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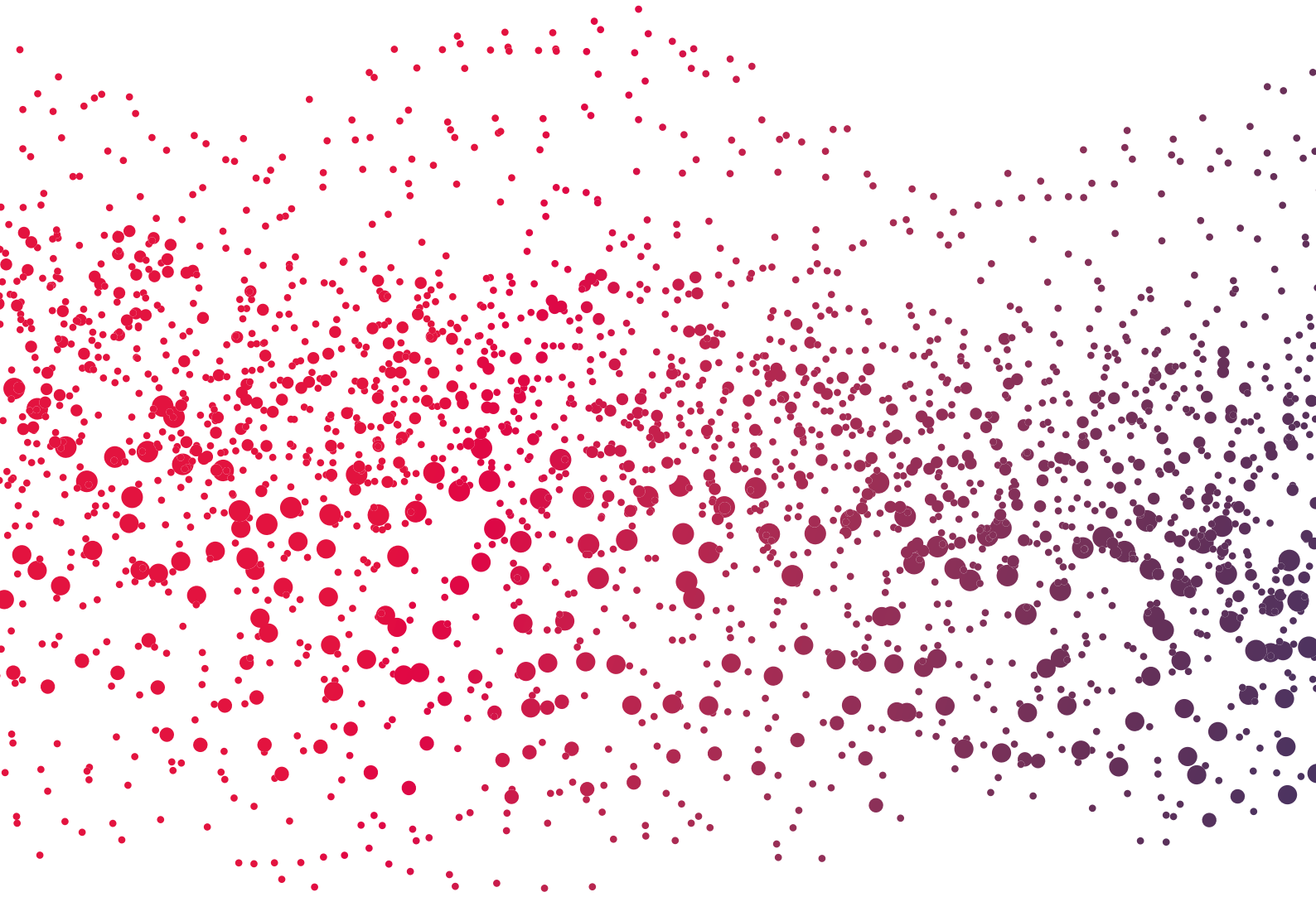
Otology & Audiology Article Review



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the filtered words test, the dichotic numerals test, the gap detection test, and the binaural masking level difference test.

- Page 17: Min Roh – New Zealand:
  - In vivo Assessment of an Endolymphatic Hydrops Gradient Along the Cochlea in Patients With Menière's Disease by Magnetic Resonance Imaging – A Pilot Study.
    - *Bier G, Bongers MN, Schabel C, Heindel W, Ernemann U, & Hempel JM.*
    - *Otology & Neurotology, 39(10), e1091-e1099.*
    - *This pilot study investigates the potential use of a novel approach to evaluate endolymphatic hydrops gradients along the cochlea within patients with Menière's Disease with good sensitivity and specificity..*
- Page 20: Reddy Sivaprasad – India:
  - Prevalence and incidence of clinically significant patulous Eustachian tube: A population-based study using the Korean National Health Insurance Claims Database.
    - *Sung-Won Choi et al.*
    - *American Journal Otolaryngology, 2018: 39, 603–608.*
    - *The study was conducted using national health insurance claim data of Korea which measured the incidence and prevalence of PET in entire Korean population from 2012-2016. The gender variations were also clearly noted.*
- Page 21: Reddy Sivaprasad – India:
  - Early Indication of Noise-Induced Hearing Loss in Young Adult Users of Personal Listening Devices.
    - *Hussain T et al.*
    - *Annals of Otology, Rhinology & Laryngology, 2018: 127(10), 703–709.*
    - *Using an established research design, authors examined PLD users in North America, measured preferred subjective and objective volume levels in SPLs. A high risk subgroup was easily identified which demonstrated permanent threshold shift at 4 kHz and 6 kHz in puretone audiometry.*
- Page 22: Reddy Sivaprasad – India:
  - Sudden Sensorineural Hearing Loss in Hemodialysis Patients Could be a Marker of Pathogenic Progression in the Mortality and Atherosclerotic Events: A National Cohort Study.
    - *Chu-Lin C et al.*
    - *Otology & Neurotology, 2018: 39, 1241–1249.*
    - *Huge number of patients receiving hemodialysis were studied to see if SSHL is a potential marker to complications in mortality and cardiovascular diseases. The findings indicate that after SSHL, significant number of patients developed complications when compared to those without SSHL.*
- Page 24: Reddy Sivaprasad – India:
  - Microstructural Alterations in the Brains of Adults with Prelingual Sensorineural Hearing Loss: a Diffusion Kurtosis Imaging Study.
    - *Zou Y et al.*
    - *Otology & Neurotology, 2018: 39, e936–e943.*
    - *A new set of parameters were used in an MRI study to find the deficiencies in white an gray matter of the auditory cortex. The technique was able to quantify the deficiencies in both parts in adults with a prelingual hearing loss compared to those with normal hearing.*

- Page 26: Reddy Sivaprasad – India:
  - Rate of Spiral Ganglion Cell Loss in Idiopathic Sudden Sensorineural Hearing Loss.
    - *Unger OJ et al.*
    - *Otology & Neurotology, 2018: 39, e944–e949.*
    - *The authors examined temporal bones of the patients affected by IISNHL and counted the rate of decay of spiral ganglion cells. They used data from unaffected ear and also from the age-matched controls to make a ratio basis which 5 years from the date of onset is found to be ideal for doing CI.*
- Page 27: Reddy Sivaprasad – India:
  - Significance of 1 kHz Pure-tone Threshold in Acute Low-frequency Sensorineural Hearing Loss.
    - *Lee CK et al.*
    - *Otology & Neurotology, 2018: 39, e950–e955.*
    - *This study examined audiological characteristics, risk factors and different treatment options for 170 patients with ALFHL. Two risk factors seem to be significant without these risk factors all treatment options seem to have yielded similar outcomes.*
- Page 29: Lorenzo Notarianni – Italy:
  - The impact of rehabilitation on quality of life after hearing loss: a systematic review.
    - *Anna Brodie, Bethany Smith & Jaydip Ray.*
    - *European Archives of Oto-Rhino-Laryngology (2018) 275:2435–2440.*
    - *The majority of research into the impact of hearing loss and quality of life provides evidence that the results of hearing rehabilitation are largely positive. A hearing device does not solely regard the improvement of auditory health, but also an increased awareness and the understanding to hearing loss and how many different areas of our lives that can be affected by the condition are equally important. Successful hearing rehabilitation can have a profound positive impact on quality of life.*

Listening through hearing aids affects spatial perception and speech intelligibility in normal-hearing listeners.

