Neurootological Aspects of Presbyacusis

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Abstract:
Presbyacusis is a growing deficiency of the function of the human sense of hearing during the second half of human life. Usually it begins at the age of 50 to 55 years. The deficiencies increase much after the age of 70-75 years. Neurootology is dealing with the normal as well as the pathologically changed functions of the cranial senses. This includes the hearing function. For objectively and quantitatively measuring the function of hearing we apply audiometry. However as the function of hearing is bound into the statoacustic system the diagnosis can be much improved when also simultaneously applying equilibriometry in the same patients.
First of all the individual complaints of the patients must be questioned by the neurootologist in a differentiated manner. Therefore we have used the neurootological scheme NODEC.
For this study we compared 98 neurootological patients of age 60 – 83 years with 68 patiants between 20 and 40 years. At all patients we applied our statoacustic neurootological diagnostics.
All in all this paper shows that our patients do not suffer from - even if they belong to the younger group between 20 and 40 years or to the older group between 60 and 83 years - not only a single sensorial deficit but regularly from a combination of various deficits which can objectively and quantitatively be demonstrated. However, the entrance key into the neurootological investigation is the history which already discriminates various complaints. It is remarkable that the younger group of patients shows more subjective stress factors like headache, migraine, loss of vigour, forgetfulness and tiredness. However, when it comes to the description of the two sleeping behaviours, we find more frequently sleep disorders and many pathologies in head and body stabilisation in the elderly.

Keywords: presbyacusis, tinnitus, neurootological analysis, audiometry, vestibulometry, statoacustic system, functional degeneration, old age

INTRODUCTION

Presbyacusis is the gradual decline of hearing function that results from aging. It is similar to other aging processes because it occurs at different ages and at different rates among the population. As a person ages, there is a gradual loss of cochlear hair cells, beginning at the basal end of the organ of Corti, with the result that hearing is gradually reduced and eventually lost, first for the highest audible frequencies (around 20,000 hertz) and then progressively for sounds of lower frequency.

Presbyacusis may be defined as hearing loss in the elderly patient, presenting mainly as an increase in pure tone thresholds in the higher frequencies and shrinkage of the dynamic acoustic range.

MATERIAL AND METHODS

In neurootology, the complaints related to disturbances and failures of the statoacoustic system play an important role. A major group of complaints comprises vertigo, instability, nausea, tinnitus, hearing loss, etc. For this study, we have randomly selected a sample of 98 individuals above the age of 60, and 68 individuals between 20 and 40 years of age.

We are specially interested in how much differences are there in hearing deficiency between the two samples and how many other factors like history bound stress factors can be found.

In the older age group, the ages of the participants extend between 60 and 83 years. In the younger age group, the age extends from minimally 20 years up to 40 years. All the patients were individually investigated and classified in the Bad Kissingen Neurootology Institute.

For the statistical analysis we are using a material available at the 4GF-Institute Bad Kissingen, Germany. The neurootological patients belong to both genders and many decades of life.

The neurootometric investigations, which were individually applied, follow this scheme:

1. ENT inspection
2. Systematic history questionnaire NODEC
3. Polygraphic ENG
4. Simultaneous ECG
5. Caloric Butterfly-test
6. Rotatory Intensity Damping Test (RIDT)
7. Vestibular Stimulus Intensity Comparison (VESRIC)
8. Cranio-corpography (CCG)
9. Standing-test (Romberg)
10. Stepping-test (Unterberger-Fukuda)

All the tests were objectively and quantitatively evaluated. The data were transferred into a spreadsheet of Microsoft excel.
Based on this array of digital data about our patients we performed various statistical analysis for obtaining answers to our different clinical questions.

