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Revue canadienne d'audition

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2014

The Link between Diabetes Mellitus and Sensorineural Hearing Loss

How Open Canal Amplification Was Discovered

Peer Reviewed

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Welcome to another stellar year of *Canadian Hearing Report*. Now that I've set the bar really high for 2014, all I have to do is deliver the goods. You might think this may not be an easy feat considering the outstanding contributors we had in 2013, but it's important to aim high; with the lineup we have for this issue, I think we pull it off.

Right off the bat, we've got the Happy HoH column from the always entertaining and informative consumer advocate Gael Hannan, who shares with us the "Easy Lessons of Hearing Loss."

Also, with kind permission from the fine folks at HearingHealthMatters.org, this issue includes an article by Robert Traynor discussing who he thinks is the "Real Father of Audiology."

We are also happy to bring you a brand new column called Shop Talk. This issue's Shop Talk sees *CHR* sitting down with Unitron's Rob Walesa to discuss Unitron's exciting new Flex program.

Not to be outdone, the issue's features are must-reads as well. First up is James Curran's excellent "How Open Canal Amplification Was Discovered," followed by a terrific article from Eirini Mihanatzidou and Rhonda Kerlew called "The Link between Diabetes Mellitus and Sensorineural Hearing Loss."

What a great way to start the New Year! Please enjoy the issue.

*Scott Bryant*Managing Editor

Canadian Hearing Report 2014;9(1):3.

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WHO IS THE REAL "FATHER OF AUDIOLOGY"

By Robert Traynor
Posted March 13, 2013

Around the world there is usually one individual that stands out as the person that began the profession of audiology in their respective country. These are often those that came to the US, or in later years, other countries as international students and took the profession home and began its practice. These individuals are often thought to be the "Father or Mother of the profession" in their part of the world. There are many individuals that have taken the field and spread it across the globe serving the hearing impaired. Our **Hearing International** quest this week is to review the beginnings of audiology to find that person that began the profession or became the true "Father of Audiology".

As professions evolve, audiology developed rather rapidly. With roots in the speech sciences of the 1920s and 1930s and the basics of audiometry by C.C. Bunch, the profession really got its start during World War II in the treatment of hearing impaired American veterans. Newby (1958) presents that the first use of the word Audiology has been traced to Trainor and Hargrave (1939). The term audiology, however, did not get regular use until 1945 when Raymond Carhart, then an Army speech pathologist and Norton Canfield, an Army otologist applied the term to the field which had been created through the tow fields of specialization that these men represented. Probably best historical discussion of the development of audiology during the World War II period is a 2002 Monograph to *Audiology Today* titled, "The Origins of Audiology: American Wartime Military Audiology," by Dr. Moe Bergman.

Dr. Moe Bergman.

Dr. Bergman, along with his contemporaries, lived the infancy of audiology. A time when there were many basic questions and very few answers about auditory evaluation and rehabilitative treatment of the hearing impaired. Bergman's treatise reads like a virtual "Who's Who" of speech and hearing in the 1950s, 60s, and 70s and should be on the reading list for every basic audiology course worldwide. It was this group of audiology pioneers and their clinical experiences, developed in the shadows of War, that shaped the profession in their publications, textbooks, teaching, research, and leadership that molded audiology into a robust, research-based, clinical profession.

While these professionals developed their skills during the War, the postwar period marked the advent of tremendous technological growth, the use of transistors and such that led to the development of tools for assessing the levels of sound individuals were exposed to, degrees of hearing loss, and in the development of smaller hearing aids. While all of these pioneers substantially contributed the development of the profession one individual, Dr. Raymond Carhart, clearly stands out as the undisputed worldwide "Father of Audiology". This week **Hearing International** focuses on Dr. Raymond Carhart (1912-1975), lest we forget our roots.

Raymond T. Carhart. Courtesy of the National Library of Medicine.

Raymond Thomas Carhart was born on March 28, 1912, in Mexico City, son of Raymond Albert and Edith (Noble) Carhart. There is not much public information as the Dr. Carhart's childhood and early education but he received a bachelor of arts degree in speech and psychology from Dakota Wesleyan University in 1932, and went on to finish master's of arts (1934), and doctor of philosophy (1936) degrees in speech pathology, experimental phonetics and psychology at Northwestern University. A student of CC Bunch, he was one of Northwestern's first PhD graduates — in speech pathology, experimental phonetics, and psychology.

Dr. Carhart remained at Northwestern with the title of instructor in speech re-education from 1936 to 1940. In 1940 he was promoted to assistant professor

and in 1943 to associate professor. The following year he joined the Medical Administrative Corps, U. S. Army, as a captain, ultimately serving 7 years. During the War, Dr. Carhart served as director of the Acoustic Clinic and as acoustic physicist at the until 1946. One of the three facilities designated for hearing rehabilitation during the War period. After World War II, he then returned to Northwestern where he became professor of audiology in 1947, a position he held until his sudden death on October 2, 1975. In 1948 Carhart was appointed assistant professor of otolaryngology at the Medical School in recognition of his work on the Chicago Campus; he was made a full Professor in 1952.

He may be best known for developing and refining speech audiometry, the measure of hearing ability, particularly as it pertains to the efficiency of hearing aids. Most of us remember the "Carhart Method" of hearing aid evaluation that was the "tried and true" technique for about 40 years. While this method was proven to be unreliable and invalid in the 1980s, the technique offered extreme face validity and patients still ask why we do not do this type of an evaluation for hearing aid fittings today.

Although his life was cut short, he has lived on through his many students that became the pillar of the profession, conducting their own research, writing the textbooks, direct audiology programs, founding associations, such as the Academy of Dispensing Audiologists (recently changed to the Academy of Doctors of Audiology), American Academy of Audiology and the Academy of Rehabilitative Audiology. His students became, generally, the teachers of my audiology generation.

As a student or a professional, I did not have the opportunity to meet Dr. Carhart, but I have had the opportunity to meet and work with a number of his students that have carried on his legacy. One of my favourite Carhart quotes is part of his introduction to Mike Pollack's first edition of Amplification for the *Hearing Impaired* in 1975 and it suggests his love of the clinic and those that practiced the profession.

