VOLUME 1 | ISSUE 2 | 2011

INNOVATIONS

TIMES ARE CHANGING

INVISIBLE. WIRELESS. WHAT'S NEXT.

THE SOUND OF THINGS TO COME

New tool helps patients point the way to better hearing

ANSWERS FROM AN EXPERT

Q & A Session with
Ruth Bentler, Ph.D.

Letter from the Editor

What comes to mind when we hear "Disruptive?" Typically, we might expect a reference to something negative and upsetting to the normal order of things. How about "Disruptive Innovation?" Depending on who you are and what you use a particular technology for, disruptive innovation might represent something very good. Take the example of the HD flip video cameras that rapidly came into popularity less than five years ago. In April of this year, Cisco, one of the earliest developers of the technology, announced that it is getting out of the business. Why? Smartphones have rapidly taken over the same functions as the flip video cameras and provide the added convenience of sharing and uploading right from the same device. The market for these HD video cameras was disrupted in an innovative way with an outcome that is generally good, unless you depend on sales of the flip cameras for your livelihood.

This issue of *Innovations* has innovative disruption as a general theme. Our interview with hearing aid researcher Ruth Bentler, Ph.D., takes on some disruptive suggestions published in March in *USA Today*, where Daniel A. Sklare, Ph.D., a Research Training Officer for the National Institute on Deafness and Other Communication Disorders, made some provocative statements. We also learn about AMP™, a hearing aid device that is being inserted into the traditional hearing aid distribution system in an effort to grow the market in an innovative way. Just when we finally became comfortable with a resurgence of behind-the-ear hearing aids, Jason Galster, Ph.D., brings us some new research that might disrupt that thinking and make us think in innovative ways about custom hearing aids again. In case you were questioning how you might use SoundPoint, the user-controlled fine-tuning method described by Brent Edwards, Ph.D., in the last issue of *Innovations*, Susie Valentine, Ph.D., brings the system down to a clinical level and makes us question how we dealt with those difficult patients in the past without SoundPoint.

Disruptive? Yes, but in very good ways. Innovation represents new and different thinking, and that is what we are trying to bring into your clinic with *Innovations*.

Dennis Van Vliet, Au.D.
Editor, *Innovations*
Senior Director of Professional Relations
Starkey Laboratories, Inc.

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TECHNOLOGY SPOTLIGHT

LET'S GET A·M·P™ed

Concept and Design of a Non-Custom CIC

Aaron Schroeder, Research Audiologist
Sid Higgins, Principal Mechanical Engineer
Starkey Laboratories, Inc.

Over the last ten years, the hearing industry has seen very little growth in the number of patients fit with hearing aids. Historically, the largest increases in sales have come with the introduction of small hearing aids including in-the-canal (ITC) and completely-in-canal (CIC) hearing devices. Today, however, the largest segment of hearing instrument sales is the behind-the-ear (BTE) market, which now accounts for approximately 67 percent of all hearing aids sold (Strom, 2010). One of the major contributors to this segment is the receiver-in-canal (RIC) style product, which makes up approximately 28 percent of the standard product market and might be considered a nice compromise between the cosmetically appealing custom products and the reliability of BTE products. Considering the now stagnant growth in hearing aid fittings, we must ask ourselves the following question: Is a behind-the-ear product really the best solution for everyone?

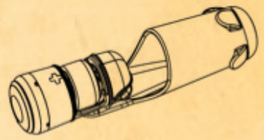

Figure 1: Line drawing of modular hearing aid and sleeve.

In the spring of 2010, Starkey Laboratories, Inc. released a new product style termed the invisible-in-the-canal, or IIC. This product is designed to sit beyond the aperture of the ear canal and ideally as deep as the second bend of the ear canal (Van Vliet & Galster, 2010). SoundLens™ (IIC) is a premium technology product including Starkey's industry-leading feedback canceller and patent pending Voice iQ² fast-acting noise reduction and speech preservation system. With the realized success of SoundLens and the success of the instant-fit RIC, Starkey wanted to create a small, open, instant-fit, in-the-ear device that would appeal to both market demands.

From a mechanical design perspective, creating a small, open, instant-fit product that could be quickly and easily fit was no small task. For instance, how could a non-custom product that is deeply inserted into the ear canal fit a majority of ears? After analyzing the anatomy of the ear canal and carefully considering that the device had to include the basic components of a hearing aid (e.g., a microphone, a battery, a circuit and a receiver), the minimum size of the device was determined. The device also had to be as open as possible, yet accommodate larger ear canals and ear canals that exhibit large amounts of movement while talking or chewing. With this in mind, a two-piece concept was designed. This concept (Figure 1) consists of a modular hearing aid that is inserted into a sleeve, which accommodates for multiple ear canal sizes and ear canal movement. This two-piece concept not only met the basic requirements but also included innovative design features to protect against microphone and receiver failure. The following article will describe the basic design features, as well as the safeguards put in place to protect and improve the overall functionality of the device known as AMP.

About the Authors:

Aaron Schroeder joined Starkey in 2007. In his current role as Manager of Hearing Aid Products, he leads a team involved in the development of Starkey's future hearing aids. Prior to this position, he worked as a Research Audiologist in the Clinical Product Research group. Before joining Starkey he worked in a variety of settings including a private practice, hospital and university. He earned his M.A. degree from the University of South Dakota and is continuing his studies as a Ph.D. student through the University of Kansas.

Sid Higgins is a Principal Mechanical Engineer in Starkey's Research & Development group and has been with the company since 2004. His 28 years in materials and process engineering have contributed to the development of Starkey's Zōn, real-ear measurement, capacitive switching and most recently AMP. He has numerous patents in the defense, consumer and medical industries. Higgins has a bachelor's degree in manufacturing engineering from Ferris State University in Michigan.

Module Design Features

The design of the AMP module began with an in-depth study of ear canal geometry and a review of conventional custom and standard hearing aid designs. In the past, these designs gravitated toward curved or bent housings with sharp corner transitions. These transitions provide an efficient use of internal space and theoretically make sense with the natural bends in the ear canal. However, the inherent flaw with this decision is that sharp corner transitions on a hearing instrument require precise placement and orientation in the canal to avoid concentrated pressure points, ultimately reducing comfort and overall physical fit rate. To reduce or even eliminate concentrated pressure points, AMP was designed with a circular cross section (Figure 2a). To accomplish this circular cross section, the receiver had to be fundamentally reengineered. In traditional custom devices, a stock receiver is selected and added to the rest of the product based on the desired gain and frequency response. In contrast, one of the first steps of this project was designing and building a receiver to meet the needs of the AMP product. Not only does this reduce the physical size without compromising performance, it allows for a few important and innovative design features including placing the microphone and receiver diaphragms orthogonal to each other in completely separate compartments, therefore reducing mechanical vibration; creating a curved off-axis five-millimeter long acoustic channel for enhanced bandwidth (Figure 2b); and providing a 360° sound inlet port (Figure 2c) to ensure an un-occluded path to the microphone regardless of variations in ear anatomy.

Sleeve Design Features

The second important hardware design innovation of the AMP product is the removable liquid injection molded (LIM) silicone sleeve. Before placing the AMP module into the ear canal, it must first be inserted into the LIM silicone sleeve. The LIM sleeve serves four main functions: 1) to aid in the comfort and retention of the device 2) to protect against moisture 3) to act as a wax barrier and 4) to aid in the removal of the device. LIM silicone was selected over other materials as it balances a range of physical properties necessary to withstand continued use within a complex environment. Properties such as chemical resistance, environmental stability, durometer retention and superb tear resistance were essential components and considerations. To accommodate comfort and retention in a wide range of ear canals, as well as a wide range of hearing losses, the LIM silicone sleeve was designed in four different sizes including small, medium, large and occluded (Figure 3).

Although the LIM silicone sleeve has excellent tear resistance, there was mild concern that the sleeve could tear during removal of the device from the ear canal. In an effort to validate the theoretical

Figure 2: Three innovative design features of AMP. (a) represents the circular cross section with no sharp corner transitions. (b) represents the five-mm long acoustic channel leading from the receiver. (c) shows the 360° sound inlet port to the microphone.

Figure 3: Four LIM silicone sleeves increasing in size from small (left) to occluded (right).

Figure 4: Four boomerang shaped receiver ports prevent wax ingress.

Figure 5: The five redundant internal ports and the hydrophobic/oleophobic fabric weave that protects the microphone from wax and moisture.

tear strength, Starkey engineers performed a statistical analysis of typical forces applied during removal of the devices. These data were used to develop a mechanical stretch test at a threshold of three times the typical required removal force. Multiple sleeves were subjected to tens of thousands of stretch cycles and exhibited minimal to no indication of damage, wear or tearing. To further test the tear-resistant properties of the sleeve, cuts were induced in the sleeves and after tens of thousands of cycles no additional damage, wear or tearing was seen. The design and LIM silicone material lived up to, and even surpassed, initial expectations.

Wax and Moisture Protection

To address wax and moisture protection, a moisture-blocking liquid polymer that cures and conforms across all internal connections was applied. AMP was also designed to be self contained, meaning that the need for additional wax and moisture protection systems was eliminated through a combination of multiple design features.

