (without triggering)	48
Intermittent (certain situations)	
Under pressure	15
Evening	9
Morning	3
After school	5
Under stress	3
During noise	1
Frequent	51
Infrequent	33
Tinnitus on one side	36
Tinnitus on both sides	66

In the case of patient 1, the cause of the lesions was bacterial meningitis, damage from which can be localized in both inner ears or in the peripheral area of the nerve statoacusticus (eighth cranial nerve) (Fig. 2).

Patient 2

Patient 2 was an 11-year-old girl who came to examination with a presumptive diagnosis of hearing loss. She stood out because she did not understand when she was addressed. She was a good pupil but, in school, her teachers observed that within the last 2 months her reactions were diminished when she was addressed. She had ear, nose, and throat medical treatment and received grommets. The hearing test at an ear, nose, and throat practice led to the assumption of a moderate hearing loss. At the interview, this patient told us that she had hearing problems and a feeling of tinnitus in the form of a wheeze for approximately 10 minutes in the morning. At the hearing test (summer 1999) the curves of air conduction lay within 50–60 dB on both sides; the curves of bone conduction in the similar area, however, were uncertain. Whispered speech was understood on both sides from 3 to 4 meters, and normal speech was comprehended from more than 6 meters' away. The discrepancy between the pure-tone audiogram and measurement of hearing distance suggested a probable psychogenic hearing disorder. The tinnitus characteristics could not be specified, as they were not present on the day of examination.

At the beginning of the checkup that we performed almost a year later (summer 2000), the diagnosis was still uncertain. During the course of the examination, however, it was discerned that the curves of bone conduction eventually lay at 0 dB and the curves of air conduction at 5–15 dB, whispered speech was finally understood from 4 meters, and normal speech was understood on both sides from more than 6 meters away. The tympanogram and the transitory evoked otoacoustic emissions were within normal ranges on both sides. The tinnitus remained unchanged.

In the case of patient 2, we assumed a disturbance in sensory perception because she experienced difficulty in hearing, although the audiometric test results were normal. She remains under pressure at school, however, and the tinnitus in conjunction with the alleged hearing difficulty are likely signs of emotional pressure (Fig. 3).

Patient 3

Patient 3, a 13-year-old boy, had been known to us since early childhood. In 1996, he complained of a sensory hearing loss bordering on deafness in the right ear

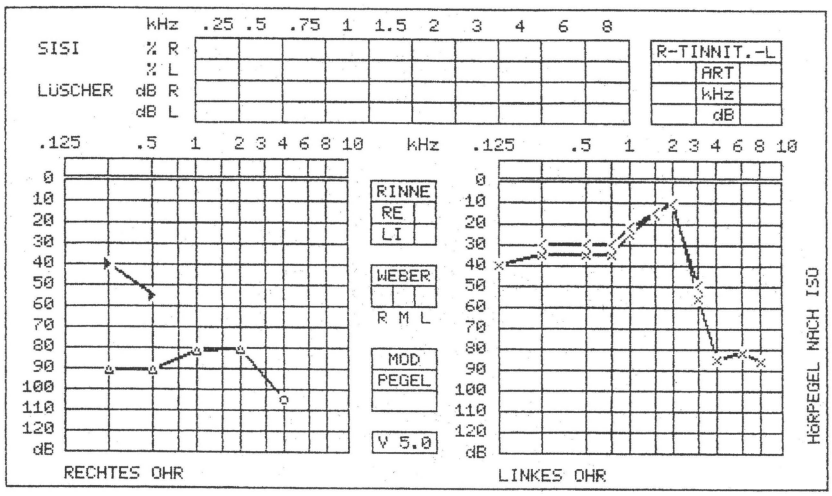

Figure 2. Pure-tone threshold audiogram of a 7-year-old girl (patient 1) with left-sided tinnitus after meningitis.

and only residual hearing in the left ear. He obtained an improvement of hearing of 40–45 dB with a hearing aid in the right ear. In 1997, he came to a checkup and reported a deterioration of hearing that we were able to confirm. In the pure-tone threshold audiogram (spring 1997), a deterioration was confirmed on the right side of (at most) 100 dB. The patient said that he also heard whistling at times in the right ear. Frequency determi-