> "The researcher can gather fact after fact at his leisure until he has a sufficient edifice of evidence to answer his question with surety. How different is the clinician's task. He too, is an investigator but the question before him is, "What can I do now about the needs of the person who is seeking my help at this moment?" The clinician proceeds to gather as much data as possible about his client as he can in a clinically reasonable period of time. He does not have the luxury to wait several months or years for other facts to appear. The decisions of the clinician are more daring than the decisions of the researcher because human needs that require attention today impel clinical decisions to be made more rapidly and on a basis of less evidence than do research decisions. The dedicated and conscientious clinician should bear this fact in mind proudly. His is the greater courage."

In the words, of Dr. Jay Hall, another of Carhart's students, "stumbling into Northwestern University [circa, 1972] was one of the luckiest breaks in my life. The students were top notch, the academic setting stimulating and, best of all, I was among a Who's Who in speech pathology and audiology. I was assigned reception desk duty to earn my stipend and each day I had the opportunity to greet the notables who entered the then new Francis Searle Building, including the Father of Audiology – Raymond Carhart."

REFERENCE

Newby H. Audiology. New York: Meridith Corporation; 1958.

Canadian Hearing Report 2014;9(1):6-8.

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What If There Was a Way to Remove the Pressure and Uncertainty for First-Time Hearing Instrument Purchases?

Unitron's Flex™ program is the industry's first risk-free hearing instrument trial and upgrade solution aimed at reducing the barriers to hearing aid adoption. With Flex:trial™, hearing health care professionals can fit patients with a same day trial of technology they recommend, at no cost or obligation, allowing them to experience the benefits of hearing instruments in their daily lives.

One year after the Flex program's introduction, *Canadian Hearing Report* catches up with Rob Walesa, General Manager, Unitron Canada to talk about the market's reaction to Flex, and the advantages it brings to clinicians and their patients.

CHR: Why is a program like Flex important in today's hearing health care market?

Rob Walesa: Our customers are facing many changes in the market. Their neighbourhood is becoming increasingly crowded. They must respond to aggressive, price-oriented marketing campaigns. And, they are dealing with a more sophisticated and educated customer. Flex is a perfect opportunity for us to help our customer tackle these challenges by differentiating themselves; changing the discussion with their patient; and addressing new wearers in a very different way.

CHR: How is Flex allowing clinicians to change the conversation with their patients?

RW: If a person is on the fence about their hearing loss, and is skeptical about the need for amplification, it can be difficult for a clinician to move them past this barrier. Until they can experience the benefit of amplification directly, they cannot place a value on it. They put more emphasis on price and go into commodity mode. Flex allows a clinician to change that conversation by allowing that new patient to "'test drive"' amplification specifically suited to their needs, right at the first appointment. When a consumer experiences the benefit of amplification, it increases their understanding of the value.

CHR: What value does this altered conversation bring to the clinician?

RW: Flex allows clinicians to really practice their craft; helping people to make better decisions about their hearing health. Clinicians who have adopted Flex:trial™ tell us that they are having more productive discussions with their patient. The conversation is focused on understanding the impact hearing loss is having on their life; rather than selling products. This also helps patients see the clinical benefit and perceive the hearing health care provider as a professional offering an important service.

CHR: Do you believe this concept can help to increase hearing aid adoption for new users?

RW: Yes, that is overall premise for Flex. It not only addresses the barrier to adoption; it is an important source of differentiation for clinics in a very crowded neighborhood where there is a lot of competitive pressure around them, and businesses are playing the price card. It is also very valuable for clinics with a high level of referral traffic, because it changes up the selling process for new wearers. A clinician can say, "If people come and present with loss, we'll give them a test drive and an opportunity to experience amplification and the way it fits into their life – at no risk, and with no upfront financial commitment. "This elevates the credibility of that clinician, and reflects well on the person who has referred the client. That's a huge differentiator.

CHR: Flex is also an upgradeable hearing aid. What has customer reaction been to this offering?

RW: Flex:upgrade™ allows the clinician to enhance the patient's ownership experience, by allowing them to improve their performance without having to push reset on the hardware. Typically the upgrade program is discussed with a client after the purchase as part of the ongoing support they can expect. It allows a clinician to say, "I would like to see you for follow-up appointments to ensure the technology is addressing your needs, and if down the road, you, or I determine you need more, we can easily apply an upgrade."

Canadian Hearing Report 2014;9(1):9.

The Easy Lessons of Hearing Loss

By Gael Hannan
gdhannan@rogers.com

About the Author

Gael Hannan is a writer, actor, and public speaker who grew up with a progressive hearing loss that is now severe-to-profound. She is a director on the national board of the Canadian Hard of Hearing Association (CHHA) and an advocate whose work includes speechreading instruction, hearing awareness, workshops for youth with hearing loss, and work on hearing access committees.

Gael is a sought-after speaker for her humorous and insightful performances about hearing loss. Unheard Voices and EarRage! are ground-breaking solo shows that illuminate the profound impact of hearing loss on a person's life and relationships, and which Gael has presented to appreciative audiences around Canada, the United States and New Zealand. A DVD/video version of Unheard Voices is now available. She has received several awards for her work, including the Consumer Advocacy Award from the Canadian Association of Speech Language Pathologists and Audiologists. Gael lives with her husband and son in Toronto.

Welcome to the first issue of *Canadian Hearing Report* for 2014 and to the Happy HoH, a column that explores the life with hearing loss. (Note: HoH is an acronym for Hard of Hearing – and it sounds like it looks. So, I'm careful not to identify myself as a HoH when I go to the store, because I'm looking for milk, not trouble.)

I've lots of experience being a HoH – since birth, apparently. I live and breathe the barriers and challenges of hearing loss. As an advocate, I talk about the communication strategies that can break them down. Are they easy? Do I *use* all the strategies, regularly, that can help me to succeed in the constant presence of hearing difficulties?

Please, I'm only human!

Just because I *know* what's good for me doesn't mean that I actually *practice* it with every word I listen to, or speak. Life with hearing loss is complex, and to communicate *well* requires a big bag of tricks that involve emotions, endless hours of effort and more than a few dollars of hard-earned money. And although I often slip into some bad communication habits, I think after a few decades, I've more or less got it down to a fine art.

It's just not always easy. Mind you, *some* things are…

It's EASY to convince ourselves that we're doing "fine" with our hearing loss:

That we're catching most of what's said
Well, at least the important stuff –
the rest's not really worth listening to, right?
And no, we don't intend to do anything about it
Like getting a hearing aid or cochlear implant –
Those are for other people, who have *real* problems.