For the receiver, wax protection is afforded by a two-fold design: 1) The sleeve itself has a redundancy of four small boomerang shaped ports (Figure 4). This shape creates a small slit-and-flap mechanism. Should wax ingress force the flap mechanism downward, it naturally springs back, lifting the wax back to the exterior of the sleeve. 2) In the case that wax forces its way past these boomerang shaped ports, it would accumulate in the curved acoustic channel on the exterior of the hearing aid module. Because this acoustic channel is relatively long at five millimeters, it greatly reduces the chance of wax or other debris actually entering the receiver port. Traditionally, microphones in canal products are exposed to wax and other unwanted debris during insertion and removal from the ear canal as it is common to push on the faceplate of the device. To protect the microphone of AMP, Starkey designed a 360° sound inlet leading to five redundant internal ports (Figure 5). This redundancy virtually ensures a clear path to the microphone even in the harshest of conditions and regardless of ear anatomy. Internally, the five ports provide access to a hydrophobic (moisture-resistant) and oleophobic (oil-resistant) microphone protector consisting of an acoustically transparent fabric weave. The moisture repellent nature of the fabric weave is naturally increased by the fact that moisture is entering through the side (smaller surface area) rather than through the face of the fabric weave. The collection cavity itself can be cleaned with the typical wire loop provided with custom products without fear of damaging the filter media.

Figure 6: From left to right, examples of ears showing Ideal, Good, Acceptable, Unacceptable and Did Not Fit ratings.

Clinical Validation of Physical Fit Rate, Acoustic Transparency, and Comfort and Retention

Over the course of six months, a clinical evaluation was completed to validate the design goals of overall physical fit rate, openness or acoustic transparency, and retention of the AMP device. The results are reported below.

Physical Fit Rate

To determine the physical fit rate of AMP, 53 people including 28 males and 25 females, who ranged in age from 23 to 83, were tested. The physical fit, as judged by a Research Audiologist, was divided into five categories: Ideal, Good, Acceptable, Unacceptable and Did Not Fit. Figure 6 illustrates examples from each category, respectively. As shown in Figure 7, 88 percent of the 105 ears examined fell into the acceptable to ideal range.

Acoustic Transparency

After completing and understanding how AMP physically fit into the ear canal from a visual perspective, a more in-depth study was completed to understand how end users perceived their experiences with AMP. The first step involved measuring the acoustic transparency or "openness" of the device. To do this, the real-ear unaided response (REUR) and the real-ear occluded response (REOR) were measured on 18 research participants. Figure 8 shows that the average difference between the REOR and the REUR with the AMP product is similar to average data from a traditional CIC with an I/O or open vent (McCabe & Galster, 2010), suggesting that the devices were non-occluding in the majority of ears and thus unlikely to lead to the perception of feeling occluded or "plugged."

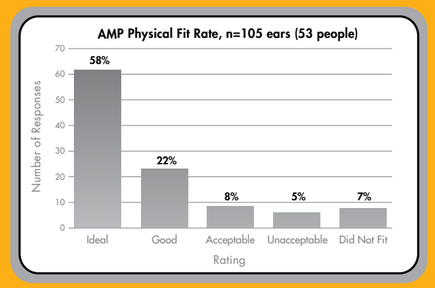

Figure 7: Percentage of people that fell into each physical fit rate category.

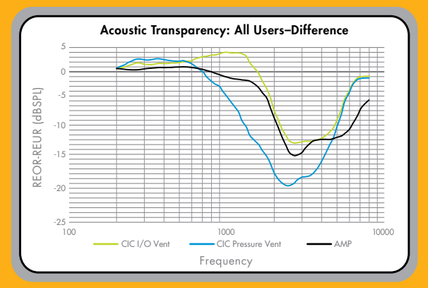

Figure 8: The average difference between the real-ear occluded response (REOR) and the real-ear unaided response (REUR). The blue curve represents the average difference with a traditional CIC with pressure vent, the green curve represents a traditional CIC with I/O vent, and the black curve represents the average difference for AMP.

Comfort and Retention

Once the physical fit rate and the acoustic transparency had been determined, comfort and retention ratings during typical use were completed. Again, using data collected from 19 research participants with Ideal or Good fit ratings, it was found that the majority of participants rated AMP as comfortable and reported that the device was staying in their ears most or all of the time. These results are shown in Figures 9 and 10.

Summary

In order to provide more options for individuals with hearing impairment, Starkey has developed multiple product offerings for those patients who desire a more compact, more discreet hearing instrument. These offerings include SoundLens and AMP, the product described in this article. Both products offer an effectively invisible solution that meets different needs. While SoundLens is a premium custom fit product, AMP is a non-custom, relatively open, instant-fit hearing aid designed as a product for those new to the hearing aid market.

AMP has not only been designed to reduce known field issues with deep fitting products but also to solve common problems associated with current instant-fit, non-custom products. The innovative features described in this article have led to a very exciting non-custom product that physically fits a large percentage of ears, is relatively "open" in most ears, and has been shown to have high average comfort and retention ratings. Yet, it must be stressed that this is a non-custom product and candidacy based on hearing loss, dexterity, and comfort and retention must be evaluated prior to determining whether or not this is the most appropriate product for your patient.

References

McCabe, E. & Galster, J.A. (2010). Out of the barrel: Reducing occlusion in CICs with custom venting. *Audiology Online*.

Strom, K. (2010). Q2 Sales Up…Slightly. *Hearing Review*, 17(9), 8.

Van Vliet, D. & Galster, J.A. (2010). Invisible-In-The-Canal (IIC) hearing aids. Starkey Laboratories, Inc. Technology Paper.

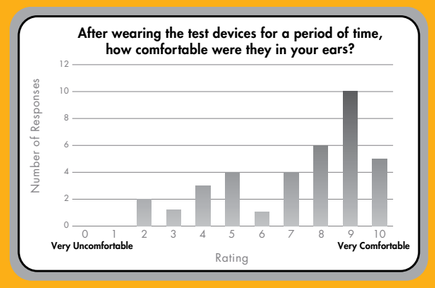

Figure 9: Comfort ratings for 19 participants (36 ears) after wearing the devices for approximately four weeks.

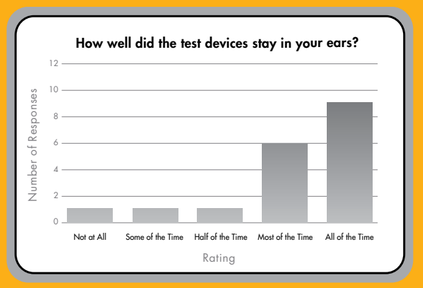

Figure 10: Retention ratings for 19 participants after wearing the devices for approximately four weeks.

EXPERT Q&A

THE POWER OF PATIENT COUNSELING & TECHNOLOGY

Ruth Bentler, Ph.D.
Director of Au.D. Studies at the University of Iowa

A recent *USA Today* article posted online (March 2011*) focused on the prevalence of hearing loss in the senior population. In the context of a discussion about improving access to hearing aids and services, Daniel A. Sklare, Ph.D., a Research Training Officer for the National Institute on Deafness and Other Communication Disorders, was quoted as saying that potentially 80 to 90 percent of seniors with hearing loss could be served by generic hearing aids that do not require fitting by an audiologist, and that there is not evidence that higher-end hearing aids are needed.

Audiologists and Hearing Instrument Specialists who spend their time counseling people with hearing loss about their options for help and guiding them through selection of, and adaptation to, hearing aids may have a different opinion about the involvement of a professional for many of the patients they see.

Ruth Bentler, Ph.D., is a professor in the Department of Communication Sciences and Disorders at the University of Iowa. Her teaching, research and peer-reviewed publications over the past 20 years have established her as an internationally known expert on hearing aids. *Innovations* asked Dr. Bentler about her opinions on the need for sophisticated hearing aid features and the professional dispensing of hearing aids.

IN (*Innovations*): Let's start with the most provocative statement by Dr. Sklare that 80 to 90 percent of seniors with hearing loss could be helped with "generic hearing aids." What are your thoughts about his assertion?

RB (Ruth Bentler): While it is not clear to me where those exact numbers come from, the reality is that our aging baby boomers are causing a significant bulge in the number of potential hearing aid consumers in this country. And a good many of them are concerned about stigma, cosmetics, and affordability, as Dr. Sklare also points out. It seems that the closer we come to accommodating the first two concerns, the further we get from the affordability clause! Your question opens a related can-of-worms, however. That is, we have increasing evidence that the real predictor of successful hearing aid use is the audibility of the speech they are intended to amplify. Now I want to clarify that a bit. I don't mean maximum audibility, but rather optimal audibility. If we maximized audibility like we used to 30 years ago by trying to make every speech sound audible, we are likely to make the hearing aid user a non-user again. It is the optimization of that audibility — that is, placing speech between threshold and discomfort — that seems to work best. I think that basic goal can be accomplished with most levels of technology if the hearing aid is appropriately selected and fit.

> "We have increasing evidence that the real predictor of successful hearing aid use is the audibility of the speech they are intended to amplify."

IN: Clinicians tell us that they spend a lot of time with their hearing aid patients. How could it be that generic devices without instructional help or fitting could yield satisfactory outcomes?

RB: Let me challenge your assumption here. Clinicians tell me that they don't have a lot of time to spend with patients; as a result, they are unwilling to verify that their fitting met the goals of audibility and comfort. Sergei Kochkin continues to tell us that 1) people are dissatisfied with the loudness of their hearing aids, and 2) their overall satisfaction is related to the number of steps in the evaluation/fitting process. Those data suggest to me that we are not spending a lot of time with our patients. But I am really digressing here. You are implying that the time spent is mostly instructional. I would argue that the time spent should be (also) observational (or gathering data for needs-assessment purposes).