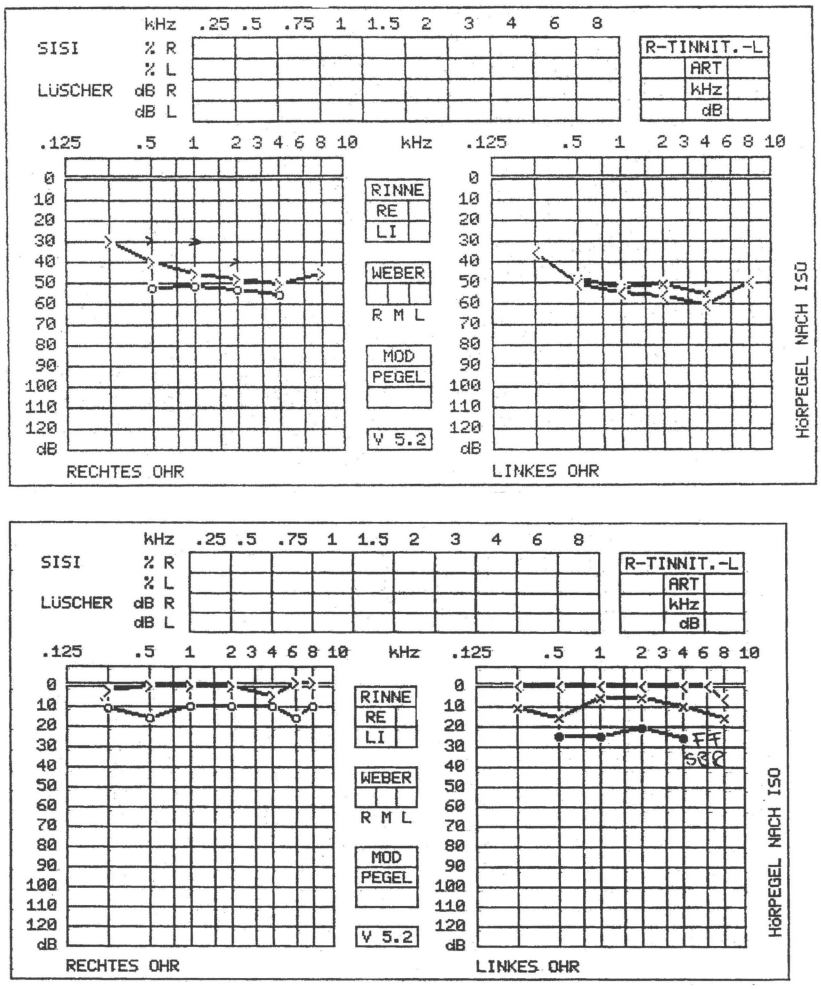

Figure 3. Pure-tone threshold audiograms from an 11-year-old girl (patient 2) with tinnitus of probable psychogenic origin.