Jens Cubick, Jörg M. Buchholz, Virginia Best, Mathieu Lavandier and Torsten Dau.

The Journal of the Acoustical Society of America 144, 2896 (2018)

Hearing aids seem to have a negative effect on SRT in noise for normal-hearing listeners. This study wants to investigate if this negative effect can be explained by a disturbed spatial perception.

10 normal hearing subjects performed SNR tests with and without hearing aids. A real-time HA processing platform was used so that, compared to the unaided condition, the provision of gain and the position of the microphones were the only influence on the ear signal. Front microphones (omnidirectional) of Phonak Ambra BTE were used, combined with tubes with foam plugs in the ear. The hearing aids generated a linear frequency-independent gain of 10 dB (insertion gain).

Speech intelligibility was measured, with the target speech in front and three maskers (speech or SSN) at 0° (collocated) or ± 90° and 180°(separated). The subjects were also asked to draw the perceived position (both in angle and distance) and the extent of the target and masker sounds.

To control if the effect of wearing a hearing aid can be predicted with energetic masking, a simulation was made. This simulation showed that the BTE micro removed the ear canal resonance around 2-3 kHz and resulted in less energy towards the higher frequencies. In the aided condition, the ILD for ± 90° was on average 5 dB more in frequencies above 2 kHz. ITD showed no systematic difference. The combined effect of better-ear listening and binaural unmasking resulted in a prediction of the change in SRT when wearing a hearing aid.

The best result (-12 dB SNR) was obtained in the unaided condition with separate speech interferers. The advantage in separated conditions (compared to collocated conditions) is the Spatial Release from Masking. The HA condition, the masker type and the spatial distribution all have a significant effect on speech intelligibility. When analyzing the effect on SRM, both the HA condition and the masker type are significant.

The position sketches showed larger variability in the image position, often broader images and differences in perceived distance when wearing HA. With the speech interferer, localisation is more precise than with SSN. And the localisation of separated interferers is better than when the interferers are collocated.

To some extent, the model can predict the difference between with or without hearing aid. This indicates that energetic masking is associated with the disadvantage of hearing aids in speech intelligibility in noise.

The disadvantage of hearing aids is not so big in the collocated condition as in the separated condition. This means that it is possible that the deterioration of the spectral cues caused by the hearing aids makes it more difficult to separate target and interferers and consequently

leads to poorer SRT in noise. (because in the separated condition spectral cues are more important)

A shortcoming of this study is that only normal hearing listeners were recruited, with no hearing aid experience. No real hearing aid was used, but a simplified HA. And one can question if a foam plug is sufficient to simulate a real custom-made earmould.

Comorbidities of hearing loss and the implications of multimorbidity for audiological care.

Besser J, Stropahl M, Urry E, & Launer S.

Hearing Research 2018; 369: 3 – 14

Many chronic health conditions, including hearing loss, increase in prevalence with increasing age. It is common for older adults to live with two or more chronic conditions and this multimorbidity can reduce patient functioning and quality of life as well as increasing healthcare costs and treatment plan complexity. This article reviewed the literature regarding comorbidities of hearing loss in older adults and discussed the implications for management of hearing loss in multimorbidity situations.
Method

A literature review was conducted of cross-sectional and prospective longitudinal studies published between 2010 and 2018 including at least 400 participants. Search queries were entered into a database for hearing loss and each of nine comorbidities (listed below) selected from a list of common chronic health conditions associated with aging and hearing loss compiled the World Health Organisation (WHO, 2015), and from two other large studies of associations between hearing loss and other health conditions.

Results
Vision impairment – Several studies show that the prevalence of dual sensory impairment–vision and hearing loss – in older adults is higher than the product of the prevalence of each impairment alone. This suggests the two conditions are not independent of each other.
Mobility restrictions – The examined studied showed greater mobility restrictions and greater odds of falling in individuals with hearing loss than those with normal hearing. Mobility restrictions were also found to increase with increasing hearing loss.
Cognitive impairment – Evidence across several large studies shows an increase in the incidence of dementia and rate of cognitive decline in adults with hearing loss. Dementia risk was found to increase with hearing loss severity.
Psychosocial health – Some studies reviewed showed higher levels of anxiety in people with hearing loss compared to the general population, particularly with increasing degree of hearing loss. Inconsistent evidence was found of a relationship between number of depressive episodes and poorer hearing.
Diabetes – Both cross-sectional and longitudinal studies reviewed showed an increased risk of hearing loss in patients with diabetes than those without.
Cardiovascular disease (CVD) – Several large population studies indicated a modest increase in the risk of hearing loss in people with hypertension or other cardiovascular risk factors, such as elevated cholesterol or high body-mass index.
Arthritis – Some studies showed an increased risk of hearing loss in patients with arthritis when the generalised term "arthritis" was used, whereas other found a relationship between hearing loss and specific types of arthritis, such as rheumatoid arthritis.
Cancer – There is a well established relationship between cancer and hearing loss that is generally attributed to radiotherapy and chemotherapy treatment rather than the cancer itself.

Stroke – A higher prevalence of stroke was found in older adults with hearing loss compared to age-conducted controls with normal hearing. A longitudinal study found that poorer hearing at baseline was associated with a history of strokes, but a history of strokes was not associated with change in hearing over time.
Mechanisms of associations: For all the health conditions assessed, aside from cancer, the mechanism of the association with hearing loss remains unclear and is likely to be complex.

Discussion
This review confirms that hearing loss is often one of multiple health problems suffered by older people and the authors conclude that understanding and counselling for these patients is important, as well as rehabilitation for hearing loss that takes into account any comorbidities. In addition, hearing loss should be considered when treating patients with other health conditions. For instance, managing health to reduce risk factors for CVD or diabetes may also reduce the risk of hearing loss for individuals. The authors recommend training for clinicians working with such patients at increased risk of hearing loss to educate and screen their patients for hearing problems and refer on when appropriate. It is suggested that integrated treatments using a "one-stop shop" model could be beneficial for patients.
It is also suggested that screening for associated co-morbidities, such as vision and diabetes, could be performed by hearing care professionals to extend their portfolio of services. Audiologists may also be well equipped to offer balance screening services to identify problems earlier and potentially avoid injuries that could affect patient mobility and general health. The structure of such an "extended audiological care model" remains unclear and the authors acknowledge that further research is needed on potential solutions for managing patients with multimorbidity.
Another role of audiologists is to improve treatment outcomes for patients by addressing hearing loss with amplification, thus removing a barrier for patients communicating with clinicians and other health professionals. Beyond improving communication, few longitudinal studies have assessed whether wearing hearing aids can alter the association between hearing loss and other health conditions. This is clearly an area for further research.

This review provides a good overview of the relationship between hearing loss and other common health conditions in older adults. The presence of each the health conditions reviewed was associated with an increased risk of hearing loss in older adults, with several conditions showing an increased risk of the health condition with increasing hearing loss severity. These relationships are important for audiologists to be aware of and consider when evaluating patients with other health issues; when educating patients or other individuals on the risks of untreated hearing loss and the importance of hearing protection; and when treating patients with multimorbidity. Other health care professionals should also be aware of the increased risk of hearing loss when treating patients with these comorbid conditions and refer for hearing assessment when appropriate. Further research clarifying the mechanism of these relationships may be beneficial in reducing the risk of developing hearing loss or developing other health conditions, depending on the mechanism identified. There is also a need for longitudinal studies assessing whether treating hearing loss with amplification can reduce the risk of developing other health conditions.