RESULTS

Concerning the biodata, the samples show the following behaviour:

Table 1: Quantitative parameters of a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

Parameter	Age 60 – 83 years	Age 20 - 40 years	Differences

	98 = 100%	68 = 100%	
Male (%)	48.98	50.00	-1.02
Female (%)	51.02	50.00	+1.02
Age (year)	67.41 ± 6.26	35.53 ± 5.77	-22.54

Patients were carefully explored by our history taking by the investigating doctors for major subjective complaints. The results are presented in table 2.

Table 2: Stress factors of a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years 98 = 100%	Age 20 - 40 years 68 = 100%	Differences in %
Headache	37.76	60.29	-22.54
Migraine	0.00	2.94	-2.94
Loss of vigour	61.22	73.53	-12.30
Forgetfulness	55.10	60.29	-5.19
Tiredness	65.31	70.59	-5.29
Sleeping disorder	45.92	38.24	+7.68

When evaluating the stress factors and subjective disease complaints of table 2, it is obvious that more of these stress factors found in the younger group of 68 patients between 20 and 40 years of age. This is especially related to headache with 22.54 % and loss of vigour of 12.30 %. But also migraine only occurs in the younger group, and there is a more frequent subjective feeling of forgetfulness and tiredness. However sleeping disorders are more frequently found in the older age group.

The specific vertigo and nausea complaints are summarized in table 3.

Table 3: Vertigo and nausea complaints of a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years 98 = 100%	Age 20 - 40 years 68 = 100%	Differences in %
Vertigo	84.69	82.35	2.34
Giddiness	67.35	60.29	7.05
Dizziness	73.47	69.12	4.35
Nausea	32.65	26.47	6.18

When analyzing table 3 we find the opposite trend to table 2. There are trendwise only higher values found for vertigo, giddiness, dizziness and nausea in the old-age group in comparison to the younger age group.

When specifically looking with other cranial senses like hearing, vision, smell, and taste, we come to the following findings as shown in table 4:

Table 4: Disturbances of the cranial nerve senses of a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years 98 = 100%	Age 20 - 40 years 68 = 100%	Differences in %
Tinnitus	76.53	72.06	+ 4.47
Hearing loss	96.94	86.76	+ 10.17
Visual disorders	45.92	38.24	+ 7.68
Smell disorders	4.08	4.41	- 0.33
Taste disorders	4.08	5.88	- 1.80

When considering the combination of disturbances of the cranial senses, we find, as expected, elevated occurrence rates for tinnitus, hearing loss and visual disorders in the old-age group. Quantitative records are led by major differences in hearing losses within the younger towards the older group, followed by visual disorders. Tinnitus is higher in the older age group with the lowest difference amounting to 4.47 %. However, the other cranial sense disorders like smell disorders and taste disorders are slightly more frequently found amongst younger patients.

We also looked into basic background diseases of both groups of patients. It is well known and understood that basic disorders like cardiovascular diseases, hypertension, hypotension, and metabolic like diabetes mellitus play also a role in the frequency of occurrence of neurosensorial deficits. The results are exhibited in table 5.

Table 5: Background diseases of a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years 98 = 100%	Age 20 - 40 years 68 = 100%	Differences in %
Whiplash disorder	23.47	36.76	-13.29
Ear surgery	0.00	1.47	-1.47
Hypertension	34.00	14.71	+19.99
Hypotension	2.04	5.88	-3.84
Cardiovascular disorders	20.41	1.47	+18.94
Metabolic disorders (Diabetes mellitus)	7.14	0.00	+7.14
Stroke	1.02	0.00	+1.02

When evaluating the background diseases as given in table 6, it is obvious that the most prominent effective background disorders are found in the old-age group with high blood pressure (19.99 %) and cardiovascular disorders (18.94 %). Also diabetes mellitus with 7.14 % is leading within metabolic diseases. However, in the group of the younger, the traffic accidents and traumas like whiplash are leading.

All the different neurootological tests as well the neurootological history are summarized in a neurootological diagnosis according to the type of Claussen Medical Expert System (CLAMEDEX) at Bad Kissingen. Table 6 comprises the results.