We have this running analogy in the lab. In cars, four-wheel drive adds to the expense of a new car. Now, everyone does not need four-wheel drive just as everyone does not need all of the bells and whistles attached to the highest-end hearing aid technology. In addition to determining the need for the high end, we believe it is important to assess the value to the consumer as well. Back to the car analogy, for example, one young mother we know acknowledges that she needs the four-wheel drive about two times a year while taking her small children to school in winter weather conditions, and she is willing to pay any added expense to have access to it. Her husband, who enjoys the challenge of driving in inclement conditions, has the same experiences as his wife, but is not willing to spring for the added feature because he doesn't see the value. The analogy (in case you are getting lost)? She values the option enough to pay for the added feature; he does not.

In the hearing aid world, we must determine not only the environmental usefulness of some of our added features, but also the value to the user of having that bell or whistle in those environments. I guess the long-winded answer to your question is that a blanket statement that 80 to 90 percent of hearing aid candidates need only generic devices is no more accurate than assuming all candidates need the higher-end devices. And to continue Catherine Palmer's long-term and public theme, if verification is overlooked in the fitting process, then there is no assurance that the top-of-the-line hearing aid works any better than the hunting magazine-purchased PSAP (personal sound amplification product)!

About the Author:

Ruth Bentler obtained her Ph.D. in speech & hearing sciences from the University of Iowa in 1987, where she is now a professor of audiology. Dr. Bentler is a Fellow of the American Speech-Language-Hearing Association and the American Academy of Audiology, as well as a member of the Acoustical Society of America, and the International Society of Audiology. She is Director of Au.D. Studies at the University of Iowa where she teaches graduate students in courses related to hearing aids and adult auditory rehabilitation. As the Director of the Hearing Aid Laboratory for Basic and Applied Research within the Department of Communication Sciences and Disorders, Bentler has been involved in numerous research endeavors involving directional microphones, digital noise reduction and, most currently, frequency lowering algorithms. Outside of the academic setting, she is the Global Director of the Hearing Aid Program for Special Olympics International and the Co-Director of the Iowa China Project.

IN: So, are you saying that if clinicians don't verify their fittings, they may as well abandon any selection process and go with generic devices?

RB: What I am really talking about is the entire process of evaluating the patient, selecting the appropriate hearing aid and features according to the patient's needs, and providing standard-of-care fitting and service for the patient. Verification of the fitting is one component of the recommended best practice protocols for hearing aid fitting. I guess I am saying that if a clinician is not verifying a hearing aid fitting, he or she really doesn't know the full scope of remediating the effects of the loss, regardless of the level of technology. The user might appropriately question what other critical steps in the selection and fitting process have been skipped. OK, some clinicians would argue that they can tell if the hearing aid is working appropriately by listening and watching the patient's response. Patients with mild to moderate hearing loss often report benefit from cupping their hands behind their ears. The boost around 2,000 Hz is helpful, but few of us would agree that the hand-cupping method is convenient or optimal. The same truth holds with the selection and fitting process: With mild to moderate hearing loss, a mild amplifier will frequently be adequate, but not optimal.

Herein lies the potential benefit of the generic, or PSAP, devices: Users may realize adequate benefit. However, without the steps of verification, the highest level of satisfaction might not be realized, and the cost to the consumer in terms of less than optimal benefit isn't obvious because they do not know what they are missing. Patients come to us because they expect help in the management of their hearing loss. If the patient expects it, we should provide the service, which includes careful selection of the appropriate product and features, and determining whether the speech they are trying to hear is actually audible. Otherwise, the patient might as well buy all prostheses, eyeglasses, artificial limbs, hearing aids — you name it — from the kiosks.

IN: Do you believe that PSAPs and generic devices would be a good thing for the market, or a negative due to the number of people who may have a negative experience with a device not matched with their needs?

RB: Why is it that we assume a generic device will be a poor amplifier? Let's not forget that what is considered "low end" today, was top-of-the-line last year. A $5,000 hearing aid that is not properly fit will get the same negative reaction (maybe stronger) than a $500 hearing aid — PSAP or generic device — that is also improperly fit. The difference is, the end user is probably less annoyed if they've spent less hard-earned money! The issue I am skirting here is the service issue, but a similar argument could be weighed. If a $5,000 hearing aid is fit to a first fit algorithm and no follow-up is provided to assess audibility, benefit and satisfaction, how is that different from a low-end product that is likewise not custom fit?

IN: What about the assertion that higher-end hearing aids may not be necessary. Clinicians tell us that they spend quite a bit of time discussing the options available and matching them up with patients' needs. Not everyone needs all options available, but what about the people who have very specific needs?

RB: A nursing home resident might indicate that he is in a noisy situation for 20 minutes a day, but during that time it is very important to him that he hear optimally — that patient needs a few extra features. Another adult might have a moderate hearing loss and have to interact with other people many times during the day. Yet, the value he places (or the importance to him) of hearing those people might not be high. So, it's not only the clinician's perceived need based on some pre-counseling needs assessment, but the value the patient places on hearing in those instances.

> "The days of limited bandwidth, inappropriate and distorted output, size that was unacceptable to many, inflexibility of shaping, and so on, are all behind us."

IN: For decades, the percentage of people who need hearing aids compared to the number who actually acquire them has remained relatively unchanged with a surprising number who go without help, even with very significant hearing losses. If you had the power to change things to encourage more people to seek help, what would you do?

RB: At the risk of sounding heterodox, let's step back a moment to consider that fact. Those of us involved in hearing aids (either in the clinic or in the lab) are fully aware of the fact that we have never had better technology. The days of limited bandwidth, inappropriate and distorted output, size that was unacceptable to many, inflexibility of shaping, and so on, are all behind us. Yet, the market penetration has not changed. Is it the stigma attached? Is it the cost of the device? Is it the perceived benefit? Probably. I have wondered for many years if the devices were more easily accessed, and at a lower price, if non-believers could become believers. The Pollyanna in me believes that once these non-users have a chance to try a good, but basic, amplifier, they'll come back for more. Perhaps that is wishful thinking, but nothing else has worked in my lifetime to increase those numbers.

*(*http://yourlife.usatoday.com/health/story/2011/03/Hearing-loss-is-incredibly-common-/45099370/1*)

CLOSE-UP

STAFF SPOTLIGHT: PJ VAN GROLL, M.A.

PJ Van Groll, M.A.
Audiology & Technology Support

What is your background?

I was born and raised in Wisconsin and completed my undergraduate studies at the University of Wisconsin–Madison with a bachelor's degree in communicative disorders. Following a brief hiatus as a ski bum in Colorado, I returned to the Midwest to complete my graduate studies at the University of Minnesota–Twin Cities.

How did you start in the hearing aid industry?

While completing my graduate work at the University of Minnesota, I was fortunate enough to be offered a practicum placement at Starkey. At the time I was intending to pursue a career as an educational audiologist. However, thanks in part to my time at Starkey, I soon realized my passion for hearing aid technology and hearing aid fittings. I was, and continue to be, fascinated with our ability to improve the quality of people's lives through the application of this cutting-edge technology.

What are your main job duties?

After working clinically for several years, I initially accepted a position as a sales representative with Starkey in 2008. After two exciting years as a field representative, I was offered a position as a member of the Customer Service Audiology/Tech Support team. I now work both on the phone and online to assist our customers with fitting questions and training needs.

What was a memorable experience or achievement in your career at Starkey?

During my four years with Starkey, I have been given the opportunity to meet and interact with some of the most intelligent and influential individuals in our field. It has been an honor and privilege to work alongside these professionals who have done so much to shape and advance our industry.

What is the most interesting and/or exciting part of your job?

At heart, I must admit that I am a true "technology geek." I am fascinated by the sophistication and complexity of today's hearing instruments. I consider myself truly fortunate to be a part of these brand-new developments and am so very happy that I have the opportunity to share this knowledge with others in our field. It brings me great satisfaction to know that I am in a position to help others learn and apply these latest technologies with the goal of improving the lives of our patients.

What are some of the challenges you face? How do you address them?

I believe that one of the greatest challenges we face with newer technology relates to providing adequate training and support for our customers. Hearing aid technology and fitting software are much more sophisticated compared to even a few years ago.

As part of the Audiology/Tech Support team, I am in a unique position to address those challenges. Working with our Education and Training team, we provide regional training and phone support, as well as real-time online support. It is very rewarding to know that we are in a position to help our customers help their patients.

What are some of the most common questions you hear in your daily work?

One of my favorite parts of this position is the diversity of questions and challenges that we face. We have the ability to assist with computer issues, programming difficulties, and more in-depth audiological recommendations. The chance to experience something different each day keeps me interested and motivated.

What do you do for fun outside of work?

When I'm not working, I spend every available minute with my growing family. I have a beautiful wife, a three-year-old son, and a two-month-old daughter. We spend as much time as we can outdoors camping and hiking. With two kids, two dogs and one cat, we don't travel light!

Is there anything else you'd like to share?

I work with an amazing group of individuals. It is both exciting and sometimes intimidating to work alongside such experience and talent. I have never met a group so dedicated to what they do and so determined to do it well. They are the very best in the business and it is an honor to be a part of this team.

Benefits of Deep-canal Hearing Aid Fittings

Jason A. Galster, Ph.D.
Manager of Clinical Comparative Research, Starkey Laboratories, Inc.