Evaluation of saccular and inferior vestibular nerve function in children with auditory neuropathy spectrum disorder.

El-Badry M, Gamal R, & Fawzy A.

European Archives of Oto-Rhino-Laryngology 2018; 275: 2925 - 2931

Most cases of auditory neuropathy spectrum disorder (ANSD) are either congenital or acquired shortly after birth and thus pre-lingual. More rarely, children acquire ANSD post-lingually, after the development of oral language. Pre-lingual onset ANSD is characterised by significantly impaired speech and language development, whereas children with ANSD of a post-lingual onset present with markedly impaired speech discrimination, particularly in the presence of background noise. The pathological site in ANSD is believed to be one or more of the inner hair cells (IHCs), synapses between the IHCs and auditory nerve, the auditory nerve, or the central auditory nervous system.
Previous studies have shown absence of cervical vestibular evoked myogenic potentials (C-VEMPs) in adults with post-lingual onset ANSD, suggesting pathology of one or more of the saccule, inferior vestibular nerve, or central connections of the sacculo-collic reflex. It has been suggested that these findings are the result of an inferior vestibular nerve pathology analogous to the pathology of the auditory nerve. Limited data is available looking at C-VEMPs in children with ANSD.
This study measured C-VEMPs in children with pre- and post-lingual onset ANSD to compare saccule and vestibular nerve function between the two groups. It was hypothesised that differences in C-VEMPs between the two ANSD groups may indicate a different site of lesion and add to the understanding of each pathology.
Method
The study included 38 children with pre-lingual onset ANSD (mean age 6.7 years), 16 with post-lingual ANSD (mean age 11 years), and 20 control children (mean age 7.2 years). In the pre-lingual ANSD group 25 children had no neonatal risk factors for hearing loss, while 13 children had one or more risk factors. All children underwent tympanometry, acoustic reflex testing, click-evoked ABR testing, and C-VEMP testing using 500 Hz tone-bursts delivered via air-conduction. Developmentally appropriate audiometry was performed where possible. Distortion product otoacoustic emissions (DPOAEs) were also recorded for post-lingual ANSD children.
The diagnostic criteria for ANSD were absent ABR, present cochlear microphonic, and absent acoustic reflexes. Additional diagnostic criteria for post-lingual ANSD were present DPOAEs, poorer speech discrimination than predicted from pure-tone thresholds, and normal MRI of the temporal bone.
Results
92.1% (35/38) of children with pre-lingual onset ANSD had present C-VEMPs bilaterally with response parameters (amplitude, asymmetry ratio, latency) that were not significantly different from the control group. There was no difference in responses between children in this group with or without neonatal risk factors for hearing loss.
In contrast, 68.8% (11/16) children with post-lingual onset ANSD had absent C-VEMPs bilaterally. C-VEMP response parameters in the five children with intact C-VEMPs in this group did not differ from the control group. Children with present C-VEMPs had significantly

better pure-tone thresholds and speech discrimination scores than children in the same group with absent C-VEMPs.

Discussion

Results indicate that whereas most children with pre-lingual onset ANSD have normal saccular and inferior vestibular nerve function, in the majority of children with post-lingual ANSD the disorder affects the saccule and/or inferior vestibular nerve to the degree that C-VEMPs are completely absent. Based on previous research showing normal sensory epithelium of the vestibular end organs in adults with post-lingual ANSD, the authors propose that the absence of C-VEMPs in these children is most likely due to neuropathy of the inferior vestibular nerve, similar to that that affects the auditory nerve and abolishes the ABR.

These results are consistent with studies showing over 90% of adults with post-lingual ANSD have absent C-VEMPs, although the rate of absent responses in children is much lower. The authors suggest that this difference is due to ANSD progressing following initial post-lingual presentation, gradually involving the inferior vestibular nerve in addition to the auditory nerve over time. They hypothesise that the better hearing in children with present C-VEMPs supports this theory of a progressive pathology and recommend longitudinal follow-up of C-VEMPs in these patients to assess changes. No information is given on time since diagnosis/onset of symptoms for spot-lingual ANSD children included in this study. The authors conclude that the pathological site in ANSD differs for the pre- and post-lingual onset forms of the disorder. The saccule and/or inferior vestibular nerve are affected in addition to the auditory nerve in the majority of cases of post-lingual ANSD, but are generally spared in pre-lingual ANSD. It is concluded that these results may have clinical implications for the management of ANSD in children, although such implications are not discussed in any detail.

This article adds interesting information to our understanding of ANSD by highlighting differences in the site of pathology in the pre-lingual and post-lingual forms of the disorder. The results indicate that post-lingual onset ANSD (but not pre-lingual) is often associated with pathology of the saccule and/or inferior vestibular nerve, however the implications of this for balance function in patients is not discussed. It is not clear if bilateral dysfunction of the sacculo-collic reflex results in significant imbalance, or how this should affect audiological management. It is also unknown at this stage whether the superior vestibular nerve is also involved and future studies using bone-conducted oVEMPs may clarify this issue. Any effect of the differential site of the pathology on potential to benefit from hearing aids and/or cochlear implants is also a key area for further research. Whereas this study provides an interesting starting point, addressing these additional questions raised by this study could help to create clearer (perhaps multi-disciplinary) diagnostic and treatment pathways for people with pre-lingual and post-lingual ANSD.

Benefit of binaural listening as revealed by speech intelligibility and listening effort.

Jan Rennies and Gerald Kidd.

The Journal of the Acoustical Society of America 144, 2147 (2018).

Intro:
The article starts with a brief overview of studies on binaural advantages for speech intelligibility to indicate that the influence of the spatial separation of speech and environmental noise was usually demonstrated in the past on the basis of an improvement in speech understanding. Furthermore, in addition to this release from masking there was little attention for the release of listening effort.
A few applications of measuring listening effort are described; Listening effort can provide important information about the functioning and speech understanding of people in realistic situations and can therefore provide more information on top of the measurement of speech intelligibility. This is how the example is given that in situations where speech intelligibility is at or close to ceiling, listening effort evaluation can make a difference in the assessment how difficult it is for the listener to follow a conversation.

Goal:
The aim of this research was to determine to what extent 'spatial noise separation' has an influence on 'listening effort' and binaural speech intelligibility in a normal hearing population aged between 18-30 years.

Method:
10 subjects rated sound files under headphones, with a frontal talker and a speech-shaped noise. Intelligibility and listening effort were measured in a broad range of SNRs both in anechoic and reverberant listening situations and the influence of maintaining only interaural level (ILD) or interaural time differences (ITD) were evaluated.

Results:
The general finding was that in situations where speech and noise were spatially separated, listening effort was lower compared to symmetric conditions. This was found even in situations where speech intelligibility was at ceiling.
In sub-ceiling situations listening effort and speech intelligibility were highly correlated for all conditions.
By comparing the results with only ITD and only ILD, it appeared that the binaural benefit was mainly achieved by the ILD cues alone.

Our opinion:
The study offers a good basis for further research on the importance of binaural listening in adverse listening situations.
It shows once again that measuring listening effort is an interesting tool for evaluating multiple real-life listening situations. It allows us to make a clear difference in the extent to which real life speech is easy to follow in situations where speech intelligibility is at ceiling. It should support us to incorporate listening effort as a tool for evaluating multiple features within hearing aid fitting, especially at high SNRs

because this leans much closer to the reality of the hearing aid users daily communication situations.
We would find it very useful to test these insights, within a normal-hearing young population, in a hearing-impaired population with and without hearing aids.

The development of a decision aid for tinnitus

Helen Pryce et al.