Table 6: Neurootological test and history of a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years 98 = 100%	Age 20 - 40 years 68 = 100%	Differences in %
Monosensorial disorder	0.00	0.00	0.00
Multisensorial disorder	100.00	95.59	+4.41
Peripheral vestibular disorder	45.92	47.06	-1.14
Central disequilibrium	95.92	75.00	+20.92
Cerebellum pontine angle disease	5.10	4.41	+0.69
Pontomedullary disease	89.80	63.24	+26.56
Mesencephalic disease	3.06	5.88	-2.82
Supertentorial disease	6.12	5.88	+0.24
Cerebellar disease	15.31	10.29	+5.01

Table 6 exhibits that there was no single patient within the younger as well as within the older group who only showed a deficiency in one neurosensorial system being objectively and quantitatively tested at Bad Kissingen. With respect to the multisensorial disorders, the amount was by 4.41 higher in the older age group.

The peripheral disorders occurred 1.14 % more frequently in the younger age group, whereas the majority of the central disorders, especially in the pontomedullary area of the brain stem are found in the old age group. Audiograms are classified with respect to tonal decay in the three areas of the pure tone audiogram, which are low-tone deficiency between 25 Hz and 750 Hz, middle-tone deficiency between 1.000 Hz and 2.000.Hz, and high-tone deficiencies above 3.000 Hz. Also pancochlear deficiencies are found. The above mentioned criteria go for the sensory neural hearing loss. When adding the middle ear component between air conduction and bone conduction, we also must take into consideration the so-called “mixed middle ear hearing loss”. Additionally, the discomfort level was investigated showing the discrimination loss between hearing threshold and discomfort threshold. When taking these characteristics into our table, we come to the values as exhibited in table 7.

Table 7: Pure Tone Audiometry of a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years 98 = 100%	Age 20 - 40 years 68 = 100%	Differences in %
Low-tone hearing	5.10	10.29	-5.19

deficiency			
Middle-tone hearing deficiency	0.00	0.00	0.00
High-tone hearing deficiency	65.31	50.00	+15.31
Pancochlear hearing loss	50.00	14.71	+35.29
Mixed middle ear hearing loss	2.04	4.41	-2.37
Discrimination loss	16.33	1.47	+14.86

The evaluation of table 7 exhibits that the older group of patients suffers more from pancochlear hearing loss (35.29 %) and high-tone hearing loss (15.31 %) than the younger group. Even the discrimination loss with a difference amounting to 14.86 % is much higher in the old-age group than in the young-age group. The mixed hearing loss type of the middle ear component between air conduction and bone conduction is slightly elevated in the younger group, and even the low-tone hearing deficiency is much more elevated with a difference of 5.19 % in the group of the younger patients.

Bruit is a real existing sound by means of auscultation through a stethoscope or a microphone derived from the skull of the patients. Usually, the patients report about a bubbling, whizzing, pulsating etc. sound, which also can be heard from outside.

All sounds can be transferred from the inner parts of the skull through the ears towards the outside.

The endogenous tinnitus is classified by being maskable and we try to cover the tinnitus by external sounds.

The exogenous tinnitus, unlike the endogenous tinnitus, is a subjective sound in the hearing pathway, which does not benefit from a masking procedure. Some authors wrongly name this illness “hyperacusis”, but these patients do not hear better as the terms “hyperacusis” would suggest. Therefore, Claussen has also named this disease “Syndrome of the hypersensitive ear”. In exogenous tinnitus, pure-tone audiometry may be normal or exhibit regular deficits in the hearing threshold. But there is no maskable tinnitus. However, when measuring the acoustic dynamics by adding the audiometrically recorded discomfort threshold, it is observed that the discomfort level, which usually lies between 1 kHz and 8 kHz below 95 dB, is rising below the level to 90, 60 or even 50 dB. Persons exposed to sounds exceeding the level of the low-discomfort threshold, experience a loss of well-understood words together with subjective pain and noise in the ear accompanied by possible vegetative reactions.