It has been suggested that completely-in-canal (CIC) hearing aids have advantages over behind-the-ear (BTE) hearing aids.

Some of these advantages include decreased occlusion (Mueller, 1994), increased patient satisfaction (Ebinger et al., 1994), decreased amplification of wind noise (Fortune & Preves, 1994), and improved localization ability (Best et al., 2010). If canal fitting of a hearing aid provides significant benefits over a BTE form-factor, then it might be assumed that deep-canal hearing aid fitting could enhance those benefits. The premier option for deep-canal fitting is the Starkey SoundLens™, the industry's first invisible-in-the-canal (IIC) custom hearing aid. Traditionally, a CIC is fit one to two millimeters inside the aperture of the ear canal, whereas the IIC is fit to the second bend of the ear canal, positioning the faceplate well past the aperture. For additional background information on the IIC, please refer to Van Vliet and Galster (2010).

A research project was developed to investigate the benefits provided by the IIC as compared to CIC and BTE hearing aids; four experimental questions were asked:

1. Does the IIC hearing aid reduce some effects of own-voice occlusion when compared to the CIC and BTE fitting styles?
2. Does the microphone placement of the IIC hearing aid offer superior sound quality when compared to the microphone placement of CIC and BTE hearing aids?
3. Does localization ability improve with the IIC hearing aid when compared to CIC and BTE hearing aids?
4. Does the IIC offer improved maximum stable gain when compared to the CIC fitting style?

Five normal hearing research participants assisted in the systematic investigation of these questions. All IIC hearing aids used SoundLens technology. Both the CIC and BTE hearing aids were from the S Series™ iQ family of hearing aids; the BTE hearing aids used standard 13 size tubing coupled to a full-shell custom earmold. All fittings were done either without vents or with a pressure vent. This article reviews the methodology used for evaluation and any clinically relevant outcomes.

Question 1: Own-voice Occlusion

When speaking, a person's own voice will be transmitted via bone conduction into his or her ear canal. For hearing aid wearers, the residual ear canal volume that resides beyond the medial end of the hearing aid will act as a resonant cavity for their own voices. This means that when wearing a hearing aid, a person's own voice will be louder than when he or she is not wearing the hearing aid. Mueller (1994) suggests that lengthening the canal portion of a hearing aid may reduce own-voice sound pressure levels (SPL) in a patient's occluded ear canal. For this reason it was expected that the IIC hearing aid would reduce the effects of own-voice occlusion when compared to the CIC and BTE hearing aids, both of which have shells that terminate in the cartilaginous portion of the ear canal. For the measurement of own-voice occlusion effect, participants were asked to vocalize a long /i/ at 65 dB SPL with and without IIC, CIC and BTE hearing aids. An Audioscan Verifit was used to record the real-ear unaided response (REUR) and real-ear occluded response (REOR) during vocalization.

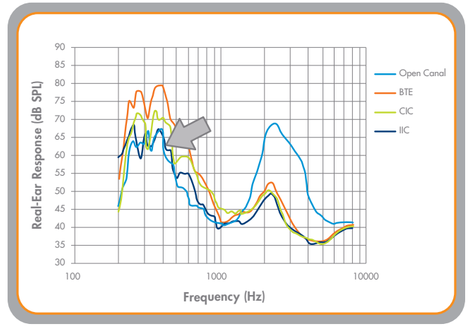

Figure 1. Average real-ear responses (dB SPL) are shown as a function of frequency (Hz) for open-canal, BTE, CIC and IIC hearing aid fittings. Each measurement was recorded during voicing of /i/ at 65 dB SPL. The arrow draws attention to the overlapping IIC and open-canal data.

Figure 1 shows the average results of the voiced occlusion measurements. As expected, the primary effect of voicing was observed between 200 and 500 Hz. Open-ear testing showed the lowest levels during vocalization; in contrast, BTE hearing aids resulted in the greatest voiced occlusion effect of the three hearing aid styles. The CIC data showed intermediate results and the IIC data indicated that on average the voiced occlusion effect is almost eliminated. This suggests that the IIC is a superior solution to the CIC and BTE for minimizing the negative effects of occlusion associated with a patient's own voice.

Figure 2. IIC and BTE hearing aids are shown. Each was specially prepared for recording; a cable has been attached to the hearing aid microphone for in situ audio recording.

Question 2: Sound Quality

The process of inserting and removing hearing aids makes it difficult to evaluate paired comparisons between device styles. For that reason, recordings were completed through specially prepared BTE, CIC and IIC style hearing aids. Examples of these research devices are shown in Figure 2. Each device was wired to

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Galster holds bachelor's and master's degrees from Purdue University and a Ph.D. from Vanderbilt University.

The following people were of great assistance in the development of this study:

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John Anderson
Drew Dundas
Sridhar Kalluri

allow for a direct recording from the hearing aid microphone while the patient wore each hearing aid. The recorded audio included samples of speech and music presented from directly in front of the listener.

Participants completed the paired comparisons of sound quality while wearing Etymotic ER-3a insert earphones. The recorded signals were presented at a level each participant judged to be comfortable. Each trial included the presentation of two stimuli (A and B); the participant made a judgment of preference for stimulus A or B using an on-screen graphical user interface (GUI). Signal presentation, randomization and response logging were managed by a custom Matlab program.

Figure 3 shows the outcomes of the sound quality judgments. Number of wins, or preferences, in a paired comparison task is plotted as a function of all possible comparisons for speech and music. Similar trends were observed for speech and music stimuli. Participants showed significant preference for the IIC microphone location over both CIC and BTE microphone locations. The CIC microphone location was also preferred over the BTE microphone location. Anecdotal comments

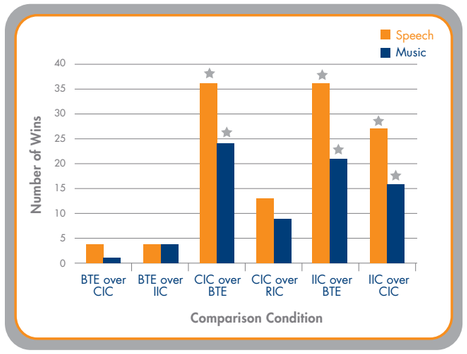


Figure 3. Number of wins for speech and music stimuli are plotted across all comparisons for judgments of preferred sound quality. Stars indicate a significant preference.

from the research participants suggested that they perceived the CIC and IIC hearing aids as providing a *brighter* or *richer* sound quality, when compared to the BTE hearing aids. Follow-up analysis of the test stimuli suggests that the microphone location of CIC and IIC hearing aids yields a high-frequency emphasis that may contribute to the preference for sound quality from the IIC.

Question 3: Localization

All localization testing used production quality BTE, CIC and IIC hearing aids programmed to meet DSL 5.0 through 6,000 Hz. During testing, participants were seated in an anechoic chamber with speakers located directly in front and directly behind their seated position. All sound field stimulus presentations (speech, music and broadband noise) were randomly presented from each speaker location at a calibrated level of 65 dB SPL. Participants identified the sound source location via touchscreen interface on an Apple® iPad®.

A two-way repeated measures analysis of variance (ANOVA) was used to examine the main effects of stimulus type and fitting style. An alpha level of 0.05 was used for this and all other statistical analyses. Prior to statistical analysis, individual percent correct was converted to rationalized arcsine transform units (RAU) as a means of constraining error variance (Studebaker, 1985); all figures retain the percent correct format to ease interpretation.

ANOVA results showed a significant main effect of device style (F1, 3=4.435, p<0.026) with no other significant effects. No significant interaction effects were observed. The data were collapsed across stimulus type for further analysis. A one-way repeated measures ANOVA

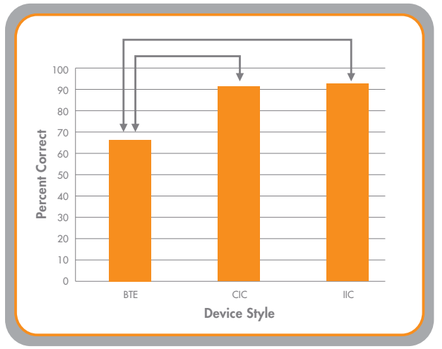


Figure 4. Percent correct is shown for front-to-back localization when wearing BTE, CIC or IIC hearing aids. Data shown are collapsed across stimulus types (speech, music, and noise). The arrows draw attention to the differences of interest within the data set.

was completed, revealing a significant main effect of style (p<0.001). A pairwise multiple comparison (Tukey Test) was completed to further examine effects within the data set. The analysis suggests that localization ability with the CIC and IIC hearing aids is significantly different than localization ability with the BTE hearing aids, whereas localization ability between CIC and IIC hearing aids is not significantly different. These findings are in agreement with previous work that has shown improved localization ability when comparing CIC and BTE hearing aid fittings (Best et al., 2010).

Figure 4 shows the results of the final data analysis; the arrows illustrate the relationships between each hearing aid style. Specifically, CIC and IIC hearing aids significantly improved localization ability when compared to the BTE hearing aids. Thus, it is reasonable to expect that some patients will experience improved localization ability when going from BTE hearing aids to a canal style device.

Question 4: Maximum Stable Gain

The final research question asked whether or not the IIC fitting style would allow for improvement in available gain when compared to the CIC. During data collection, each participant placed a telephone next to his or her ear while each hearing aid's feedback canceller was initialized. The initialization process allows for estimation of a hearing aid's maximum stable gain. These modeled data were used for the comparison between styles. Due to telephone placement, it was felt that the BTE hearing aid style did not offer a valid direct comparison in these measures.