International Journal of Audiology, 2018, Vol. 57, N°. 9, 714–719.

Shared decision-making is becoming the standard in healthcare when more than one possible treatment option is available. This is the case in tinnitus treatment. Clear information about the different treatment options should be given to the patient including pros and cons. Therefore, it is important that clinical practices provide standardized information instead of the current highly variable quality of information given to the patients. Variation in healthcare is not a problem in itself provided that patients informed preferences cause this variation. Confusion between outcome preferences in patients and their treatment preferences should be avoided by providing clarity in the interactions between patients and clinicians.
Evidence-based information of all current therapeutic options including harms, benefits and potential side effects must be included.
Therefore, the British Tinnitus Association funded this research to develop a targeted one-page grid style decision aid, as it is proven to be as effective as a more expensive DVD decision tool.
Decision aids have the advantages for the patient of feeling better informed and having more realistic expectations.

In this research the procedure of Marrin's guidance on decision aid development (2013), conform to the standards required by the International Patient Decision Aid Standards IPDAS (Sepucha 2018), were followed.

First the patient treatment and outcome preferences and frequently asked questions for tinnitus treatment have been identified.
In depth interviews with 41 individuals who had sought help for tinnitus have been conducted to develop themes of how preference for coping with tinnitus occur and are mediated. Explicit and inferred preferences both were analysed and formed the coded themes. Five questions summarize the main concerns expressed by participants.

These five frequently asked questions have been included in the grid:
- *Will this option mean I hear my tinnitus less or cure it?*
- *What does this do to tinnitus?*
- *How does this approach help tinnitus?*
- *How do I access this option?*
- *Can I choose more than one option?*

Secondly evidence based treatment options, best supported by research evidence, have been listed.
25 articles were selected in the search for systematic review and clinical guidance to determine clinically relevant interventions that are frequently recommended in practice. The editorial team agreed not to specify the precise intervention, but to refer to options as "approaches". The four options (Figure 2) derived for the decision aid were:

- *Understanding tinnitus,*
- *Talking therapies,*
- *Using sound and*
- *Group support.*

These therapeutic approaches were worded in broad terms and encompass a range of possible interventions.

The third step was to form an editorial team to design a draft of the decision aid, including the research team and other volunteers with appropriate expertise. No conflicts of interest were reported for the evidence reported on the decision aid draft. A wider reference group of professionals evaluated whether the content of the draft reflected current views of tinnitus treatments. In the setup of the grid, the most pressing question is chosen to be the first question on the grid. Participants decided that the first option for tinnitus care should be 'understanding tinnitus'.
The consensus on time and way to introduce the tinnitus decision aid is before the initial dedicated tinnitus appointment with the audiological clinician.

Step four was user testing the draft by six focus groups of patients and professionals (Table 1). These focus groups answered a list of questions ((Table 2) to capture their views of decision aids, the potential use of the tinnitus decision aid and the choice of treatments.

The Fifth step was to assess readability by using Readable.io software. This way average reading age was determined. Longer clauses have been simplified and shortened and some technical language like "cognitive behaviour therapy" was replaced by "talking therapy". Reading age is lowered from 8,7 to 7,8. Technical terms "tinnitus" and "audiologist" remained in the grid.

The last step was the assessment of usability of the decision aid by the participants at focus groups, by trying it out in clinical practice after reading it and checking that the intended meaning was clear. Subsequently feedback was given on the feasibility and acceptability in routine practice and further clarifications needed. Two clinicians answered that it was clear and easy to use. They reflected that it was challenging because it required a change to usual practice, introducing shared decision-making.

Conclusion
It was a complex process to develop the decision aid. Therefore the structured approach outlined in Marrin et al. (2013) has been followed. The grid can now be used to inform the patient of the opportunities for care and encourage shared decision-making. Clinicians are guided how to apply shared decision making using the video at: https://www.youtube.com/watch?v1/46726cCoRDrE and at www.tinnitus.org.uk/decision-aid

Critical note

It is an important step towards shared decision-making for chronic tinnitus treatment.

Unfortunately, I was not able to access the video on YouTube and I did not find it at www.tinnitus.org.uk/decision-aid. On YouTube I found this video: https://www.youtube.com/watch?v=6726cCoRDrE&t=1002s

Future directions of research into this area should incorporate more results on how to apply the decision aid. How to explain the grid in detail including the pros and cons of different options? What training do professionals need to apply the grid in daily practice giving evidence-based information and clearly outline the harms, benefits and potential side effects of all available options? Do patients have more realistic expectations using the decision aid?

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The Danish test battery for auditory processing disorder evaluated with patient and control data

Pedersen, E. R.

International Journal of Audiology, 2018, Vol. 57, N°. 10, 755-763.

Introduction
A test battery is used to assess the presence of Auditory Processing Disorder (APD). There are four tests within the Danish APD test battery: the filtered words test, the dichotic numerals test, the gap detection test, and the binaural masking level difference test. The filtered words test involves the participant being presented the same 25 low-pass filtered monosyllabic words to each ear independently in a different order and repeating what they have heard. In the dichotic numerals test participants are presented with sets of four monosyllabic numerals – two played in the left ear and two in the right ear and they must repeat as many numerals as possible. The gap detection test involves the participant being presented with 22 white noise segments of varying durations monoaurally and the participant reports the number of gaps heard. During the binaural masking level difference test, participants are presented with 31 band-pass filtered white noise segments containing tone beeps and asked to respond "yes" if at least two beeps are heard or otherwise say "no".

When evaluating a patient, the results of the APD test battery are considered, together with the results of language and cognitive tests, standard audiological tests and the patient's medical history. APD is suspected when at least two tests in the APD test battery have been failed.

Clinicians have been using the Danish APD test battery since 2008 but it has only been studied in respect of children who have no known auditory problems. The present study extends research in the field by including both children with APD and a control group without the APD diagnosis. The objective of this research was to (1) set cut-off values (criteria for passing and failing the tests), (2) calculate the sensitivity and specificity of the APD test battery and (3) investigate the failure rate of different test combinations.

A group of 112 children diagnosed with APD (57 boys, 55 girls, aged 6-16 years) and a control group containing 158 children without auditory problems (75 boys, 83 girls, aged 6-16 years) were part of this study.

The tests were presented to participants by trained audiologists in a quiet room. MATLAB R2016a (www.mathworks.com) was used for the statistical analysis. The researchers performed simple multiple linear regressions for each of the four tests and the two subject groups independently.

Results
- *New cut-off values were established for each of the four tests in the APD test battery based on the results from the simple linear regressions (with ear, sex and age as explanatory variables).*

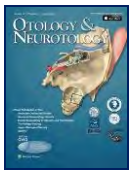
- *The sensitivity of the whole APD test battery was 95.3% and the specificity was 91.6%, each determined with sensitivity and specificity weighted equally.*
- *The percentages of participants failing different test combinations (when sensitivity and specificity were weighted equally) was determined. The filtered words and dichotic numerals tests were failed by 78.1% of the children in the APD group whereas 40.6% of the children in that group failed both the gap detection and binaural masking level difference tests. Although the gap detection and binaural masking level difference tests were the least sensitive, these tests contributed to a significant number of children in the APD group failing the APD test battery and their omission results in specificity increasing and sensitivity decreasing.*
- *In a comparison of cut-off values from a previous study completed by the author with only participants with no auditory problems (with data adjusted to ensure a like for like comparison), all but one of the cut-off values in the present study were the same or slightly higher.*
- *On the filtered words and dichotic numerals tests, scores for the right ear were significantly better than scores of the left ear in both the APD and control groups.*

Critical note

A strength of this study is the study design which includes both children diagnosed with APD and a control group without auditory processing problems.