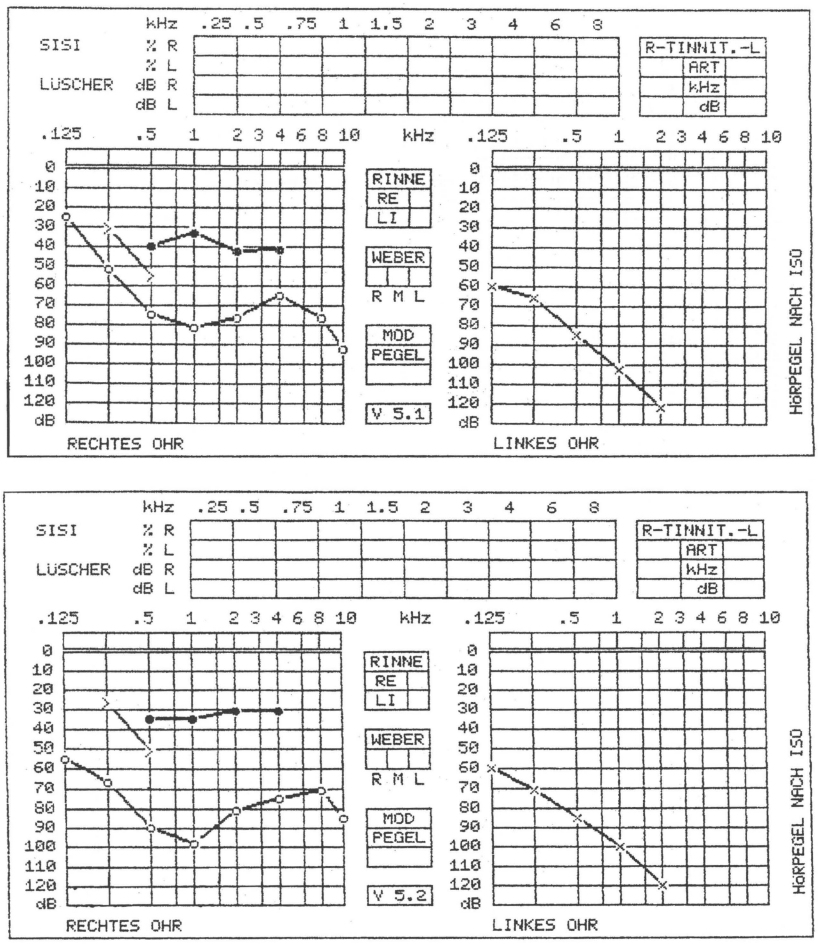

Figure 4. Pure-tone threshold audiograms from a 13-year-old boy (patient 3) with progressive hearing loss and tinnitus.

nation and temporary appearance were not possible. The hearing ability did not appear to have deteriorated with the use of a hearing aid on the right.

The cause of this patient's hearing deterioration is not known to us. Illness was not a factor. We discussed degeneration of the right inner-ear structures, which might be responsible for the tinnitus (Fig. 4).

Patient 4

Patient 4, a 12-year-old girl, was introduced to our clinic because of hearing problems in the right ear. At the age of 12, she had whistling tinnitus and vertigo. One year before the examination, she suffered skull or brain trauma in a car accident, after which her symptoms appeared. Fractures of the skull could not be verified with imaging techniques. We detected a profound hearing loss on the right side, which could be verified with transitory evoked otoacoustic emissions. In addition, we recorded an intensive spontaneous nystagmus. The caloric reactions were in normal ranges.

As a result of our findings, it can be assumed that there is a commotio labyrinthi on the right side. A minimal temporal bone fissure is also conceivable; however, this condition could not be proved by x-ray examination (Fig. 5).

DISCUSSION

The results of this study show that 102 (7.2%) of 1,420 children examined in our center complained of tinnitus. The accumulation of hearing disorders among our patients, however, is not representative of the population as a whole but rather is explained by the function of our facilities, which provides support to children who are hard of hearing and to their families. Only 27 (26.4%) of the 102 children with tinnitus had come to the examination primarily because of existing tinnitus concurrent with normal hearing.

The contributions of Nodar [1, 2], of Graham and Butler [3], and of Shulman [4] are considered landmarks in the field of pediatric tinnitus [5, 6]. Nodar found in a group of children screened for hearing im-