It's EASY to give in to frustration and the emotional roller coaster of hearing loss:

Because nothing has ever prepared us for this –
This…*invisible separation*…from the life we're used to,
And the people we were close to.
It's like standing outside, looking through a window
Rapping on the glass and trying to talk to our family on the inside.
It hurts.

It's EASY to slip into bad habits of bluffing, of tuning out:

Because we just can't get what's being said,
Even though we're trying so hard to follow.
It makes us tired
And before we even realize it,
We're nodding and smiling as if we're totally in the conversation
And we hope no one calls us on it.
Because we would be embarrassed – and they would be irritated.

It's EASY to blame other people for communication breakdowns:

"They won't face me,
They forget all the time,
They just…they just don't understand.
Even though I've explained it
Over and over again.
I've done all I can and now it's up to them.
Hell, I'm the one with the damn hearing loss!
How about a little consideration?"

It's EASY to blame our hearing loss for everything that's not going right:

"My marriage would be better if it wasn't for my hearing
My kids wouldn't laugh or take advantage of me
I would be happier at work,
I'd feel better about myself
And I could focus my energy on making things better
Instead of using it all up
On trying to communicate,
Or even hiding it completely
And don't tell me that's wrong, that I shouldn't do it –
I'd like to see *you* struggling every day, all day,
With hearing loss like mine."

It's EASY to let hearing loss define us:

Life was better before.
Now it's not.
My hearing loss affects everything,
Everything I do, everyone I talk to.
I am my hearing loss.

No one ever said that being a HoH is easy. But it doesn't have to be this hard, either.

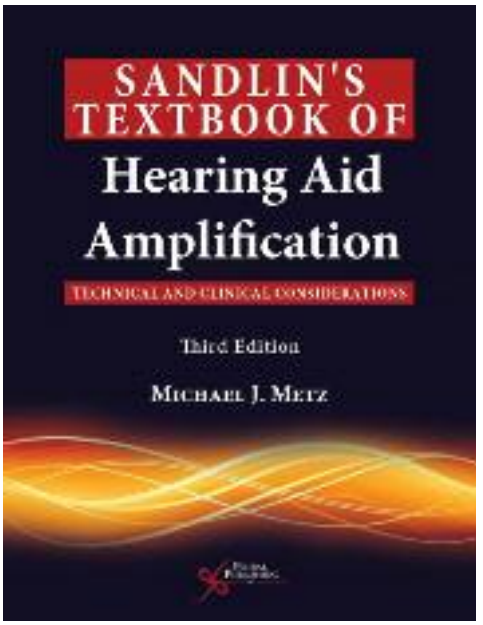
We – all of us – have bad hearing days when we want to crawl into bed, pull the covers over our head, and cry in frustration over the relentless pressure of communication gone wrong. But if we stay in hiding, if we keep crying, our negative attitudes will harden into *cement* and we won't be able to break free.

There's another easy lesson if we want to take it: help is available, standing by, waiting. If you – or anyone you know – is struggling with hearing loss, reach out for help. Read this magazine and other publications. Speak to your doctor or visit a hearing care professional. Contact a hearing loss group in your community, or online, where there are people with hearing loss who understand what you're going through. *They* can help, because they've been there, too.

Reach out. It's the easiest lesson of hearing loss.

Here's to the new *Allied Hearing Health* magazine! When you're done reading, pass it along, because you probably know someone else with hearing loss who needs help, too.

Canadian Hearing Report 2014;9(1):10-11.



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SANDIN'S TEXTBOOK OF HEARING AID AMPLIFICATION: TECHNICAL AND CLINICAL CONSIDERATIONS, THIRD EDITION

Edited by: Michael J. Metz

ABOUT THE BOOK

The comprehensive Sandlin's Textbook of Hearing Aid Amplification, now in its third edition, provides the hearing health professional with an overview of the technological advances related to hearing aid devices. The authors give particular emphasis to the most current advances in clinical assessment techniques and hearing instrument technology, and provide a detailed analysis of the application of digital signal processing. Clinical insights into the psychology of hearing health are included to help professionals meet clients' emotional as well as acoustic needs. This is a valuable text for academic and clinical professionals involved in the selection and fitting of hearing aid devices for the acoustically impaired.

New to the third edition:

- Updated chapters on earmold and earshell acoustics; principles and applications of high-fidelity amplitude compression; and microphone technology
- Major revisions to chapters on digital signal processing; hearing aid selection, fitting, and verification; mathematical formulae for applying amplification; measures of validity and verification; and surgically-implanted hearing devices for unilateral hearing loss
- Discussion of distribution methods; considerations for treating children; elements of design and implementation of DSP circuits; the evolution from analog to digital hearing aids; and future consideration for the field

This text is regularly used by clinicians at the graduate level of training in the 70 to 90 universities offering graduate degrees in audiology. Furthermore, practicing clinicians in countries all over the world have included this recognized text in their professional libraries.

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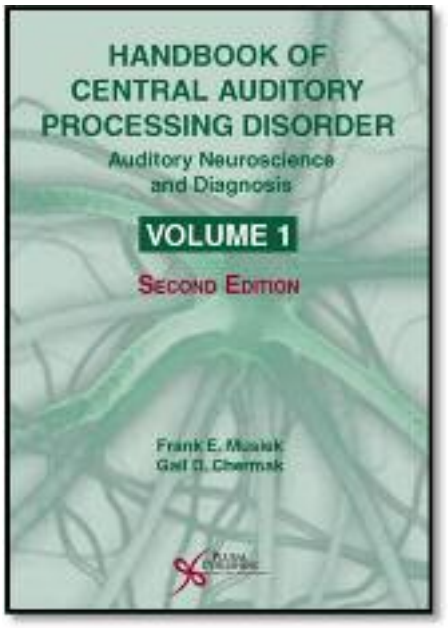
Appendix A: American Academy of Audiology Ethical Practice Guideline for Relationships with Industry



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HANDBOOK OF CENTRAL AUDITORY PROCESSING DISORDER VOLUME 1: AUDITORY NEUROSCIENCE AND DIAGNOSIS, SECOND EDITION

Edited by: Frank E. Musiek, PhD and Gail D. Chermak, PhD

ABOUT THE BOOK

Musiek and Chermak's two-volume, award-winning handbooks are back in newly revised editions. Extensively revised and expanded, Volume I provides comprehensive coverage of the auditory neuroscience and clinical science needed to accurately diagnose the range of developmental and acquired central auditory processing disorders in children, adults, and older adults. Volume II provides expanded coverage of rehabilitative and professional issues, detailing intervention strategies for children and adults.