A weakness of this study is that not all participants completed the four tests. 38% of the APD group did not complete the gap detection test in one or both ears. The author notes that the gap detection test is the most time consuming and demanding test in the battery and suggests that it would improve the APD test battery if efforts were made to reduce the duration of this test or replace it with an alternative test. Another limitation is that when determining the sensitivity and new cut-off values, it was assumed that all children in the APD group had problems with all aspects of the APD test battery, which is not necessarily the case as all tests do not need to be failed for a diagnosis of APD. This assumption may result in lower cut-off values for the filtered words, dichotic numerals and binaural masking level difference tests and higher cut-off values for the gap detection test, resulting in APD being suspected in fewer cases. Overall, the article provides clinically useful cut-off values for the tests in the Danish APD test battery and makes some suggestions for improvement to the current testing process.

In vivo Assessment of an Endolymphatic Hydrops Gradient Along the Cochlea in Patients With Menière's Disease by Magnetic Resonance Imaging – A Pilot Study.



Bier G, Bongers MN, Schabel C, Heindel W, Ernemann U, & Hempel JM.

Otology & Neurotology, 2018; Vol 39 (10): e1091-e1099

Introduction
Menière's Disease (MD) is classically characterized by a trio of audio-vestibular symptoms: hearing loss, tinnitus or aural fullness, and rotary vertigo. The hearing loss characteristically involves the lower frequencies of the audiogram, though in some instances, patient do present with a more flat hearing loss.
Hypothetically, the low frequency hearing loss would be associated with a deficit in the apical turn of the basilar membrane of the cochlea, meaning that it would have to be more susceptible to any pathologies that may be involved in MD, or at least be the most susceptible to the pathophysiology of MD.

The presence of endolymphatic hydrops, which are acknowledged as the morphological correlate to MD, have long been visualized using Magnetic Resonance Imaging (MRI) with a T2 weighted inversion recover sequence.
Previous studies have graded the degree of endolymphatic hydrops in the cochlea, and the degree of correlation to the reported audio-vestibular symptoms. However to date, there have been no studies using imaging techniques to assess a hydrops gradient along the cochlea itself (from apical to basal).
Therefore the authors decided to investigate novel ways to assess an endolymphatic hydrops gradient along the cochlea using MRI techniques and a mixture of qualitative and quantitative measures.

Methodology
A total of 10 patients (six women, four men) with definite MD (as diagnosed according to criteria specified in AAO-HNS) were included in the study. The age range was 32 to 72 years of age, with a median age of 60.

A six-frequency pure-tone audiometry (PTA) was conducted immediately before the 3T MRI scan.
MRI scans were conducted after an intravenous injection of Gadobutrol (contrast) with a four-hour delay.
- *MR-cisternography (MRC) with sensitivity encoding.*
- *Two heavily weighted volume isotropic turbo spin echo acquisition inversion recovery (hT2w-VISTA-IR) sequences with varying inversion times were used to obtain both a positive endolymphatic image (PEI) and a positive perilymphatic image (PPI). The HYDROPS subtraction image was obtained by subtracting the PEI from PPI.*

Image Evaluation
1) Two radiologists with 6 years' experience in inner ear imaging each, graded in consensus, the presence or absence of endolymphatic hydrops (none, mild, significant) of

the HYDROPS image. The radiologists also subjectively assessed a potential gradient of endolymphatic space distention (apical, basal, mixed) (qualitative).
2) Both radiologists independently performed quantitative measurements of the endolymphatic space distention using both the MRC and HYDROPS images loaded onto a 3D viewer. This was performed in two ways:
a. Index-based approach (semi-quantitative): an apical-basal index (ABI) was calculated by dividing the ratio of the endolymphatic area to the cochlear area of the apical plane versus the basal plane.
b. Slope-modelled approach (quantitative): the slope of the endolymphatic hydrops were calculated by averaging the slopes across various segments of turns from the round window. This was then correlated to the average slope of the PTA of patients.

PTA results were corrected for both age and sex with the correction values stated by the OSHA. A frequency-wise segmentation of the cochlea was done according to a system presented by Verbist et al. (2010) and this was used to assign the age- and gender-corrected PTA to the cochlea for comparison.

Results
Clinical examinations suggested the presence of MD as right-sided in five cases, left-sided in four cases, and bilateral in one case. In contrast, MRI examinations suggested the presence of endolymphatic hydrops as right-sided in three cases, left-sided in one case, and bilateral in six cases. The grading of hydrops was mild in nine ears, significant in seven ears. There was no significant difference found between the unilateral/bilateral presentation of hydrops and the configuration of the pure-tone audiometry curve.

Comparison of models
1) Qualitative Approach (Grading gradient of HYDROPS image). 13 of 16 ears showed an 'apical' gradient, while 3 of 16 ears showed a 'mixed' gradient. The results were in good concordance to the results of the PTA.
Predicting low frequency hearing loss: Sensitivity = 100%. Specificity = 42.86%.
2) Semi-Quantitative Approach (Index Model). The index model predicted a medial ABI (apical-basal-index) = 1.25 for a low frequency hearing loss (PTA-predicted ABI = 1.69) and 1.17 for a flat hearing loss (PTA-predicted ABI = 1.17). Correlation between Index model and PTA derived ABI were not significant.
Predicting low frequency hearing loss: Sensitivity = 77.8%.
3) Quantitative Approach (Slope Model). The slope model predicted a median steepness to be 7.44 (PTA-predicted steepness = 7.38), indicative of a more apical endolymphatic hydrops distribution.
Predicting low frequency hearing loss: Sensitivity = 88.9%. Specificity = 71.4%.

Discussion
The radiological findings of the study suggested that there were bilateral hydrops in six patients, whereas confirmed MD was only in one patient. This discrepancy can be seen frequently in current literature, and further studies investigating the link between hydrops and hearing loss will help develop a more rounded description of MD and its early diagnosis and prognosis.

Critical Note:
Limitations of this study included a very small sample size of patients that have confirmed MD. Thus a broader application of this study should be considered investigating into non MD patients as well. The study had presumed that basal

endolymphatic hydrops was not consistent with MD, and though not typical for MD, would have been important to incorporate into this study.

Furthermore, the PTA correlation used for the study had been age- and sex-corrected as per standards from the OSHA, and the pathophysiology of age- and gender- related changes to endolymphatic spaces in MD patients have yet to be investigated. Frequency segmentation in the cochlea was based on a frequency map of the human cochlea, however the inter-patient variation of frequency distribution was not accounted for (lack of in vivo measurements to confirm).

In summary, this pilot study provides evidence for a methodology to describe the longitudinal distribution types of endolymphatic hydrops in patients with Meniere's Disease. This may have potential implications in future management of the disease, including surgical aspects such as endolymphatic sac removal or cochlear implants. Non-invasive pharmacological strategies could involve specific locations along the cochlea.

Prevalence and incidence of clinically significant patulous Eustachian tube: A population-based study using the Korean National Health Insurance Claims Database.

Sung-Won Choi et al.

American Journal Otolaryngology, 2018: 39, 603–608.

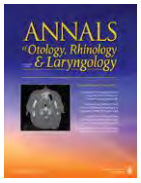
The eustachian tube (ET) is normally closed and open briefly while performing several activities including swallowing. Patulous Eustachian tube (PET) is a disease that affects patients with auditory symptoms such as aural fullness and autophony of breathing sounds due to persistent opening or inadequate
closing of the ET. PET results in permanent hearing loss and some vestibular symptoms, while there is a relief noted in certain postures like lying. The diagnosis of PET can be confirmed by directly observing the inward and outward movement of the tympanic membrane at the same time as forced nasal breathing. The aim of this study was to investigate prevalence and the incidence of PET using the Korean National Health Insurance (NHI) claims database.

Population-based medical data for patients of all ages with PET were extracted from NHI claims database retrospectively from January 2010 to December 2016. The data was analysed by sex and age for these identified patients with PET, and further used the population data provided by the Korean NHI to determine the incidence and prevalence of PET. Prevalence rate, incidence rate and the age standardization rate were measured.