The results of comparative IIC and CIC maximum stable gain measures revealed significant improvements in the IICs maximum stable gain between 1,200 and 3,000 Hz. Specifically, the average IIC hearing aid fitting offered an additional six dB of maximum stable gain when compared to the CIC hearing aid. This improvement may be the result of an improved fit in the ear with the IIC, or an increase in the efficiency of hearing aid performance resulting from decreased residual canal volume. These observations suggest that patients fit with IIC hearing aids may experience less feedback while talking on the phone than those fit with CIC hearing aids.

Conclusion

This study aimed to document select benefits of the IIC style of hearing aid. Four experimental questions were addressed: own-voice occlusion, sound quality, localization ability and maximum stable gain. Outcomes with the IIC hearing aids were compared to BTE and/or CIC hearing aids. The following observations were made:

When compared to BTE and CIC hearing aid fittings, deep canal hearing aid placement decreases own-voice occlusion effects.

Deep canal microphone placement improves sound quality when compared to BTE and CIC hearing aid fittings.

Front-to-back localization ability is improved with IIC and CIC hearing aids when compared to BTE hearing aids.

In a comparison between IIC and CIC hearing aids, the occurrence of feedback with IIC hearing aids was reduced when talking on the phone.

While existing work has focused on CIC hearing aids and comparative benefits to BTE hearing aids, modern hearing aid technology has made smaller, deeply fit hearing aids possible. These IIC hearing aids provide patients with an invisible hearing solution that leverages unique benefits of the wearer's pinna and ear canal to provide distinct benefits over other hearing aid form factors such as the traditional BTE and CIC hearing aid.

References

Best, V., Kalluri, S., McLachlan, S., Valentine, S., Edwards, B. & Carlile, S. (2010). A comparison of CIC and BTE hearing aids for three-dimensional localization of speech. *International Journal of Audiology*, Early Online, 1-10.

Dillon, H. (2001). Hearing Aids. New York, NY: Thieme.

Ebinger, K.A., Mueller, G.H., Holland, S.A. & Holland, J.W. (1994). Assessing the speech-understanding benefit from CIC hearing aids. *The Hearing Journal*, 47(6), 35-42.

Fortune, T. & Preves, D. (1994). Effects of CIC, ITC and ITE microphone placement on the amplification of wind noise. *The Hearing Journal*, 47(9), 23-27.

Gudmundsen, G. (1994). Fitting CIC Hearing Aids—Some Practical Pointers. *The Hearing Journal*, 47(7), 10, 45-48.

Mueller, G.H. (1994). CIC hearing aids: What is their impact on the occlusion effect? *The Hearing Journal*, 47(11), 29-35.

Studebaker, G. (1985). A rationalized arcsine transform. *Journal of Speech and Hearing Research*, 28, 455-462.

Van Vliet, D. & Galster, J.A. (2010). Invisible-In-Canal (IIC) hearing aids. Starkey Laboratories, Inc.,Technology Paper.

THE DISCOVERY OF OPEN CANAL AMPLIFICATION

Jim Curran, M.S.

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 in-the-ear (ITE)/in-the-canal (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 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 care professional in Manhattan, wrote an article for *Audecibel*, a publication of the National Hearing Aid Society, titled "CROS: The New Miracle Worker." (Dunlavy, 1970). Why would he call CROS, of all things, a miracle? And was it really? This article deals with a specific and unique application of the CROS aid that was never originally intended but that eventually became its most significant form of usage — i.e., a solution to the problem of feedback.

Early BTE aids usually had occluded or minimally vented molds to control feedback.

CROS wired eyeglass aids were commonly fitted for patients with severe hearing loss when CROS was introduced.

Until the advent of CROS, problems with feedback dogged the industry. Today, open canal fittings are routine and feedback issues are seldom a concern. Starkey's feedback cancellation algorithm makes bilateral high frequency fittings a walk in the park. One can literally grab a couple of unoccluded earbuds from off the shelf and fit them without giving a thought to the issues faced years ago.

The Harvard Report on Hearing Aids

To get a full appreciation of the impact of CROS on the practices of the day, we need to 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 (Davis et al., 1947). At the time, the Psycho-Acoustics Laboratory at Harvard University was the single most influential research center in the United States regarding auditory and acoustic matters. The report bore the names of some of the true pioneers of psychoacoustics and, as such, was received with the highest respect. The report recommended that a flat or six 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.

> **"The Harvard Report** recommendations led the early audiology world astray for years."

The Harvard Report recommendations led the early audiology world astray for years. The Report was treated with some reverence and was taught accordingly. But fitting hearing aids with a flat response or a six dB per octave response on patients with sensorineural losses led to many dissatisfied patients with poorly performing hearing aids. It seemed heretical to question the puzzling recommendations of these prestigious authors, so professionals just quietly ignored them and ended up making their own decisions about which frequency response to fit. Some of the hearing aid companies also questioned the Report and continued to supply aids with responses that emphasized frequency ranges where the loss was greatest (Watson & Tolan, 1949).

A witch's brew of selection methods permeated the hearing aid world for the next decades. Included were the Carhart Method (discussed later), selective amplification, prescriptive formulas, master hearing aids and suprathreshold sound pressure testing. Few, if any, professionals in the decades between 1950 and 1980 had a clear idea, or even an inkling, of how to choose the most appropriate frequency-gain response. Lybarger's half-gain rule, which became the starting point for some of today's prescriptive fitting algorithms, was generally known only to a select few and hadn't spread enough to influence the rest of the hearing aid world (Lybarger, 1944 & 1963).

About the Author:

James Curran, M.S., was one of the very first dispensing audiologists. He opened his office in 1967, and then in 1970, joined a hearing aid manufacturer. Over the years he has authored many articles and textbook chapters and has had extensive experience speaking and writing on industry topics. A member of many industry organizations and professional societies, he was elected to the board of the American Academy of Audiology and to the Executive Committee of the American Auditory Society. He also represented the industry in developing the initial FDA research protocols for establishing the efficacy of amplification.

Hearing Aid Evaluations in Clinics

At about the time of the Harvard Report, Raymond Carhart, generally considered the "father of audiology," published procedures for selecting the most appropriate hearing aid (Carhart, 1946 & 1950). This method gained much ascendancy in the university clinics. Aids were preselected from clinic stock for inclusion according to the best judgment of the professional. As a result, the selected aids varied widely according to the personal preference of the professional. When body aids were being evaluated, they were placed on a baffle board alongside the patient; sometimes with custom and sometimes with stock molds, sometimes with venting and sometimes without venting. Head worn aids were also connected to stock and sometimes to custom molds with and without venting. Aided and unaided tests including functional gain, discomfort, and word recognition in noise and quiet were performed. It's hard to imagine today, but conventional wisdom held that on average, aided word understanding 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 earphones. The patient was then referred to a hearing care professional for the purchase. This method had some face validity, having been developed during WWII in veteran's rehabilitation clinics. Eventually, however, studies showed it to be completely unreliable and non-predictive (McConnell et al.,1960; Shore et al.,1960; Resnick & Becker, 1963).

Examples of body worn hearing aids.

Further problems ensued when early behind-the-ear (BTE) and eyeglass aids were first introduced in the 1950s. Better bandwidth was theoretically possible with head worn aids, but the transducers were positioned much closer to each other than in body aids, and manufacturers had a difficult time isolating one from the other. The result was a high incidence of internal and external feedback. One could use full-shell earmolds with minimal venting in order to eliminate external feedback, but that exacerbated the occlusion effect for some patients.

It is no wonder that hearing aid fitting became one of the least desirable aspects of audiology during those years. Few 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. Professionals were fitting rather large aids with little or no understanding of earmold acoustics on patients who, then as now, invariably presented with losses having a high frequency component. Plus, most head worn aids in the 1950s and 1960s had very limited flexibility, feedback issues, short battery life, and inadequate gain, output and response characteristics.

The Beginning of Wisdom

Fully five years prior to the Harvard Report mentioned above, Earl Harford, Ph.D., a professor at Northwestern University, began to document the advantage of the CROS concept and reported it to the scientific community. He and his colleagues published a series of studies in the professional journals exploring its potential and benefits (Harford, 1966, 1967, 1968; Harford & Barry, 1965; Harford & Dodds, 1974; Dodds & Harford, 1968). 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 bilateral high frequency losses. Since nearly all fittings in

those days were monaural anyway, every patient who presented with a bilateral sloping high frequency loss was a candidate and was assured of a nearly perfect fitting in at least one ear. It was finally possible to deliver the satisfaction that the hearing aid ads 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 CROS fittings compared to scores that had been obtained under earphones (McClellan, 1967; Green & Ross, 1968; Hodgson & Murdock, 1970; Jetty & Rintelmann, 1970). 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 that had never fully registered in the case of hearing aid fittings. The improvement in scores was a result of the following:

1. The high frequencies received markedly greater amplification than had been possible heretofore.
2. The high frequency amplification bandwidth was significantly more extended than was previously achievable.
3. Reduced upward spread of masking effects was due to the absence of amplification in the low frequencies.
4. As a bonus, the occlusion effect was virtually eliminated.

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. It also produced many studies dealing with the effect of the earmold/coupling on the frequency response.