Building on the excellence achieved with the best-selling 1st editions—which earned the 2007 Speech, Language, and Hearing Book of the Year Award—the second editions include contributions from world-renowned authors detailing major advances in auditory neuroscience and cognitive science; diagnosis; best practice intervention strategies in clinical and school settings; as well as emerging and future directions in diagnosis and intervention.

Exciting new chapters for Volume I include:

- Development of the Central Auditory Nervous System, by Jos J. Eggermont
- Causation: Neuroanatomic Abnormalities, Neurological Disorders, and Neuromaturational Delays, by Gail D. Chermak and Frank E. Musiek
- Central Auditory Processing As Seen From Dichotic Listening Studies, by Kenneth Hugdahl and Turid Helland
- Auditory Processing (Disorder): An Intersection of Cognitive, Sensory, and Reward Circuits, by Karen Banai and Nina Kraus
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- The CANS and CAPD: What We Know and What We Need to Learn, by Dennis P. Phillips

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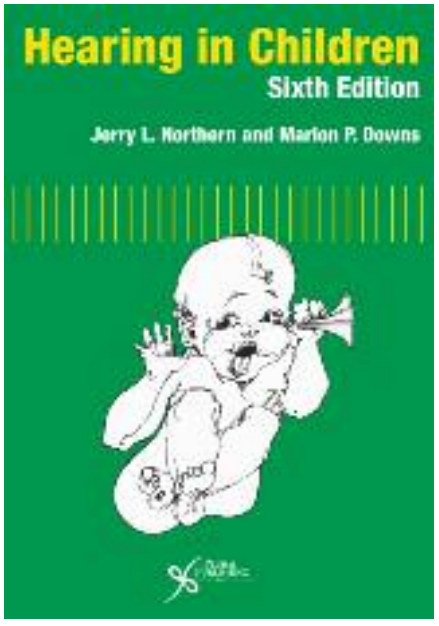

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HEARING IN CHILDREN, SIXTH EDITION

Jerry L. Northern, PhD and Marion Downs

ABOUT THE BOOK

In this completely updated sixth edition, Hearing in Children thoroughly examines the current knowledge of pediatric audiology, and provides a medical perspective on the identification, diagnosis, and management of hearing loss in children. This enduring text, written by two universally recognized pediatric audiologists, has been the chief pediatric hearing resource used worldwide by audiologists for nearly 40 years.

Key features to Hearing in Children, Sixth Edition include:

- An expanded review of the medical aspects—early intervention, genetics, diseases and disorders, and treatments—of pediatric hearing loss as well as hearing and auditory disorders in infants, toddlers, and young children
- Practical descriptions of age-specific testing protocols and hearing screening technologies, and early hearing loss detection and intervention procedures
- Comprehensive coverage of amplification for children with hearing loss, including fitting and management issues in hearing aids, cochlear implants, and assistive listening devices
- Valuable information on the role of family-centered services related to all aspects of childhood deafness
- A revised appendix of hearing disorders that includes 90 syndromes and disorders associated with childhood deafness
- Nearly 500 new and current references

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PROGRAMMING COCHLEAR IMPLANTS, SECOND EDITION

Edited by: Jace Wolfe, PhD and Erin Schafer, PhD

ABOUT THE BOOK

Cochlear implants offer significant benefits for children and adults with severe to profound hearing loss; however, to realize these benefits the device must be carefully and correctly programmed. With current information on cochlear implant technology, *Programming Cochlear Implants, Second Edition*—a volume in the Core Clinical Concepts in Audiology Series—is a valuable guide for clinicians providing services to cochlear implant users or as a teaching tool for graduate-level students.

Programming Cochlear Implants, Second Edition introduces the basics of cochlear implant hardware and programming and continues through advanced programming techniques, with manufacturer-specific information and case studies. The text reviews clinical protocols for cochlear implant management; programming considerations for bilateral cochlear implant; troubleshooting during the programming process; device-specific programming techniques; use of objective measures to set cochlear implant programs; use of FM and assistive listening devices with cochlear implants; and providing support to difficult-to-program users, such as infants, cognitively-impaired individuals, persons with disabilities, and so forth.

New topics addressed in the second edition include:

- Preservation of residual hearing following cochlear implant surgery
- Programming cochlear implants for patients with substantial residual hearing in the low-frequency range, including electrode array options
- Cochlear implant impedances and the impact of impedance on programming and management
- Signal coding strategies and signal processing
- Theoretical concepts that may influence cochlear implant programming

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Canadian Hearing Report 2014;9(1):12-17.

An Interview with Earl Harford

Earl Harford

CHR: When you hear the name Earl Harford one normally thinks of CROS hearing aids. Specifically, Harford and Berry (1965) in the *Journal of Speech and Hearing Disorders* was the article when I first read about your work with what to become known as the CROS hearing aid. What led you to do work in this area?

Earl Harford: I worked in an audiology/otolaryngology clinic that we held once a week at Northwestern University in Chicago and there was an otolaryngologist that I worked with named George Shambaugh, a distinguished otolaryngologist and a long-time editor of the *Archives of Otolaryngology*.

One day we had a patient come in with a unilateral hearing loss. We counseled him in the routine manner for at that time delete there was nothing that could be done in a medical or surgical manner and from the standpoint of using a hearing aid he was not a candidate because his good ear was too good and his bad ear was too bad to make any sense of amplified sound.

We told him he can compensate for this to some degree by ensuring that his good ear is aimed towards the speaker and to seat where he would always favor his good ear – we discharged the patient in the usual manner. Then Dr. Shambaugh turned to me and asked whether I had every considered putting a microphone on the bad ear and running a polyethylene tube around and sticking it in the good ear. That would carry the sound across the head. I hadn't really thought too much about that since there would be too much loss of the higher frequencies due to the presence of this long tube.

I went back to Evanston, Illinois (these clinics were always held in the medical school in Chicago) and I told Joe Barry, my grad assistant, about this and we both laughed and thought that this idea would not work. After a few days of thinking about it, it occurred to me that we don't have to use a tube – we could use a wire.