A total of 20,533 PET patients reported during the study period from 2012 through 2016. Both the crude and age- and gender-standardized annual prevalence rate of PET was 10.3 per 100,000 persons in 2016. The prevalence of PET was among men and women were 7.2 and 13.4 per 100,000 persons in 2016, respectively. The male and female ratio was 39.9% for males and 60.1% for females. The rates were higher among females during the study period. The analysis of prevalence rates revealed that this measure peaked in the age group 20–29 years for female and decreased thereafter, respectively. A 43% increase (from 7.2 to 10.3 per 100,000 persons) in the crude annual prevalence of diagnosed PET from 2010 to 2016.

This is a national population-based study which clearly shows age and gender variances in the prevalence and incidence rates of PET, which a rare condition.

Early Indication of Noise-Induced Hearing Loss in Young Adult Users of Personal Listening Devices.



Hussain T et al.

Annals of Otology, Rhinology & Laryngology, 2018: 127(10), 703–709.

Surge in usage of multifunctional smartphones to listen to music as a personal listening device (PLD) is now a clear phenomenon among the youth. This presented along with a recent finding that the prevalence of hearing loss among the teenagers is on a rise has lead to speculations but it is not clear if PLDs are causing it. Authors conducted this study in a North American context, with young study participants who had already been using their devices for multiple years and assessed their listening preferences as well as their hearing ability.

50 young adults who have been using iphone or ipod for the past several years were recruited. Subjective scale was administered to identify the usage pattern, duration, subjectively preferred volumes (on a scale) in quiet and in background noise. Objective measurement PLD output in SPLs in ear canal were recorded in quiet and in background noise. Routine puretone audiometry was also conducted for all the participants. Based on NIOSH criteria of permissible noise levels, a high-risk subgroup was also identified. Their exposure in dB SPL shown in the table.

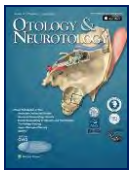
Preferred Listening Level:

Noise Environment	*High Risk Group (n=11)*	*Low Risk Group (n=39)*
Quiet	*74 dBSPL*	*71 dBSPL*
Background Noise	*96 dBSPL*	*85 dBSPL*

Further analysis showed that study participants who exhibited potentially hazardous listening preferences (⩾2h PLD use per day, ⩾91 dBA preferred volume level in a noisy environment, n = 11) had an increased hearing threshold at 4000 Hz and 6000 Hz compared to other participants.

This study used an already well-established research design and replicated the findings in an American context. However, clearly demonstrated how subgroups of PLD users are at high risk for a permanent hearing loss.

Sudden Sensorineural Hearing Loss in Hemodialysis Patients Could be a Marker of Pathogenic Progression in the Mortality and Atherosclerotic Events: A National Cohort Study.



Chu-Lin C et al.

Otology & Neurotology, 2018: 39, 1241–1249.

Sudden Sensorineural hearing loss (SSHL) is defined as a shift if HTLs by 30 dB with an onset less than 72 hours. Though several causes and theories have been proposed to explain the ethology, the causes largely remain unknown. Haemodialysis is known to increase the risk of SSHL as shown by several studies. The risk of SSHL showed that the incidences of SSHL were0.49, 2.12, 2.95, and 2.37 per 1,000 person-years in the general population, haemodialysis (HD) patients, peritoneal dialysis (PD) patients, and patients with end-stage renal disease (ESRD), respectively. Furthermore, SSHL was reported to be a predisposed risk of acute stroke during a 5-year follow-up in the general population.

This study was conducted in Taiwan, which reports highest incidence and prevalence of HD in the world. The objective of the study was to use the national database (from 1997 to 2008) to examine the incidence and subsequent outcomes, such as mortality, haemorrhagic stroke, ischemic stroke, acute coronary syndrome (ACS), and peripheral arterial occlusive disease (PAOD), of incident HD patients with new-onset SSHL among HD patients.

The data was divided into two groups, namely HD patients with new-onset SSHL (N=288) and non-SSHL HD (N=1728), matched by age, sex, and duration after the first time HD. The index date was defined as the onset date of SSHL. The study follow-up time began from the onset date of SSHL. To evade the confounding effect of HD, each control in the non-SSHL group was matched with a case in the SSHL group that had the same duration of HD.

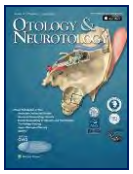
Results:

	Sudden Sensorineural hearing loss (SSHL)	*Non – SSHL*	*p-value*
Mortality	*27%*	*17%*	*<0,001*
Haemorrhagic stroke	*5%*	*2%*	*<0,001*
Ischemic stroke	*10%*	*4%*	*<0,001*
Acute Coronary Syndrome	*8%*	*4%*	*0,001*
Peripheral Arterial Occlusive Disease	*11%*	*7%*	*0,018*

The table above shows that the mortality, haemorrhagic stroke, ischemic stroke, ACS and PAOD all are significantly higher in HD group with SSHL. The findings can be summarised as: HD patients with subsequent SSHL had a significantly higher incidence and risk of all-cause mortality than did HD patients without SSHL, and HD patients with subsequent SSHL had a significantly higher incidence and risks of acute stroke (haemorrhagic stroke and ischemic stroke) and CVDs (ACS or PAOD).
Basis these findings, the authors call for immediate attention when SSHL is seen in HD patients.

As claimed by authors, this is the first of its kind study on this subject. This study was included a large number of SSHL patients with all necessary follow-up data, which itself is a rare opportunity. The subject selection (matching for age, sex etc.,) makes it more relevant. While many variables have been controlled in the design, the findings need to be replicated in other races too.

Microstructural Alterations in the Brains of Adults with Prelingual Sensorineural Hearing Loss: a Diffusion Kurtosis Imaging Study.



Zou Y et al.

Otology & Neurotology, 2018: 39, e936–e943.

The development of cortex in the brain is stimulus driven from respective sensory/ motor organ. In subjects with prelingual SNHL, their auditory cortex can be activated by other sensory input such as
visual and tactile stimuli, which is due to the ''cross-modal'' plasticity and as has been shown in studies using magnetic resonance (MR), positron emission tomography, as well as animal experiments. Some studies pointed out the structural alterations in both grey matter (GM) and white
matter (WM) but no consistent findings were seen.

Diffusion kurtosis imaging (DKI) is a new diffusion-weighted technique that has evolved from DTI and is based on non-Gaussian diffusion by estimating the kurtosis of water distribution, in addition to estimating DTI derived metrics. DKI technique helps in studying alteration in both grey and white matter and thus has been applied to study the brain microstructure of healthy subjects and those with various diseases such as Alzheimer's disease, epilepsy, multiple sclerosis, and haemophilia.

The objective of this study was to further reveal microstructural alterations in adults with prelingual SNHL using DKI and explore the correlation between the structural changes and the clinical data. The hypothesis was that microstructure of the whole brain in prelingual SNHL subjects changed, and DKI could provide additional features to detect subtle changes in both GM and WM with using voxel-based analysis (VBA) method.

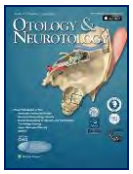
The experimental group consisted of 80 prelingual (hearing loss onset before 3 years of age) adults with a profound hearing loss (PTA above 80 dB HL) with mean age of 41 years and the control group had 78 age-, sex-, and education matched healthy controls (HCs) (mean age: 44.0 years). All subjects underwent the imaging performed on a 3-T MR scanner equipped with a 16-channel head coil.