Table 8 now exhibits our findings about the different tinnitus classifications also including slow-brainstem syndrome. Claussen and his group found among the older patients cases who complain a hazy tinnitus in combination with vertigo, giddiness and dizziness. These persons also report about a reduced state of alertness. They suffer from connected statoacoustic problems. Objectively these persons exhibit an increase in the latencies of the experimentally provoked vestibular nystagmus as well as of the acoustically evoked brainstem potentials. This group of tinnitus cases is summarized under the heading of “Slow-brainstem syndrome” (Claussen).

Table 8: Tinnitus phenomena in a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years 98 = 100%	Age 20 - 40 years 68 = 100%	Differences in %
Endogenous Tinnitus	32.65	27.94	+4.71
Exogenous Tinnitus	39.80	42.65	-2.85

Table 8 exhibits that there are more cases with an endogenous, maskable tinnitus in the older age group, whereas the exogenous tinnitus is found more frequently in the younger group.

All the patients explored in this study underwent investigations for three different types of evoked potentials with a bilateral derivation from the skull. The three types we applied are the acoustic brainstem evoked potentials (ABEP), the acoustic late evoked or cortical potentials (ALEP) and the visually evoked potentials (VEP). The potentials being derived from an electrode screen between the two ears and the vertex or between the two sides of the occiput and the vertex are evaluated for ipsilateral, contralateral, and bilateral defects. The stimulation was always performed monosensorially either from one ear or one from eye.

The results are depicted in table 9.

Table 9: Evoked potentials of a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years 98 = 100%	Age 20 - 40 years 68 = 100%	Differences in %
Defective ABEP	68.37	67.65	+0.72
Defective ALEP	38.78	30.88	+7.89
Defective VEP	39.80	11.76	+28.04

Table 9 thus shows that the defects in EEG analysis of the hearing pathway in the brainstem (ABEP) is nearly equally frequent. However, the late evoked potentials like the acoustic late evoked potentials (ALEP) and the visually late evoked potentials (VEP) are much more frequent with the deficits in the old-age group.

For measuring the equilibrium capacities, we have investigated the vestibular spinal system by Cranio-Corpo-Graphy and the vestibular ocular system by monaural and binaural electronystagmography tests of the caloric and of the perrotatory tests. Deficits in the equilibrium pathways between the central equilibrium regulated in the inner ears and in the brainstem towards the body as measured by CCG and towards the eye motor responses as measured with the vestibular recruitment and decruitment are displayed in table 10.

Table 10: Comprised Cranio-Corpo-Graphy- and ENG-Findings in a randomly selected sample of 98 individuals above the age of 60 years and 68 individuals between 20 and 40 years of age.

	Age 60 – 83 years	Age 20 - 40 years	Differences

	98 = 100%	68 = 100%	in %
Central disorder in CCG	55.10	27.94	+27.16
Peripheral disorder in CCG	27.55	26.47	+1.08
Vestibular recruitment	19.39	23.53	-4.14
Vestibular decruitment	44.90	26.47	+18.43

When evaluating the gross values of an equilibrium analysis through the vestibular spinal as well as through the vestibular ocular system, we find many more pathologies in the head and body stabilisation in the older age group with an elevated rate of 27.16 %. This goes together as being shown by Nagy et. al. with the old-age patient's complaints of rocking vertigo, sensation of instability and falling tendency. Still, it also can be seen that the peripheral vestibulo-spinal disorders are slightly elevated. Also the central blocking mechanisms within the vestibulo-oculomotor regulations as being expressed by the various types of decruitment, are remarkably elevated in the elderly. However, the recruitment phenomena which are also combined with bypass regulations and capacity stabilisations are found rather in the younger age group with 4.14 %.