Perhaps I could get a couple of hearing aid companies to make such a device for me and we could do a little study on it. I had access to Zenith, Maico, and Beltone at that time – Zenith and Beltone were housed in factories in and around Chicago at that time and it made it easy, and I had a good working relationship with Maico as well.

We tested quite a few people and it turned out that it really worked quite well. In the Harford and Berry (1965) paper we emphasized that the best success was when a person had a high frequency hearing loss in the good ear. Many people forget this and the greater the high frequency hearing loss that a person would have in their good ear, the more difficulty a person would have in compensating for their unilateral hearing loss. Consequently the experience of greater benefit and also greater acceptance of the device was seen with those who also had a high frequency hearing loss in their good ear.

Another thing that we pointed out in the 1965 article was that the more recent the hearing loss in the bad ear, the more acceptance we had with the CROS aids. Conversely if a person is congenitally deaf on one side, he becomes so adjusted to that, he won't appreciate much improvement from the CROS aid. Still we had some people (even some with congenital losses) who accepted the CROS and used it on a regular basis.

CROS hearing aids are still being used. Soon, we branched off from the original CROS and did a lot of work with different devices that sought to address the issue of imbalance between the two ears. These included a multitude of names and acronyms such as BICROS, HI-CROS and the power CROS Versions of the CROS Hearing Aid. The power CROS is really the same thing that Roy Sullivan referred to as the transcranial CROS.

Jim Curran (who was then with Maico and later with Starkey) used to tell a romantic story of one of the first CROS aids that went from side to side with a black headband – I believe that he was a lawyer. After using it in court, the lawyer refused to give it up. We had some people that when we took the prototypes back from them they were really concerned and didn't want to give them up.

Elizabeth Dodds was a speech pathology student and after taking my clinical audiology course, she switched over to audiology. I then hired her as a clinical supervisor when she graduated. She was a ballerina before she went into audiology, so this being her "second career" meant that we were of a comparable age. In 1968 Elizabeth and I published an article in the *Journal of Speech and Hearing Research* entitled "Modified Earpieces and CROS for High FrequencyHearing Loss,"

At the time we were not aware, but it ultimately stimulated some people to think about open ear canal fittings. We followed that up in 1970 with "Followup-Report on Modified Earpieces and CROS for High Frequency Hearing Loss," (Elizabeth Dodds and Earl Harford, 1970, JSHR, Vol.13, #1, 41-43).

We still didn't realize what an impact that would have on open canal fittings. Jim Curran has pointed this out to me several times and from that time on I always vented as much as I could except under extreme circumstances with very severe losses.

I remember when I had students at the University of Minnesota I told them step #1 was use binaural whenever possible; step #2 is to cut the lower frequencies; step #3 was vent as much as you can; and step #4 use in-the-ear fittings because you were taking advantage of the auricle and the various structures of the pinna to amplify high frequency sounds prior to reaching the actual hearing aid. And to this day I would not change those basic four rules. I wear in-the-ear hearing aids to this very day and favour them over behind the ear hearing aids whenever possible.

I received my master's from Vanderbilt and then went to Northwestern University in Chicago for my PhD in 1955. There were three faculty member there – Ray Carhart, Jim Jerger, and John Gaeth. John Gaeth later went to Wayne State.

After I completed my PhD studies, I moved to Montreal, Quebec and joined the faculty at McGill University and established the Audiology Clinic at the Royal Victoria Hospital in 1958. After about a year in Canada, I was invited back to the faculty at Northwestern and apparently to fill John Gaeth's vacancy. I was a faculty colleague of Raymond Carhart for over 16 year. Jim Jerger stayed until 1961 then left for the VA in Washington, DC, and then down to the Baylor College of Medicine in Texas where he spent many years.

Tom Tillman was the next to come on to the faculty and then Bill Rintelmann and also Bill Carver came through the post-doctorate program there. Bill Rintelmann and Wayne Olsen both ultimately joined the faculty at Northwestern. Noel Matkin came from the University of Connecticut – we had a great faculty there for many years.

CHR: After moving from Northwestern I understand that you moved to Vanderbilt and later to the University of Minnesota. You had some famous students at that time.

EH: Yes. Over the years I had some super students who ultimately contributed greatly to the field – Jay Hall, Bob Johnson, Deborah Hayes, Wayne Olsen, and Brad Stach to name just a few.

CHR: Let's switch over to the fact that many people call you "Dr. Real Ear Measurement." I guess that we can't really talk about real ear measurement unless we mention the name of David Preves in the same breath.

EH: I started to work on real ear measurement in 1975 which was my last full year at Northwestern University. I went to Vanderbilt on January 1, 1976 but my last few months at Northwestern David Preves and I got together and talked about Knowles new, tiny (at the time) microphones being placed in the ear canal. I don't know how it all began but it was David or myself that thought about putting the actual microphone in the ear canal. Later, Starkey called this the RE-4 and was marketed in the mid to late 1980s as a probe microphone (and not a probe tube microphone).

CHR:I recall that up to 3000 Hz the RE-4 was actually quite good but above that (due to the physical volume of the microphone itself and the fact that it could turn sideways in the ear canal) the higher frequencies were suspect.

EH: It was pretty crude – the microphones were large and we had to use rather crude equipment. When I left Northwestern, I went to Vanderbilt and became an administrator. I became the director of the Bill Wilkinson Hearing and Speech Center and Head of the Division of Hearing and Speech Sciences so I was a busy guy pushing papers and solving people-problems. I didn't do any research while at Vanderbilt but I did write some articles while I was there.

One was with Jennifer Fox called "The Use of High-Pass Amplification for Broad-Frequency Sensorineural Hearing Loss," where we emphasized the importance of cutting the lower frequencies for people with flat sensorineural hearing loss.

I ultimately married Jennifer Fox and she and I have been married for 35 years. Actually Jennifer followed a similar path as Elizabeth Dodds and she eventually became my graduate assistant but I never really got to know her until about five years after she left the program. I see her every day now and we only talk about the benefits of high pass amplification … (just joking, we also talk about other things).

Then when I went to Minnesota I was 10-15 minutes away from David Preves at Starkey and we had a regular pipeline of these miniature microphones. We were ruining the microphones every couple of days and at first we didn't understand it. It turned out that there was a build-up of an electro-static charge on them by walking across a carpeted floor in the sound rooms.

I ran over 8000 measurements in the Medical School Audiology Clinic because we had a lot of patients there. The equipment was working very well and we were able to collect a lot of data – I felt like Jim Jerger! If you had your protocol set up correctly you could gather a lot of data.