All DTI and DKI markers indicated a decreased grey matter around the superior temporal gyrus (auditory cortex) compared to the control group. This indicated a loss of microstructural complexity in the auditory cortex that might result from axonal disintegration and cell loss, in line with dystrophic changes in neurons, smaller cochlear nucleus, and reduced volume of the auditory cortex in deaf animals. The study also found decreases in WM around bilateral superior temporal gyrus, in adults with prelingual SNHL. The reduction indicated deficits of microstructural integrity in the auditory pathway. Alterations can also be attributed to microstructural damage such as myelin damage and cell structure loss in the axial direction of WM fibers.

Authors concluded that this new technique could successfully demonstrate the deficiencies in the microstructure of the brain – both in grey and white matters of auditory cortex.

This study was well designed and the strength is in the research design and the markers chosen to be studied. The study may possibly have potential to predict the success of cochlear implantation.

Rate of Spiral Ganglion Cell Loss in Idiopathic Sudden Sensorineural Hearing Loss.



Unger OJ et al.

Otology & Neurotology, 2018: 39, e944–e949.

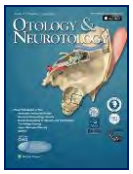
Several theories have been proposed to explain the sudden sensorineural hearing loss, still largely it remains idiopathic (ISSNHL). Temporal bone (TB) surveys of patients with ISSNHL have reported that the pathology is primarily sensory and not neural, supporting the use of cochlear implantation in them. However, prolonged absence of auditory or electrical stimulation can cause neural loss too. Therefore, an understanding of the rate of loss of spiral ganglion cells over time in ISSNHL will help choosing appropriate candidates for cochlear implantation. This study aimed at defining the spiral ganglion cell count (SGCC) and decay rate among people suffering ISSNHL.

The authors collected 18 temporal bone samples of those who had a history of unilateral ISSNHL (from 9 subjects) from the Massachusetts Eye and Ear Infirmary temporal bone collections. From these samples, haircell presence or absence was noted. The number of cochlear neuronal cells was also counted, using a microscopic grid, calculated and expressed as a percentage of normal for age-matched control subjects. Same was done from the unaffected ear (control ear) too and both were compared with age matched general population. The SGCC decay was defined as: SGCC decay = (SGCC of control ear - SGCC of ISSNHL ear) / SGCC of control ear

Results showed that the number of remaining spiral ganglion cells in the contralateral unaffected ears was similar to values reported for age-matched controls. The average ratio was 1.007. Based on the decay rate from the date of diagnosis, and x/y plot can be made. The plot in the article clearly shows a stable SGC count in the first 4-5 years after an attack of ISSNHL, making it the most suitable time for doing a CI. Authors strongly recommend this period to be considered in selecting the candidature.

This is a one of a kind study where in temporal bone samples were used to study the rate of decay of spiral ganglion cell count and recommend CI candidature basis that. Though sample size is small, the study set a precedent for answering such frustrating questions.

Significance of 1 kHz Pure-tone Threshold in Acute Low-frequency Sensorineural Hearing Loss.



Lee CK et al.

Otology & Neurotology, 2018: 39, e950–e955.

Acute low frequency SN hearing loss (ALFHL) is now considered an independent clinical entity (earlier was thought to be a subtype of idiopathic sudden Sn hearing loss). Thought the pathophysiology remains unknown, it seems to be related to cochlear hydrops or early stages of Meniere's disease. In general, ALFHL has better prognosis and responds well to treatment. Also, there is a segment of the population with spontaneous recovery. Similarly, the rate of recurrence is high and its progression is also common though not much literature is available on this topic. In this study, the authors analysed relationships between clinical characteristics and hearing recovery of ALFHL patients and compared treatment methods in the presence or absence of risk factors.

170 patients who reported with acute onset ear fullness and showed at least 30 dB AC thresholds at 250 Hz and 500 Hz (no conductive hearing loss) were included. lesions. All the patients were treated with one of four therapeutic methods as follows: low-dose steroid (LD-steroid), high-dose steroid (HD-steroid), LD-steroid and diuretics (LD combination therapy), and ITDI and diuretics (ITDI-combination therapy).
Thresholds were measured before the treatment and 4 weeks afterward. Complete recovery was defined as recovery of the hearing thresholds < 25 dB at both low frequencies (250 and 500 Hz). Partial recovery was defined as a decrease in the hearing thresholds >10 dB at the average of the two low frequencies (250 and 500 Hz) in the absence of complete recovery. No improvement was defined as a <10 dB difference in hearing. Risk factors for hearing recovery were reviewed as age, sex, the chief complaint, accompanying symptoms (ear fullness, tinnitus, hearing impairment), diabetes, hypertension, time from disease onset, the extent of hearing loss, treatment methods, and 1 kHz involvement. The results of patient profiles shown below.

	Response (n=122)	*No-Response (n=48)*	*P-value*
Age (y)	*43y*	*45y*	*0,25*
Sex (% female)	*72%*	*62%*	*0,26*
Time from disease onset (d)	*7*	*13*	*0,004*
Initial average of 250 & 500 Hz (dB)	*37dB*	*42dB*	*0,008*
Diabetes (%of total)	*7%*	*4%*	*0,63*
Hypertension (% of total)	*7%*	*8%*	*0,72*
1 kHz involvement (% of total)	*20%*	*38%*	*0,015*
Treatment methods (% of total)			*0,95*
LD-steroid	*25%*	*21%*	
HD-steroid	*23%*	*25%*	
LD-combination	*30%*	*29%*	
ITDI-combination	*23%*	*25%*	

Of the risk factors tested, the most significant risk factors for prognosis were time from onset and 1 kHz involvement. Results showed that all treatments yielded similar improvements in patients without any of these risk factors. Further analysis showed that for patients with such risk factors, combination therapy was more effective than oral administration of steroids.

This study focuses on lesser known clinical disorders providing clear visibility on the risk factors for prognosis and all treatment options in one study.

The impact of rehabilitation on quality of life after hearing loss: a systematic review.

Anna Brodie, Bethany Smith & Jaydip Ray.

European Archives of Oto-Rhino-Laryngology 2018; 275:2435–2440

Introduction:
Hearing loss is associated with problems in communicating and as a side effect poor quality of life. The aim of this systematic literature review was the impact of different methodologies of hearing rehabilitation on quality of life. A systematic literature search was conducted on 549 articles retrieved from PubMed. 29 systematically reviewed articles, regarded cochlear implants, bone anchored hearing devices and traditional amplification hearing aids. Hearing rehabilitation was found to be beneficial in all types of hearing loss and treatment but bone-anchored hearing devices and cochlear implants were shown to produce greater improvements in this domain than conventional hearing aids.

Hearing loss, an often-overlooked health problem can cause poor quality of life, decreased socialization, lack of independence, and can affect interpersonal relationships.
It can lead to secondary problems such as learning disabilities, social isolation, depression and possible early dementia which all effect quality of life (Valente et al). 549 articles were retrieved for the research and underwent a careful narrowing down to 45 articles. Most of the articles were excluded after reading the title and abstract because irrelevant to the research question. Of the 45 articles, which received a complete-text read, 29 were included in the results. The main reason for exclusion was due to different outcome measures than quality of life such as hearing improvement solely.

Results
Cochlear implants
Aimoni et al. conducted a case–control paradigm to assess whether cochlear implants influenced quality of life in 57 participants aged over 65. Of these, 42 participants were assigned to the case group and the remaining 15 to a control group. All participants had been fitted with a cochlear implant to treat profound hearing loss. The results showed the improvements obtained in post implant scores in both their audiological tests and quality of life.