DISCUSSION AND CONCLUSION

All in all this paper shows that our patients do suffer from - even if they belong to the younger group between 20 and 40 years or to the older group between 60 and 83 years - not only a single sensorial deficit but regularly from a combination of various deficits which can objectively and quantitatively be demonstrated. However, the entrance key into the neurootological investigation is the history which already discriminates various complaints. It is remarkable that the younger group of patients shows more subjective stress factors like headache, migraine, loss of vigour, forgetfulness and tiredness. However, when it comes to the description of the two sleeping behaviours, we find more frequently sleep disorders and many pathologies in head and body stabilisation in the elderly.

When talking about presbyacusis, we usually think that the degenerations in the statoacoustic pathways are due to degenerations occurring only in the old age. Therefore, in this paper, we have compared the results in tinnitology of a group of 98 individuals above the age of 60 years and 68 individuals in the typical adult period of 20 to 48 years of age.

Both the samples are comprising a similar amount in gender of approximately half and half, i. e., 50 % of males to 50 % of females in the age group of 20 to 48 or 48.98 % of males with respect of 51.02 % of females. The difference in the latter group is neglectable with approximately 1 %. When, however, looking into the accompanying stress factors (table 2), we find that the group of the younger tinnitus patients is predominantly suffering more from headache (60.29 % with respect to 37.76 %) and loss of personal efficacy with 73.53 % in the younger group and 61.22 % in the older group.

Only with respect to the accompanying sleeping disorders in tinnitus, we find an incidence rate which is much higher in the older group with 45.92 % and 38.24 %.

The opposite is to be seen in the vertigo and nausea complaints as depicted in table 3. The parameters like vertigo, dizziness, giddiness, and nausea occur more frequently in the group of the older patients than in the group of the younger patients. The major differences above the percentages of 5 % are to be found with giddiness and nausea. When looking at the general cranial sense and their disorders, we find that the occurrence rate, hearing loss and visual loss is more frequent in the old-age group in comparison to the younger. In smell and taste disorders, the differences are neglectable. The old-age group shows much more pathology (above the difference of 5 %) with respect to hearing loss and visual disorders (see table 4).

When looking into table 5 depicting the statistics of the major background disorders, we find a mixed picture. The head and neck trauma of the whiplash type affecting the cervical regulatory loop and creating a cervical tinnitus is much more frequently to be found in the younger group. However, tinnitus due to hypertension and cardiovascular failures as well as due to diabetes mellitus is more frequently seen in the old-age group. This differentiation expresses that the old-age group also suffers in the background from the regular old-age disorders like hypertension, cardiovascular diseases, cardiac insufficiency and metabolic disorders like diabetes mellitus. However, the civilization disorder whiplash, which occurs due to modern traffic, mainly is the sequelae of a car accident, is much more frequent in the younger age group, who are also known to be more risky drivers.

The evaluation of the comprising statistical diagnostic as being performed in Bad Kissingen by means of the Claussen medical expert system comparing pathologies occurring in different pathways is exhibited in table 6. There, we have a significant finding in the first row. When evaluating all the hundreds of parameters, which have been analyzed, we come to the conclusion that there is no monosensorial disorder. This would mean that only the subjective hearing interpretation in the form of tinnitus occurs or only a maskable tinnitus is to be found. All the patients are suffering from multisensorial disorders. The multisensorial disorders include peripheral and central diseases. This means that, when we also go in for the functional topodiagnostic, we can localize many of the pathologies at various levels in the peripheral vestibular receptors, in the pontine brainstem, in the pontomedullary brainstem, in the mesencephalon or supratentorially or cerebrally. This means that, when in this circuit loops in the pathways some sort of pathology occurs, also a hearing function as well as the equilibrium function is affected at the same time.

Therefore, it is important that, in future, in the tinnitus cases of a clinically important tinnitus complaint, we have the possibility to derive a systematic therapy. Table 7 then describes the localization of the tinnitus phenomena in the modern functional representation of the audiometrically charted hearing. Most frequently, in both the samples, we have to deal with a high tone hearing deficiency. However, this occurs much more frequently in the old age than in the younger patient group.