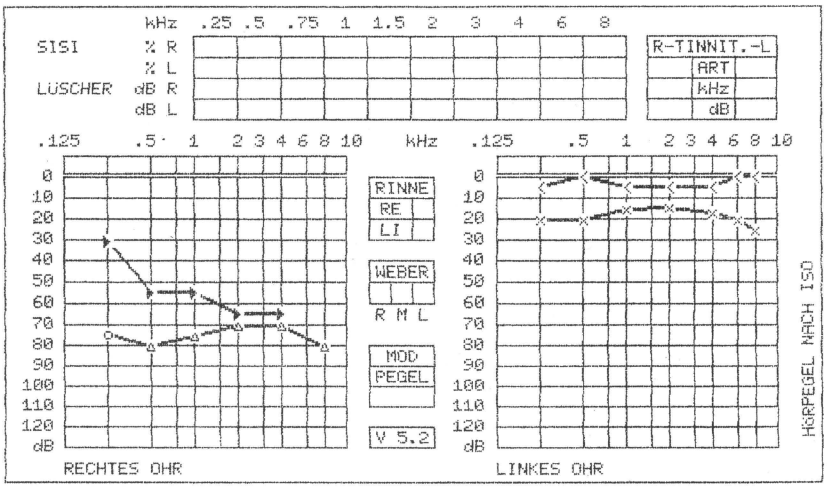

Figure 5. Pure-tone threshold audiogram from a 12-year-old girl (patient 4) with tinnitus, hearing loss, and vertigo after head trauma.

pairment that 13% with normal hearing had tinnitus. In this study, children with sensory hearing loss showed a 59% occurrence of tinnitus, and 3% complained spontaneously about tinnitus. Mills at al. [7] and Mills and Cherry [8] reported that children with conduction hearing loss showed a 40% occurrence of tinnitus.

Compared with that of adults, the level of disability connected with tinnitus was altogether lower in the children. Many children first indicated tinnitus during questioning, and it was also a surprise for parents to learn that their child had tinnitus. The deterioration in those who were hard of hearing was found to be more serious than was the tinnitus itself. Similar observations were made by various other investigators as well [3–6, 9–12].

We received information about possible causes of the appearance of tinnitus from a large number of the patients. The most frequent information given (in 29.4%) was the progression of an existing hardness of hearing. The exact cause for this deterioration, however, was not clear. Degenerative processes and hereditary factors probably play a large role in inner-ear disorders [5, 8, 13, 14–16].

Tinnitus frequently appears in children who are under pressure (60%) [7, 12, 17]. This condition might also represent a noise-induced hearing loss in the inner ear, which may be caused by powered hearing aids that are not adjusted correctly or limited sufficiently. The damage to the sensory epithelium of the inner ear by hearing aids was discussed recently and remains controversial, with the result that some children with residual hearing are not being properly provided with hearing aids [18–20]. We have since discovered that children with hearing disabilities are seriously dependent on powered hearing aids with respect to their hearing and speech development. We also found that children's toys, toy pistols, and noise during leisure activities represent important factors in the emergence of hearing disorders and tinnitus, as shown by a number of researchers [21–25].

Meningitis is an important cause of hearing loss and of tinnitus. This cause could be identified in 20% of our patients. Hearing loss or impaired equilibrium (or both) frequently develop during or after a period of meningitis. We observed frequent inner-ear damage after this disease had been present. This finding has been confirmed in the scientific literature. In particular, distinctive damage to the inner-ear structures is seen in connection with bacterial meningitis [26]. We also encountered a clear cause of tinnitus resulting from skull or brain trauma, in acute hearing loss, and after stapes surgery with cerebrospinal fluid gusher [24, 27].

The mechanisms of development of tinnitus were, however, not as clear in a large proportion of the children. Problems with central sensory perception were found in 14.7%, and emotional factors affected 11.8%; in 14.7%, we were unable to obtain any further information. In these children, pressure situations in school and in the parental home play an important role in tinnitus development (60%).

SUMMARY

Tinnitus appears to be a frequent symptom in childhood. Because children seldom complain about their tinnitus, their problems must always be taken seriously. The diagnostic workup should exclude metabolic disturbances, possible damage to the sensory level of the central nervous system, and evaluation of the circulation. One should always also consider emotional problems and disturbances of perception.