In a similar retrospective study, Hilly et al. research review of cochlear implants. 87 participants aged over 60 were recruited. The effects of cochlea implants were investigated 5 years post implantation and it was revealed that none of the audiometry scores had declined. Cosetti et al. conducted a longitudinal study in which they researched the impact of cochlear implants on the cognitive functioning of elderly female patients and though only seven patients were recruited, results showed that 45% of the participants showed moderate to pronounced improvement, with the memory and verbal being the most successful domains. Necula et al. looked at the quality of life after cochlear implantation in comparison to after traditional hearing aid fittings in children. The Nijmegen cochlear implant

HRQoL questionnaire was used. 84 of the participants were cochlear implant users and 50 participants were using hearing aids. Their results demonstrated that the greatest improvements in speech production and in audiometry compared to a traditional hearing aid cochlear implants. Francis et al. proposed a hypothesis on the possible factors that makes cochlear implantation successful; they suggested that clinical and psychological factors could determine how well an individual adapts to their cochlear implant. Their demonstrated that poor education, residing in assisted living facilities and poor general health had a negative impact on speech perception. Therefore, health and psychosocial factors have an impact on successful cochlear implants.

Bone anchored hearing aids

Arunachalam et al. used the GBI questionnaire to conduct a retrospective study to measure quality of life post BAHA implants. 60 participants were recruited, and their results revealed the BAHA had greatly improved quality of life. Analysing the general benefits, the mean score was + 34, the mean score for social benefit was + 21, and the mean scores for physical benefits was + 10 . Research by Hol et al used the health survey (SF-36), the hearing handicap and disability inventory (HHDI) and the EuroQoL-50 (EQ-50) questionnaire. 56 adult participants were recruited after completing the pre-surgery questionnaires and again 6 months post BAHA fitting. Significant improvements were demonstrated in certain areas of participants' lives after surgery such as improvements regarding their handicap and disability. De Wolf et al. conducted a retrospective questionnaire study to investigate if the BAHA had the same success for quality of life when administrated to children with unilateral or bilateral hearing impairments. 31 children were divided into three groups: 10 with bilateral conductive hearing loss and normal cognition (BHL-NC); 6 with bilateral conductive hearing loss with mental disability (BHL-MD); 15 with unilateral hearing loss (UHL). Results from the APHAB, revealed 70% of the BHL-NC found it to be beneficial. Results demonstrated that the younger the patient fitted with the BAHA, the more it was beneficial. Other results using the GHABP showed an overall benefit for all three groups yet greater benefits were reported in the BHL-NC and UHL groups. Doshi et al. also conducted a retrospective case review to investigate the quality of life outcomes after BAHA surgery in children with single sided sensorineural deafness. The GCBI questionnaire was used and the results showed all, but one of the eight children reported a positive GCBI score. Though the sample size is questionable, and not generalizable, these findings support a De Wolf et al., research that the BAHA is an effective strategy for hearing rehabilitation in children, especially when they single-sided deafness. Gillett et al. received responses to a retrospective postal questionnaire from 41 patients between 6 and 88 years old in a district general hospital. The results revealed that quality of life, as measured by the GBI, significantly improved post implant. No major complications reported with 33% reporting minor temporary skin infections. This research supports the safety of BAHA, its effectiveness and reliability as at treatment. They were able to conclude that the BAHA successfully reduces psychosocial consequences of profound unilateral SNHL. Carr et al. highlight how it has already been suggested that the bone conduction hearing aid in an elderly population can lead to more complications, and therefore, reduce the quality of life benefits. They performed a retrospective case note review with a telephone and postal questionnaire. 51 participants aged over 60 participated and received implantation due to single-sided deafness, mixed or conductive hearing loss. The outcome measures were rates of complication and quality of life measured by the GBI. Global scores were 82% and the satisfaction scores were 70%.

These results disprove the hypothesis that the BAHA is not as effective in the elderly demonstrating how bone conduction hearing aids are a reliable method of rehabilitating a variety of different hearing impairments in the elderly.

Hearing aids

A prospective longitudinal outcome-based study by Stewart et al. was used to measure hearing specific status and quality of life in conductive hearing loss before and after hearing aid and surgery treatments. Results demonstrated in all participants significant improvements in the hearing threshold regardless of the type of treatment. These results demonstrate that hearing-specific functional status in conductive hearing loss can improve with treatment, although surgical treatment has shown to be more promising. Murlow et al. highlight however that hearing loss in the elderly affects quality of life due to lack of communication.

The 188 hearing loss participants were randomly assigned to receive a hearing aid or join a waiting list. Both groups underwent a generic quality of life and a complete battery of disease-specific measures at baseline, 6 weeks and 4 months. Those assigned to receive a hearing aid significantly improved in all areas (social and emotional function $p \leq 0.0001$; communication function $p \leq 0.0001$; cognitive function $p = 0.008$; depression $p = 0.03$) thus supporting the hypothesis that the negative effects on quality of life because of hearing loss has negative effects on quality of life that are reversible with hearing aid rehabilitation. Lotfi et al. conducted a similar study on the quality of life in elderly people with hearing loss after they have been fitted with a hearing aid. 207 subjects completed the HHIE questionnaire to determine the severity of their hearing loss and their communication problems and quality of life. The results reveal there was a significant difference when measuring quality of life before and 3 months post receiving a hearing aid ($p \leq 0.000$). These results highlight that hearing aids are extremely beneficial in treating presbycusis in the elderly population. Niemensivu et al. conducted a more recent study evaluating health-related quality of life in those with a hearing impairment before and after receiving a hearing aid.

Those with hearing loss had, unsurprisingly, significantly poorer health-related quality of life on most dimensions both pre and post rehabilitation compared to the control group. Even if rehabilitation with a hearing aid did improve mean scores on the dimensions of hearing, the improvement of the overall score was marginal. These results support the assumption that hearing aids improve subjective hearing and marginally improve health-related quality of life in adults. Chen et al. investigated the impact of sudden SNHL on mental health in adults. The 147 participants recruited all were admitted with sudden SNHL. The degree of mental distress was measured after a follow-up of around 1 year. The association between mental distress, tinnitus and hearing recovery was measured. Subjects who recovered from their hearing loss reported less symptoms of depression. Those who had tinnitus reported more disruptive personal relationships and activities, more physical symptoms and more depressive attitude. The results point towards the importance of rehabilitation and treatment of sudden SNHL. Carlsson et al. who investigated the same issue, but with a bigger sample size of 369 subjects. Tinnitus was the strongest predictor of negative effects on quality of life.

Discussion

Hearing rehabilitation modifies quality of life in many different ways. With cochlear implants, measures have systematically demonstrated how the device is beneficial in treating hearing

loss and improving quality of life. Research has demonstrated how surgery has few risks associated and long lasting benefits. Regarding the BAHA the Quality of life is consistently improved throughout a large range of different research methodologies, which is proof of the reliability and consistency of the BAHA. Patients report high levels of satisfaction and the positive effects found to be long - lasting in longitudinal studies. The device is essential in preventing isolation caused by difficulties in communication and towards preserving cognition in a growing elderly population.
Research on conventional hearing aids has not been as important as the other research in terms of quality of life improvement, yet it does play an important role in preserving hearing abilities.
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Conclusion
The majority of research into the impact of hearing loss and quality of life provides evidence that the results of hearing rehabilitation are largely positive. A hearing device does not solely regard the improvement of auditory health, but also an increased awareness and the understanding to hearing loss and how many different areas of our lives that can be affected by the condition are equally important. Successful hearing rehabilitation can have a profound positive impact on quality of life.
It is important that positive behaviours, attitudes and making hearing loss a more understood disability are important factors to be promoted within the general population. Medical professionals and personal carers need to work towards to improve hearing rehabilitation as improved rehabilitation programs providing clients and their carers alike with the most appropriate strategies to overcome communication breakdown, as this is highly important in dealing with and managing the impact of hearing loss.

A rather straightforward and run of the mill systematic review of the available literature spanning from 1960 to 2017 providing the obvious information yet still useful as material to support EBP strategies in rehabilitation. This is mostly the case for those scenarios where the Hearing Aid Specialist is transitioning from a commercial status towards that of an intellectual profession, and where collaborating in multidisciplinary situations requires the use of protocols and EBP which is beneficial both to the patient as the H.A professional.