The first article that actually appeared in *Ear and Hearing* in 1980 but the first paper I wrote wasn't actually published until several years later in the proceedings of a University of Minnesota conference on sensorineural hearing loss, tinnitus and vertigo held in September 1979.

The most inspiring thing happened after my presentation. Dr Hallowell Davis attended the symposium delete and told me that I was on the right track and we should have been looking at this many years ago. He was the senior author of the first text book of audiology (Hearing and Deafness, A Guide for Laymen) that I had studied back when I was 20 years old. I'll never forget his words of encouragement.

CHR: I understand that other than being Dr. CROS and Dr. Real Ear Measurement, you were also known as Dr. Tympanometry?

EH: I did some early work on tympanometry with Gunnar Liden from Sweden. He and I were very close colleagues and we had spent some sabbaticals together.

When I was at Northwestern he came over and spent 15 months and he brought with him the notion of tympanometry from Sweden (based on the work of Henry Anderson and Klockoff at the Karolinska Institute of Technology [KTH]).

To digress, we used to ski together and one day we were discussing what other work we could do together so that he could have a reason come back to the States to work (and ski). On a chair lift in Utah we discussed the BAHA that he was doing some work with Anders Tjellstrom at the University of Gothenburg and we thought that we would develop this. Ultimately he spent two years at the University of Minnesota where we did early research on BAHA (1983–1985).

To come back to tympanometry in the mid 1960s at Northwestern we had to use two bottles of water mounted on a wall rack and we would move them up and down for high pressure and low pressure while a tube was connected to a subject's ear canal. Electronic manometers were not available to us. We never did actually publish an article on that unfortunately. We were preoccupied on trying to get the apparatus to work, but we did run some very early tympanograms.

Audiology was so romantic back then delete. I never remembered a day I resented going to work. In the early years we had to do everything by hand. For example, my first 80–90 publications were done without a computer they all had to be done on a typewriter with no errors and had to be submitted with carbon copies.

I took my first course in audiology at Florida State University in 1950 and never looked back. I was about 20 years old then. I've been in audiology for about 62 years now and I've seen a lot of changes. It's been a whole lot of fun.

CHR: It's been a pleasure talking to you. Thank you for your contributions to the field.

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How Open Canal Amplification Was Discovered

By James R Curran, MS

About the Author
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If you were asked to name the most significant developments in hearing aids over the last fifty years, which ones would you consider? Digital signal processing? The custom ITE/ITC family? The directional microphone? First fit algorithms? Technologies for feedback control? They are all very worthy of inclusion, but there are those who would place the introduction of CROS amplification very near the top of that list. In point of fact, the CROS concept, introduced over fifty years ago, was the impetus for a revolution in the thinking of hearing care professionals of the day, and it spawned any number of understandings over the next decades that remain an influence in our modern approach to fitting.

Recall that CROS is an acronym for Contralateral Routing of Signals, a hearing aid system first recommended (and still fitted today) for unilateral hearing losses where the patient's hearing is good on one side and a loss is on the other. Originally conceived for use with eyeglass aids, a microphone in the temple of the unaidable side picked up the signal that was transmitted by a thin wire/cord connected to the circuitry and receiver in the other temple. The amplified sound was delivered by a tubing to an open ear, obviating the use of standard earmolds. Later, the industry developed wireless CROS instruments that did away with the need to use wires and cords to connect each side.

In 1970, Al Dunlavy, a hearing aid dispenser in Manhattan wrote an article for *Audecibel*, a publication of the National Hearing Aid Society,[1] with the title, "CROS: The New Miracle Worker." Why would he call CROS, of all things, a *miracle*? And was it really? This article deals with the specific and unique application of the CROS aid that he wrote of that was never originally intended, but that eventually became its most significant form of usage, such as, a solution to the problem of feedback.

Until the advent of CROS fittings, problems with feedback dogged the industry. Today open canal fittings are routine, seldom requiring a second thought to feedback issues. Feedback cancellation algorithms make bilateral high frequency fittings a walk in the park. One can literally grab a couple of unoccluded ear buds from off the shelf and fit without ever giving a thought to the issues faced years ago.

THE HARVARD REPORT ON HEARING AIDS

To get a fuller appreciation of the impact of CROS on the practices of the day, we can go all the way back to 1947, about the time audiology began. That year a famous research monograph on hearing aids was published, referred to as the *Harvard Report*.[2] At the time the PsychoAcoustics Laboratory at Harvard University was the single most influential research center in the United States on matters auditory and acoustic. The report recommended that a flat or 6 dB per octave slope frequency response was adequate for the majority of patients who needed a hearing aid, and it severely criticized other methods of fitting, implying they were a waste of time.

At about the time of the *Harvard Report*, Raymond Carhart, generally considered the "father of audiology" in North America, published procedures for selecting the appropriate hearing aid.[3–5] Although criticized by the *Harvard Report*, this (comparative) method gained much ascendancy in the university clinics. Aids were pre-selected from clinic stock for inclusion according to the best judgment and preferences of the professional. Only body aids were available then, and during the evaluation, the instrument's case was placed on a (baffle) board alongside the patient. The patient was tested in a sound field, usually but not always, with stock molds,

and often, but not always, without venting. Feedback problems were not a big issue unless the loss was substantial, for the aid's microphone and receiver were at a good distance from each other. Importantly, conventional wisdom at that time held that on average, aided word recognition scores were not expected to exceed the unaided score, which served as a target. The best performing aids were those that provided aided scores approximating the unaided score obtained under circumaural earphones, for it was expected by comparison, that the degraded signals provided by the hearing aid would result in lower scores.[6]

The Harvard Report recommendations led the early audiology world astray for years. Fitting hearing aids with a flat response or a 6 dB per octave response on patients having other than flat or moderately sloping threshold configurations led to many dissatisfied, poorly performing patients. And easily accessible information regarding the effect of the earmold on the amplified response was, for all intents and purposes, nearly nonexistent.