Also the pancochlear hearing loss occurs much more frequently in the old age than in the younger group. When going into audiometry, we also find that the loss of discrimination is significantly more frequently to be seen in the sample of the old-age tinnitus patients. When classifying the two groups with tinnitus according to our four-

colour system, especially into endogenous tinnitus, which means a maskable tinnitus with maskable characteristics, and into exogenous tinnitus, meaning a tinnitus with decayed hearing performance, we see that the two groups are of differently positioned. We find more tinnitus of the endogenous type in the old age and more tinnitus of the exogenous type in the younger group. This then also means different approaches for the counterregulation of tinnitus, However, when looking at the analysis of the evoked potentials in the hearing pathways as well as in the visual pathways (see table 9), we have to observe that the acoustic brainstem evoked potentials are equally affected in two thirds of the patients of the younger as well as the older group. However, the late evoked cortically acoustic potentials show significantly more pathology in the old-age group than in the younger group. This goes together with a finding in table 8 that also the endogenous tinnitus, which is much due to degenerations and dysfunctions in the central hearing pathways, is more frequent in the older age group than in the younger age group.

Astonishingly, the central function of another central sensorial pathway system, which is the visual pathway system, shows much more defects in the old-age group than in the younger. The difference amounts to 28.04 %.

When summarizing all the different details of the equilibrium pathways as being found in a thorough neuro-otometric investigation, we see in table 10 that the amount of central CCG disorders are much more frequent in the old-age group than in the younger adult group. The peripheral disorders in the CCG test is nearly equal for both the samples. The analysis of the stepping test cranio-corpography recorded and evaluated by means of the CCG, all in all shows a pathology of 82.65 % in the old-age group. This exhibits that cranio-corpography is very sensitive for a combined analysis of the statoacoustic pathways.

In the younger adult group with tinnitus, we find only 54.41 % of pathology in the pathology. However, this also shows that even in this group, the vestibulospinal equilibrium pathways are affected. So, generally speaking, we should apply cranio-corpography with the most sensitive arrangement of the stepping test in all the future cases approaching us for a differential diagnosis of tinnitus and for receiving a plan for therapy.

When going on the other road from the inner ear in the statoacoustic pathways towards the cortex, we can use the very sensitive tests of caloric and perrotatory vestibule-ocular nystagmus. The pathology in these tests mainly is comprised in the definitions of vestibular recruitment and vestibular decruitment. Vestibular recruitment mostly including peripheral, vestibular or inner ear disorders, shows to be more frequent (23.53 %) in the younger group than in the older age group (19.39 %). However, when going into the overshooting or sensorial block phenomena in the equilibrium pathways as exhibited by the vestibular decruitment, we see much more pathology in the old-age group (44.90 %) than we see in the younger adult group (26.47 %). The difference amounts to 18.43 % (see table 10).

When comprising the pathology being detectable with this sensitive tool of the vestibular stimulus response intensity comparison (VESRIC), we find in the old-age group 64.29 % of a concomitant pathology in the vestibular pathways. In the younger adult group, the two pathologies of the vestibular recruitment and vestibular decruitment amount to 50 %.

All in all, the most sensitive tool for finding pathology in the vestibular system here can be proved to lie in the field of the very sensitive stepping test as recorded in the radar-image-like chartings of the cranio-corpogram. But also the sensitive vestibulo-ocular tests like the caloric test and the per- and postrotatory nystagmus test help us to detect 50 % of pathology occurring parallel to tinnitus.

So, when drawing a line on the whole of our findings, we come to the conclusion that there is not such a thing like a monoparametric tinnitus. Tinnitus always seems to come together with deficits along the statoacoustic pathways. For localizing the site and the kind of the lesion, the equilibriometric analysis is very hopeful. More details in this field will come out from recent studies concerning a major group of tinnitus patients coming for rehabilitation to the 4-GF Institute in Bad Kissingen.

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