Achieving Miracles

It is instructive to review the steps of hearing care professionals 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 was persuaded to purchase a pair. If the patient did not wear glasses, he or she was 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 from hinge to hinge in the back of the frame. 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 cover of each temple was 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 re-glued 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 pipe cleaner that had been shaved down was inserted into a length of earmold tubing and bent to the right shape for secure placement in the ear canal. The tubing was then heated with a blower until it set. If needed, the response could be manipulated somewhat by changing the depth of the tubing in the ear canal, or by using tubing with different dimensions.

Why would the professionals go through such a complicated, lengthy and convoluted process? The answer is that they never had so many grinning, enthusiastic, happy customers. Handholding just about disappeared if the patients were fitted with CROS; most old and new customers experienced success right out of the box. Even with all the rigamarole that attended CROS installation and fitting, countless professionals routinely chose to recommend and 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 percent of all head worn aids. Harford and Dodds (1974) suggested that by 1972 CROS fittings had probably reached close to 40 percent 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 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 open canal amplification, 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 mold 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 today's professionals are standing on the shoulders of some very tough, resolute experts who developed the technique, changed a lot of widely held assumptions, and brought to the fore many of the important understandings we hold today about amplification.

References.

Carhart, R. (1946). Selection of hearing aids. *Archives of Otolaryngology*, 44, 1-18.

Carhart, R. (1946). Tests for the selection of hearing aids. *Laryngoscope*, 56, 780-794.

Carhart, R. (1950). Hearing aid selection by university clinics. *Journal of Speech and Hearing Disorders*, 15, 106-113.

Davis, H., Stevens, S.S., Nichols, R.H., Hudgins, C.V., Peterson, G., Marquis, R.J. & Ross, D.A. (1947). Hearing Aids: An experimental study of design objectives. Cambridge: Harvard University Press.

Dodds, E. & Harford, E. (1968). Modified earpieces and CROS for high frequency hearing loss. *Journal of Speech and Hearing Disorders*. 11, 204-218.

Dunlavy, A. (1970). CROS: The New Miracle Worker. *Audecibel*, Fall, 141-148.

Green, D. & Ross, M. (1968). The effect of a conventional versus a nonoccluding (CROS type) earmold upon the frequency response of a hearing aid. *Journal of Speech, Language and Hearing Research*, 11, 638-647.

Harford, E. (1966). Bilateral CROS. Two-sided hearing with one hearing aid. *Archives of Otolaryngology*, 84, 426-432.

Harford, E. (1967). Innovations in the use of the modern hearing aid. *International Audiology*, 6, 311-314.

Harford, E. (1968). Recent development in the use of ear-level hearing aids. *Maico Audiological Series*, V5, #3, 10-13.

Harford, E. & Barry, J. (1965). A rehabilitative approach to the problem of unilateral hearing impairment: the contralateral routing of signals (CROS). *Journal of Speech and Hearing Disorders*, 30, 121-138.

Harford, E. and Dodds, E. (1974). Versions of CROS hearing aids. *Archives of Otolaryngology*, 100, 50-57.

Hodgson, W. & Murdock, C. (1970). Effect of the earmold on speech intelligibility in hearing aid use. *Journal of Speech, Language and Hearing Research*, 13, 290-297.

Jetty, A. & Rintelmann, W. (1970). Acoustic coupler effects on speech audiometer scores using a CROS hearing aid. *Journal of Speech, Language and Hearing Research*, 13, 101-114.

Lybarger, S. (1944). U.S. Patent Application SN 532, 278.

Lybarger, S. (1963). Simplified fitting system for hearing aids. Radioear Specifications and Fitting Information Manual, October, 1-8.

McClellan, M. (1967). Aided speech discrimination scores in noise with vented and unvented earmolds. *Journal of Auditory Research*, 13, 93-99.

McConnell, F., Silver, E.F. & McDonald, D. (1960). Test-retest consistency of clinical hearing aid tests. *Journal of Speech and Hearing Disorders*, 25; 273-280.

Resnick, D.M. & Becker, M. (1963). Hearing aid evaluation—a new approach. *American Speech-Language-Hearing Association*, 5, 695-699.

Shore, I., Bilger, R.C. & Hirsh, I.J. (1960) Hearing aid evaluation: Reliability of repeated measurements. *Journal of Speech and Hearing Disorders*, 28,159-170.

Watson, W. & Tolan, T. (1949). Hearing tests and hearing instruments. Baltimore: Williams and Wilkins.

DEEP INSERTION EAR IMPRESSIONS

As hearing aid styles such as receiver-in-canals (RIC) have become more popular, taking ear impressions is done less often. With the introduction of the invisible-in-the-canal (IIC) hearing aid, we are reminded that impression-taking skills are a cornerstone of successful hearing aid fittings. The IIC hearing aid is designed to fit deeply in the patient's ear, near the second bend of the ear canal, effectively making the hearing aid invisible.

The basic skills required for traditional ear impressions are essentially the same for the IIC impression. The primary difference is that the cotton block is gently placed near or against the eardrum rather than tightly against the ear canal walls lateral to the eardrum. For the IIC impression, the cotton block is designed to separate the impression material from the eardrum. A properly placed cotton block for the IIC impression will have no voids between the cotton block and the eardrum, eliminating the possibility of the impression material "blowing by" the cotton block, yet allowing for safe and comfortable removal of the cured impression.

Basic prerequisites, tools and supplies for taking deep ear impressions:

- As with any ear impression, a combination of a comprehensive patient history, the otoscopic examination, and sound clinical judgment are used to rule out any medical contraindications before proceeding with the procedure.
- Silicone impression material: low shore rating so it cures relatively soft and flexible.
- Good quality otoscope: handheld or video otoscope for a well-lit view of the ear canal and eardrum. Many clinicians use a microscope, or head mounted loupe for more illumination and magnification.
- Cotton block: less abrasive than foam and the shape can be manipulated for accuracy of fit and comfort.
- Lubricant such as OtoEase to help compress the cotton block and allow for comfortable release of the cured impression.
- Bright ear light with markings to judge depth; lighted curette or other tool of your choice, to allow careful and accurate insertion of the cotton block.

Hundreds gather to watch a live deep ear impression at AudiologyNOW! 2011 in Chicago, Ill.

The Otoscopic Examination

As with a typical ear impression, the otoscopic examination will identify the presence of cerumen, foreign objects, or anatomical considerations that would rule out taking a safe ear impression or necessitate a medical referral. Judging the anatomical characteristics along the full length of the canal is very important with the deep impression to assist in the proper placement of the cotton block. Gently touching the tip of an ear light or curette to a patient's canal wall may prepare them for the sensation experienced with a deep canal earmold impression, offering tactile cues as to what they will experience during the impression.

Preparing the Cotton Block

A cotton block is recommended over foam because it is more comfortable against the eardrum and is easily thinned and shaped by tearing away excess material. The cotton block should be trimmed and shaped so that it is as thin as possible, yet will fully cover the eardrum when placed in the ear canal (Figure 1). Using a lubricant such as OtoEase will help compress the cotton and ensure a comfortable separation when removing the cured impression.

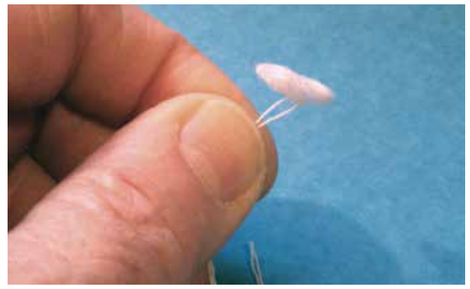


Figure 1. Cotton block, flattened for a deep ear impression.

View of the ear canal from the first bend showing the second bend and ear canal anatomy.

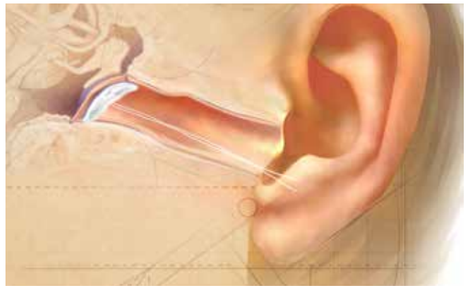


Figure 2. An illustration of a cotton block properly placed against the eardrum.

Placing the Cotton Block

The flattened cotton block is walked down the ear canal with a light touch that keeps the proper orientation of the disk shape of the cotton block, avoiding tipping or rotation. The insertion tool is guided in a way that avoids touching the ear canal as much as possible for comfort.
The experienced clinician uses a combination of knowledge of the patient's ear canal gained during the otoscopic inspection and tactile feedback from the insertion tool to determine when the cotton block is properly placed (Figure 2).

Inserting the Impression Material

Silicone impression material is recommended for optimal comfort, safety and stability, but for many ears, any standard impression material and injection method will yield an impression suitable for construction of the IIC hearing aid. With the cotton block in place, the tip of the mixing cannula or syringe is inserted right inside the tragus and pointed directly at the cotton block. A headlight or other light source helps ensure proper placement. The material is delivered with sufficient force to completely fill the ear canal up to the cotton block without voids. The patient will normally feel some additional pressure during the impression, not unlike the pressure felt when diving under water at a six- to eight-foot depth. Once the impression material starts flowing into view around the tip, the tip may be slowly removed and the remainder of the impression should be taken. A full concha and helix impression is necessary not only so that there is sufficient material to grasp when removing the impression, but so a full impression scan may be on file in the event that another type of mold or product is desired.