Fitting problems multiplied when the first BTE and eyeglass aids reached the market in the early 1950s. The two transducers were positioned much closer to each other in head worn instruments, and manufacturers had a difficult time keeping receiver vibrations from spilling over into the microphone. Further, wider bandwidth was possible with head worn aids, and this increased the probability of acoustic feedback problems. The result was a high incidence of internal and external feedback issues. One could use full shell earmolds having minimal or no venting in order to eliminate external feedback, but that exacerbated the occlusion effect for many patients. Professionals were fitting rather unrefined aids with little or no understanding of earmold acoustics to patients who, then as now, invariably presented with losses having a high frequency component. The usual outcome was frustration on the part of the professional, and dissatisfaction on the part of the patient.

It is no wonder that hearing aid fitting became one of the least desirable aspects of audiology during those years. Few if any students opted for making hearing aids the major focus of their studies; in fact it was regarded as somewhat *déclassé* if one did, and pity the brave instructor who taught amplification, for reliable facts were few and far between.

THE BEGINNING OF WISDOM

Fully five years prior to Dunlavy's article mentioned above, Earl Harford, a professor at Northwestern University, began to document the advantage of the CROS concept and reported it to the scientific community.[7] He and his colleagues published a series of studies in the professional journals exploring its potential and its benefits.[8–12] Almost immediately professionals recognized that CROS was not just a solution for unilateral hearing loss, but rather, because the microphone and receiver were on separate sides, *it was possible to provide high gain, high frequency amplification without encountering feedback for patients with high frequency losses.* Since nearly all fittings in those days were monaural anyway, every patient who presented with a bilateral (or unilateral) sloping high frequency loss was a candidate, and was assured of a nearly perfect fitting in at least one ear using an open mold. It was finally possible to deliver the satisfaction that the hearing aid advertisements promised.

In one fell swoop this unique CROS application dealt with a number of issues. Papers began to appear in the audiological literature showing that aided discrimination scores actually *did* improve markedly with open canal amplification compared to scores that had been obtained under earphones or with occluded earmolds.[13–16] This was a surprise to many for although it was known that test scores varied as test conditions changed (talker, level, transducers, test stimuli, etc,) for some reason this understanding had never fully registered in the case of hearing aid fittings. The improvement in scores resulted from, 1) the high frequencies receiving markedly greater amplification than had been possible heretofore, 2) the high frequency amplification bandwidth being significantly wider than was previously achievable, 3) the occlusion effect being virtually eliminated, and, 4) as a bonus, upward spread of masking effects being reduced due to the absence of amplification in the low frequencies. These results set in motion countless research studies over the years dealing with the benefits and usefulness of high frequency amplification and its contribution to word recognition in both children and adults, and produced many studies dealing with the effect of the earmold/coupling on the frequency response.

ACHIEVING MIRACLES

It is instructive to visit the steps of hearing aid dispensers who were fitting CROS hearing aids, (prior to the introduction of wireless CROS). First, the patient had to be wearing *zyl* (special plastic) eyeglasses, or the patient was persuaded to purchase a pair. If he/she did not wear glasses, they were asked to get a pair with plain glass lenses. The frames had to have so-called "standard hinges" because the graduated temple terminations furnished with the eyeglass

hearing aids were only available with this type of hinge. Then a small circular motor-tool saw blade was used to cut a trench across the back of the plastic frame, from hinge to hinge. A very thin plastic cable containing two or three extremely fine wires was placed in the trench and covered over with a plastic sealant. After it had dried, the inside covers of both hearing aid temples were removed, and the fine wires were soldered to the microphone on one side and to the circuitry and receiver on the other. The temple covers were then reglued or screwed back into place. The eyeglass temples and frame were heated, bent and adjusted so that the patient was comfortable with the glasses. A shaved-down pipe cleaner was inserted into a length of earmold tubing and bent to the right shape for secure placement in the ear canal. The tubing was heated with a blower until it set. If needed, the hearing aid's response could be manipulated somewhat by changing the depth of the tubing in the ear canal or by using tubing with different exterior dimensions.

Why would professionals go through such a complicated, lengthy and convoluted process? The answer is that they never had so many grinning, enthusiastic, happy customers. Hand-holding just about disappeared if the patients were fitted with CROS; most old and new customers experienced wearing success right out of the box. Even with all the rigamarole that attended CROS installation and fitting, countless professionals routinely chose to recommend and to fit them. To them, fittings without feedback problems *were indeed* miracles. In the early 1970s, the records show that in some years CROS fittings accounted for nearly 20% of all head worn aids. By 1974, Harford and Dodds[11] suggested that CROS fittings had probably reached close to 40% of all recommendations in University audiology clinics.

The CROS concept and the children that it spawned (IROS, BiCROS, Hi-CROS, etc) became a somewhat neglected fitting option in ensuing years, as custom ITE aids grew in importance. The wonderful solution to feedback issues that CROS provided was essentially forgotten, and CROS was seen again solely as an application suitable for fitting unilateral losses. The advantage of an open canal fitting however, never disappeared, and when it appeared feasible again as a result of modern feedback control methods, the miracle happened all over again.

During an audiology convention a few years ago, a speaker remarked to the audience that the open canal technology of today shouldn't be confused with the old CROS and IROS fittings of years ago. The speaker was in error, of course, for it's the same idea. Today's professionals are standing on the shoulders of some very tough and committed professionals who developed the original technique, changed a lot of widely held assumptions, and brought to the fore many of the important understandings we hold today about providing acceptable amplification for high frequency losses.

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The Link between Diabetes Mellitus and Sensorineural Hearing Loss: A Summary of the Evidence

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Diabetes Mellitus (DM) is one of the fastest growing chronic diseases of our era. Recent studies suggest that sensorineural hearing loss is more prevalent in diabetic patients than in people without the condition. The aim of this article is to review the existing literature on the relationship between hearing loss and diabetes. Data was obtained by literature search using the MEDLINE, EMBASE and PubMed databases.