REFERENCES

1. Nodar RH. Tinnitus aurium in school age children, a survey. *J Audit Res* 12:133–135, 1994.
2. Nodar RH. Pediatric tinnitus. Proceedings of the Second International Tinnitus Seminar. *J Laryngol Otol (Suppl)* 9:234–235, 1984.
3. Graham JM, Butler J. Tinnitus in children. Proceedings of the Second International Tinnitus Seminar. *J Laryngol Otol (Suppl)* 9:236–241, 1984.
4. Shulman A. Epidemiology of Tinnitus. In A Shulman, JM Aran, J Tonndorf, et al. (eds), *Tinnitus Diagnosis/Treatment*. Philadelphia: Lea & Febiger, 1991:242–245.
5. Graham JM. Tinnitus in children with hearing loss. *Ciba Found Symp* 85:172–192, 1981.
6. Graham JM. Pediatric tinnitus. Proceedings of the First International Tinnitus Seminar. *J Laryngol Otol (Suppl)* 4:117–120, 1981.
7. Mills RP, Albert DM, Brain CE. Tinnitus in childhood. *Clin Otolaryngol* 11:431–434, 1986.
8. Mills RP, Cherry JR. Subjective tinnitus in children with otological disorders. *Int J Pediatr Otorhinolaryngol* 7:21–27, 1984.
9. Baguley DM, McFerran DJ. Tinnitus in childhood. *Int J Pediatr Otorhinolaryngol* 49:99–105, 1999.
10. Ben-David J, Podoshin L, Fradis M. Tinnitus in children—still a neglected problem. *Int Tinnitus J* 1:155–157, 1995.
11. Podoshin L, Ben-David J, Teszler CB. Pediatric and geriatric tinnitus. *Int Tinnitus J* 3:101–103, 1997.
12. Rosanowski F, Hoppe U, Pröschel U, Eysholdt U. Chronischer Tinnitus bei Kindern und Jugendlichen. *HNO* 45:927–932, 1997.
13. Glanville JD, Coles RR, Sullivan BM. A family with high-tonal objective tinnitus. *J Laryngol Otol* 85:1–10, 1971.
14. Kimberley BP. Applications of distortion-product emissions to an otological practice. *Laryngoscope* 109:1908–1918, 1999.
15. Martin K, Snashall S. Children presenting with tinnitus: A retrospective study. *Br J Audiol* 28:111–115, 1994.
16. Streppel M, Betten T, von Wedel H, et al. Ein Beitrag zum progredienten Hörverlust bei hörgestörten Kindern. *Laryngorhinootologie* 76:23–126, 1997.
17. Drukier GS. The prevalence and characteristics of tinnitus with profound sensorineural impairment. *Am Ann Deaf* 134:260–264, 1989.
18. Brügel FJ, Schorn K. Die In-situ-Messung als notwendiger Bestandteil der Hörgeräteanpassung. *Laryngorhinootologie* 70:616–619, 1991.
19. Brügel FJ, Schorn K. Die Bedeutung der In-situ-Messung zur Einschätzung der wirksamen Hörgeräte-Verstärkung bei höheren Schalldruckpegeln. *Laryngorhinootologie* 72:301–305, 1993.
20. Stange G. Variation of the tinnitus on moist tubotympanical catarrh and otoscopy after operation. *Laryngorhinootologie* 61:128–131, 1982.
21. Matschke RG. Gehörschäden durch nichtberuflichen Lärm. *Dtsch Ärzteblatt* 90:1518–1519, 1993.
22. Plath P. Schwerhörigkeit durch Freizeitlärm. *HNO* 42: 483–487, 1994.
23. Zenner HP, Struwe V, Schuschke G, et al. Gehörschäden durch Freizeitlärm. *HNO* 47:236–248, 1999.
24. Fleischer G, Hoffmann E, Lang R, Müller R. Dokumentation der Auswirkungen von Kinderknallpistolen. *HNO* 46:535–540, 1999.
25. Ising H. Gehörgefährdung durch laute Musik. *HNO* 42:465–466, 1994.
26. Aust G. Früh- und Spätschäden im auditiven und vestibulären Bereich nach Meningitis im Kindes- und Jugendalter. *HNO* 42:14–21, 1994.
27. Kempf HG, Tempel S, Johann K, Lenarz T. Complications of cochlear implant surgery in children and adults. *Laryngorhinootologie* 78:529–537, 1999.