Removing the Impression

Once the material is cured, the impression is removed by first asking the patient to move their jaw, and the tissue around the ear is gently manipulated in an effort to break the seal to avoid uncomfortable suction. A firm grasp of the impression is needed to allow a steady, but slow, rotation and removal of the impression. If the patient feels discomfort, slow the process to allow pressure relief, but continue the removal until the impression fully releases. Inspect the ear following the removal to determine canal health and to ensure all material has been removed.

The Impression

After removal, inspect the impression for voids and proper length. Twelve millimeters beyond the second bend is needed for an IIC with the faceplate at the second bend. The width of the impression at the second bend needs to be no less than six millimeters, and the height should be 12 millimeters. The sizing key may be used to estimate how appropriate the impression and anatomy will be for an IIC. If necessary, take a second impression. IICs will be built and placed in the ear canal according to the anatomy and space available.

the Gift of Hearing

Images from the Starkey Hearing Foundation missions to Africa. Bottom: Adrian Peterson, Minnesota Vikings running back, with a child.

Starkey Hearing Foundation Shares the Gift of Hearing with Thousands in Early 2011

The Starkey Hearing Foundation was extremely busy in early 2011. A mission to Africa covered five countries (Kenya, Uganda, Rwanda, Burundi and Zanzibar) and 10 cities in 24 days — providing more than 11,000 kids and adults with the gift of hearing. Marlee Matlin, who starred on NBC's most recent "The Celebrity Apprentice" and is deaf, nine NFL players, Jordin Sparks, Larry Fitzgerald (Ruhengeri) and *USA Today* reporter Alison Brower joined Foundation staff, volunteers and sponsors to make the missions a success.

The missions were held in schools, behind churches and in open markets. Each place had its own challenges and stories, but the overriding outcome was the same — the gift of hearing for many people.

MISSION TO AFRICA

5 countries

10 cities

24 days

More than 11,000 children, parents and grandparents given the gift of hearing!

Here are a few of the stories that Foundation co-founder Tani Austin shared about their adventures in Africa.

Uganda

USA Today reporter Alison Brower and nine NFL players engaged with the children and the work until late into the night. The team fit hearing aids in front of the headlights of their vehicles.

We spent one of the mission days with Sister Rosemary Nyirumbe, who runs the St. Monica Girls' Tailoring and Day Care center — providing education, vocational training and dignity to girls who've been traumatized by brutal militias. Hundreds of patients, many who had traveled from war-torn Sudan, waited in the rain for their chance at better hearing, and the Foundation staff and volunteers helped them all.

Brower blogged about her adventures with the Starkey Hearing Foundation in Africa and interviewed Foundation co-founder William F. Austin.

Read the blog and interview at:
yourlife.usatoday.com/health/sk-hearing-loss/index.

Rwanda

The team arrived at the University of Kigali to fit 600 people and only had one small tent and a few chairs! A bit of scrambling and they moved to a soccer stadium, set up again and got to work. Wax and ear infections made the days long and arduous, but every single person was seen. The next stop in Rwanda was Ruhengeri Hospital, where the team gave the gift of hearing to more 500 people.

Tani Austin shares the gift of hearing.

Top: A volunteer works with a child. Middle: Bill Austin talks to a child just fit with hearing aids and her mother. Bottom: Marlee Matlin with a child during the mission to Africa.

Burundi

The last mission day in Burundi was held at a deaf school and church. The "deaf" children often take a lot of time because they have never heard before, don't know what they are listening for and don't want to fail the people trying to help them. Eventually, the children were all fit and the schoolyard was much louder than it had been before the Foundation team arrived!

Another amazing story from Burundi: A man heard about the mission on the radio in Rwanda and got his 92-year-old mother out of the hospital to drive her to the site where the Foundation was working. The woman was not able to walk well, so the team went to her in the car. They found her ears completely impacted with wax. It took eight people to hold her down so they could remove the wax. She was sure they were trying to kill her, according to the interpreter, but when the wax was removed, she heard and forgave them with hugs, kisses and blessings.

NBC's "The Celebrity Apprentice"

In addition to the mission to Africa, the Foundation was honored with Marlee Matlin's support on NBC's "The Celebrity Apprentice." Matlin raised nearly $1 million — the largest amount raised for a charity in show history — for the Starkey Hearing Foundation. In addition, Gary Busey, another contestant on the show, was on "The Tonight Show with Jay Leno," "The Ellen Degeneres Show," and more to talk about his experience, including his new Starkey hearing aids.

CLINICAL EXPERIENCES WITH SOUNDPOINT

Susie Valentine, Ph.D.

Recently, Starkey introduced SoundPoint, an interactive patient counseling tool that allows the patient to assist in the fine-tuning of his or her hearing aids. The development of SoundPoint was a deliberate process. From the outset we knew that a successful clinical tool must have certain attributes that appeal to the hearing care professional while also benefiting the patient. For example, SoundPoint uses a graphical interface, and that interface must be accessible for any patient — even those inexperienced with technology should be able to intuitively interact with the system. Next, allowing patients the opportunity to assist in the fine-tuning of their hearing aids will improve their experiences. Ultimately, this technology must be productive. In other words, SoundPoint must simplify interaction with the hearing aids while fitting seamlessly into routine clinical practices. Three years ago, I was fortunate to be part of a team of Starkey researchers with expertise in audiology, digital signal processing, software development and computer human interaction, as they began to work through these complex requirements.

> "SoundPoint must simplify interaction with the hearing aids while fitting seamlessly into routine clinical practices."

As an experienced clinician, I appreciated the nuance of each requirement. In the early phases of design, many ideas were proposed in an attempt to conceptualize what would be the most accepted application of SoundPoint. The reality is that, as an adjustment tool, SoundPoint could be used in countless fashions: it could be implemented as a portion of the expert fitting assistant or as a method of fine-tuning parameters of individual processing algorithms (e.g., digital noise reduction). Ultimately, it was decided that the most powerful role that patients can play in the fitting of hearing aids is in the fine-tuning of sound quality, effectively tailoring the hearing aid fitting to their own listening preferences.

If you are wondering how you should incorporate SoundPoint into your clinical procedures or how SoundPoint can be beneficial to you, included are some clinical experiences that I have encountered. In each of these, SoundPoint proved or would have proven to be a valuable tool to improve clinical outcomes.

Example 1: An older gentleman — we'll call him Mr. Smith — wanted to replace his nine-year-old analog devices. (He was the one that always arrived 90 minutes early for his appointments.) At the time, Mr. Smith received a pair of S Series™ iQ 11 mini BTEs and left for a two-week trial period. At the end of the trial, he returned commenting that the hearing aids worked well in noise but he missed the "warm" sound quality of his old hearing aids. After further discussion, I found that this difference was especially evident with his wife's voice. Befuddled by this description of "warm" sound quality — if anyone knows what frequency provides "warm" sound quality, I would love to know — I invited his wife to our next fine-tuning appointment. At the next appointment, I introduced the patient and his wife to SoundPoint, demonstrating how simply moving his finger around the screen, while listening to his wife, could help find that warmth that he was looking for. A few minutes later, without the awkwardness of our typical interview and clinical routine, Mr. Smith was happy with his hearing aids, Mrs. Smith was happy that she could be heard, and I was happy that my patient was successfully treated. That was a good day.

> "I introduced the patient and his wife to SoundPoint, demonstrating how simply moving his finger around the screen, while listening to his wife, could help find that warmth that he was looking for."

Example 2: While in graduate school — before SoundPoint was available — I was working on my clinical audiology degree, and there was one patient at the university clinic that no student wanted to see on his or her schedule — a retired professor of engineering. He was very nice and pleasant to interact with, but he was very particular about how he wanted his hearing aids to sound. The main problem we experienced was his familiarity with technology. He would routinely comment that there was "2.5 dB too much amplification at 4,135 cycles" or "I think the filter slope is too steep." He was very specific in his choice of words and what those words meant to him; unfortunately, he didn't come with a retired-engineering-professor-dictionary and his electrical experience with acoustics meant very little in terms of sound quality. Again, SoundPoint would have alleviated the need to guess at what a word meant to him, thereby reducing time spent and likely the number of follow-up appointments. Through SoundPoint he would have been able to explore a world of sound quality and find that "resonant spot" that eluded my classmates and me for years.

Example 3: A middle-aged professional was being fit with his first set of hearing aids. He arrived at the appointment with his smartphone in hand, checking email, sending texts and surfing the Internet. Obviously, he was quite comfortable with technology. This made me think that SoundPoint could be a great fitting tool for him. Using SoundPoint on the iPad® wowed him, and he had the opportunity to actively participate in his fitting. He was won over by how a simple interface controlled the complexity of the hearing aids. Finding his "sweet spot," or preferred settings, took only a few minutes and was a rewarding experience. At the end of the appointment, he commented that he didn't know what to expect during the hearing aid fitting, but the experience of tuning his hearing aids to his preference was exciting. With technology becoming a staple in our lives, SoundPoint provides patients with a gratifying experience.

These are cases where SoundPoint has or could have improved my experience as a hearing care professional and my patients' experiences in the clinic. We are beginning to hear stories of success with SoundPoint from clinics around the world. And as more professionals take SoundPoint for a "test drive," I'm sure they will continue to find unique applications and exciting stories of success. I recently received an email from the field reporting that SoundPoint helped a clinician fit one of his most challenging patients. "Within four minutes [of exploring SoundPoint] this patient, says 'WOW…my hearing aids sound great!'" SoundPoint is designed to assist the clinician in the hearing aid fine-tuning process and to create a unique positive experience for the patient. I look forward to hearing more exciting stories of success from the thousands of you who have already accessed SoundPoint in the Inspire® software!