Diabetes mellitus is a group of metabolic disorders characterized by an elevated blood sugar and abnormalities in insulin secretion and action.[1] This group of disorders disrupts the metabolism of protein fats and carbohydrates rendering the body unable to utilize these nutrients. The resultant hyperglycemia can lead to dysfunction of several organs. Damage is noted in the nervous system, eyes, kidneys, heart and blood vessels.[2] In the non-diabetic individual blood glucose levels are controlled by insulin, a hormone produced by the beta-cells of the pancreas. When glucose levels rise in the blood stream (for example after a meal) insulin is released to normalize glucose levels. In the diabetic patient insulin production is either severely deficient in the pancreas or the pancreas is producing insulin but the body is unable to utilize it.[3]

There are two major types of diabetes. DM type I results from autoimmune destruction of the beta-cells of the pancreas. Ten percent of all diabetics in the United States are typically diagnosed in childhood or adolescence. Patients with DM I are insulin dependent and require close monitoring of blood sugar levels to ensure blood glucose is controlled throughout the day. This type of diabetes was formerly known as insulin-dependent diabetes mellitus (IDDM).[4] DM type II is characterized by resistance such as a lack of response to insulin by the cells of the body (mainly fat and muscle cells), along with increased insulin production by the liver to overcome this resistance. It accounts for 90% of all cases of diabetes. It is typically diagnosed in adulthood and is closely associated with obesity. DM II is managed by diet, weight management, oral medications and/or insulin.[5] Type II diabetes was formerly known as non-insulin-dependent diabetes mellitus (NIDDM), but this term has been abandoned since most of the patients with DM II will require insulin treatment at some point in the course of their condition.[6] The prevalence of diabetes among adults within the 20–79 year range was estimated to be 6.4% in 2010, affecting 285 million people worldwide. The prevalence is expected to rise to 7.7% and 439 million adults by 2030.[7]

Both types of diabetes are associated with a number of chronic complications and co-morbidities. The most prevalent and well known complications include retinopathy, nephropathy, and peripheral neuropathy.[8] Each of these complications carries its own set of losses and dysfunction such as blindness, kidney failure, and peripheral vascular disease requiring amputation.[9] Another, less well known complication of diabetes is hearing impairment. Accumulating evidence suggests that there is a higher prevalence of hearing loss in the diabetic versus the non-diabetic population.[10–12] The hearing loss is bilateral, sensorineural, symmetrical, and tends to affect the high frequencies more than the low/mid ones.[13,14]

More specifically, Dalton et al. found that 59% of diabetic subjects had a hearing loss as opposed to 44% of non-diabetic subjects.[15] The association between diabetes and hearing loss was significant when results were analyzed excluding subjects with non age-related hearing loss. In a study conducted by Bainbridge et al. 68% of patients with diabetes were found to have some high-frequency hearing loss compared to 31% of subjects without diabetes.[16] The prevalence of low/mid frequency hearing loss was 28% in the diabetic patients as opposed to 9% in the non-diabetic group. The association between diabetes and hearing loss remained even after controlling for age, race, sex, poverty level, history of noise exposure, ototoxic medication use, and smoking status. The study by Mitchel et al. is in line with the above findings.[17] More specifically, hearing loss was found in 50% of diabetic patients compared to 38% of the non-diabetic subjects after adjusting for multiple risk factors. Furthermore, a study by Uchida et al. found that diabetes may affect the high-frequencies more strongly in the age bracket of 40–64 years of age than at age 65 and above.[18] Finally, a study conducted in 2009 by Cheng et al. revealed that the prevalence of hearing loss amongst diabetics has remained high over the decades when compared to non-diabetic persons.[19] More specifically, the authors compared the two cross-sectional National Health and Nutrition Examination Surveys of 1971-1973 and 1999-2004 (NHANES I and NHANES II). They discovered that from 1971 to 2004 in adults without diabetes aged 25–69, the unadjusted prevalence of hearing loss decreased by 9% whereas in the diabetic population there was no significant change.

With regards to the risk factors for hearing impairment in the diabetic population, evidence is conflicting. A number of studies have shown that hearing loss is correlated with glycaemic control (i.e. with the blood glucose levels) and duration of disease.[20–22] More specifically, Okhovat et al. compared the hearing thresholds of 100 patients with DM I aged 5–18 years.[23] They found that 21% of them had a hearing impairment and that the hearing thresholds were positively correlated with poor metabolic control (defined as an annual HbA1C of more than 7.5%). Furthermore, thresholds were significantly higher in patients with a history of diabetes of more than five years. Additionally, two studies by Lerman-Garber et al. and Konrad-Martin et al. reported a positive association between poor glycaemic control and impaired auditory brainstem responses in DM II patients.[24,25] Pudar et al. examined the effects of peripheral neuropathy and retinopathy on hearing impairment in 50 patients with DM I and found that the average sensorineural hearing loss was increased by 73% in the presence of neuropathy, and by 50% in the presence of retinopathy.[26] Bainbridge et al. found a strong correlation between neuropathy, duration of disease and high-frequency hearing impairment in 536 diabetic patients, whereas Dabrowski et al. found higher mid frequency thresholds in 31 patients with DM I and retinopathy.[27,28] However, both of these studies, as well as a third study by Asma et al., failed to find a correlation between glucose levels and hearing loss.[29]

Recent studies suggest that diabetes may also increase the susceptibility to noise-induced hearing loss and sudden idiopathic sensorineural hearing loss (SISNHL). More specifically, Wu et al. and more recently Fujita et al. reported on an animal study in which diabetic rats had a significantly impaired recovery from a temporary noise-induced threshold shift.[30,31] Furthermore, Jang et al. found that the hearing thresholds at 4 kHz in 2,612 automobile factory workers were significantly worse in subjects with impaired fasting glucose and diabetes than in non-diabetic subjects.[32] Aimoni et al. studied the prevalence of diabetes in patients with sudden idiopathic sensorineural hearing loss and found that it was almost doubled when compared with the normal hearing subject group.[33] It has been suggested that diabetes can mediate SISNHL through cerebral microangiopathy and changes in blood viscosity.[34,35]

The exact mechanism involved in the pathogenesis of hearing loss in diabetic patients remains unknown. A number of histopathological studies conducted in humans found thickening of the capillary walls of the stria vacsularis, the basilar membrane and the endolymphatic sac, atherosclerotic narrowing of the internal auditory artery, atrophy of the stria vascularis, loss of outer hair cells especially in the lower basal cochlear

turn, spiral ganglion neural atrophy, and VIII cranial nerve demyelination.[36–39]

In all, hearing impairment is one of the less well known complications of diabetes. More research is needed to delineate associated risk factors and mediators in its pathogenesis. Untreated hearing loss can negatively impact the social and emotional wellbeing of individuals.[40–43] The proportion of hearing impairment in the diabetic population in comparison with the non-diabetic population is high. In light of its high prevalence and its detrimental psychosocial effects, health care providers, primary care physicians and endocrinologists should consider referring all diabetic patients for a hearing test. Audiometry should be a routine evaluation in the annual test battery of all diabetic patients.

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