About the Author:

Susie Valentine, Ph.D., is a Research Audiologist at the Starkey Hearing Research Center. She holds a certificate of clinical competence in audiology from the American Speech-Language-Hearing Association and is a Fellow of the American Academy of Audiology. Since coming to Starkey she has worked in multiple aspects of hearing aid research including algorithm research and software research. Additionally, she has continued to conduct research designed to better understand hearing loss. Her main interest lies in understanding the sound segregation abilities of hearing-impaired listeners and how amplification influences sound segregation for those listeners. Valentine holds a bachelor's from Lenoir-Rhyne University, a master's in audiology from the University of Tennessee and a Ph.D. in hearing science from Indiana University.

WIRELESS INTERNET

Did you know?

Wireless Networking ≠ Wireless Internet

For security and other reasons, many workplace environments are configured so that wireless connections to the Internet are not available. A local wireless network may still be set up to take advantage of convenient installation and connectivity between computers and peripheral devices.

Wireless networking is simply a method of using a radio frequency transmission and receiver system to connect devices instead of using physical wires. The technology is very convenient for simple installations and reduces clutter by eliminating connecting cables. As technology allows us to add peripheral devices to our systems, such as printers and iPads® (or other Graphical User Interfaces (GUI)), wireless networks make the installations quick and easy.

Want wireless networking, but don't want Internet? You can create a wireless network without having Internet access, allowing you to enjoy wireless file and print sharing, as well as other convenient features. You can also set up a network to connect to the Internet.

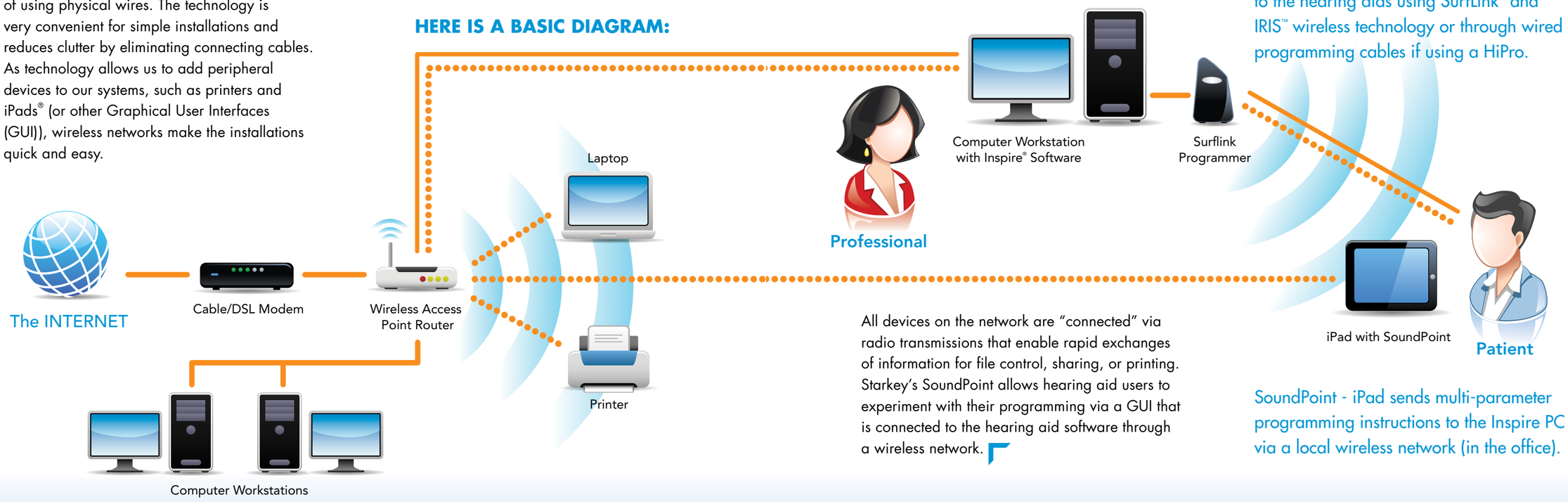
Note: Cable/DSL modem and Internet are optional.

Here's what you need from the computer store:

Wireless Access Point
or Wireless Router if you want to connect to the Internet
Prices start at **$20**

Wireless adapter for your desktop computer
Most laptops come with built-in wireless adapters
Prices start at **$40**

HERE IS A BASIC DIAGRAM:



Inspire® sends programming commands to the hearing aids using SurfLink™ and IRIS™ wireless technology or through wired programming cables if using a HiPro.

All devices on the network are "connected" via radio transmissions that enable rapid exchanges of information for file control, sharing, or printing. Starkey's SoundPoint allows hearing aid users to experiment with their programming via a GUI that is connected to the hearing aid software through a wireless network.

SoundPoint - iPad sends multi-parameter programming instructions to the Inspire PC via a local wireless network (in the office).

OPTIMIZING THE **WIRELESS EXPERIENCE**

Elizabeth Galster, Au.D., & Matthew Burk, Ph.D.
Research Audiologists, Starkey Laboratories, Inc.

Wireless technologies in hearing aids can enhance the patient journey by adding convenience, enhancing signal processing performance, and offering media connectivity. Wi Series™ from Starkey Laboratories, Inc. introduces IRIS™ Technology, the only wireless hearing aid system to offer ear-to-ear communication, wireless programming, and wireless media streaming without any relay devices. Surpassing the limitations of existing wireless systems, IRIS Technology leverages the 900 MHz band within the Industrial and Scientific Medical Spectrum to accomplish a unique combination of near-field and far-field wireless communication. Starkey's commitment to evidence-based design drove the design and implementation of this advanced wireless technology, providing professionals and patients with a seamless and effortless wireless solution.

Starkey's IRIS Technology was evaluated in a large scale field trial. Forty-seven patients from nine private practice and university audiology clinics evaluated Wi Series i110 receiver-in-canal (RIC) hearing aids, SurfLink™ Programmer, SurfLink Remote and SurfLink Media over a period of eight to 12 weeks. Subjective feedback regarding the devices was collected, and clinicians and patients alike were overwhelmingly satisfied with Starkey's wireless system. Results of the Device Oriented Subjective Outcome scale (DOSO) (Cox, Alexander & Xu, 2009), displayed in Figure 1, indicated greater satisfaction and improved performance with Wi Series devices over the patients' own devices.

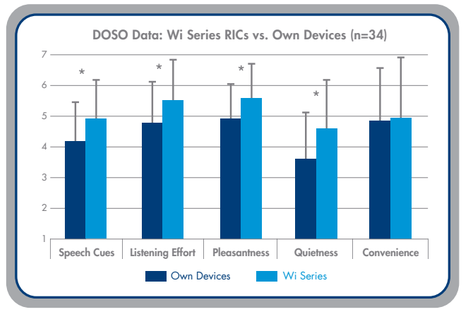


Figure 1: DOSO questionnaire results (34 participants completed the DOSO twice: at the beginning of the study for their own hearing aids and at the conclusion of the study for the Wi Series hearing aids). Asterisks (*) mark significance at the p < 0.05 level.

Adaptive Frequency Agility

With advancements in technology, hardwired connections are giving way to completely wireless systems. One of the challenges faced when implementing a wireless system is that the system must be smart enough to handle interference created by a multitude of wireless signals. Starkey's IRIS Technology utilizes Adaptive Frequency Agility, which continuously monitors the 900 MHz band. If an alternate frequency channel would improve the quality of signal transmission, IRIS Technology will transition to that channel seamlessly. This not only allows for optimum wireless performance in varied environments, but also makes it possible for multiple clinicians and patients to be operating their wireless programmers, hearing aids, and accessories within the same environment.

SurfLink Programmer

In developing IRIS Technology, Starkey was committed to designing something that is as easy for professionals to use as it is for patients. Our goal was to make wireless programming truly wireless, such that a clinician can bring a patient into the office and begin a programming session, without the need for cables or neck-worn devices. Thus, the distraction of connecting the hearing aids to programming cables or hanging a relay device around a patient's neck is eliminated, allowing the professional to focus on the patient and the patient to focus on his or her hearing needs.

SurfLink Programmer, displayed in Figure 2, connects to the professional's computer via a USB cable and can be positioned wherever convenient. The SurfLink Programmer performs high-speed wireless programming at a range of at least 20 feet, allowing the patient to move about the room during a programming session. The Inspire® fitting software automatically detects instruments within range and allows the professional to select the devices to be programmed. Additionally, the Inspire fitting software sends programming changes to the hearing aids instantaneously, so if a patient walks out of range, there is no need to worry that the adjustments have not been saved. Finally, there is no need to reboot the hearing aid after a programming session. For clinicians, the move from wired to wireless programming is an easy and quick transition with a minimal learning curve.

Figure 2: SurfLink Programmer.

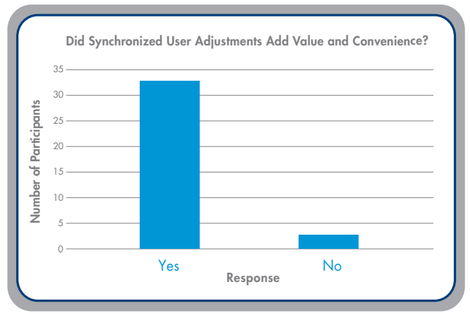


Figure 3: Subjective data collected during the Wi Series field trial (36 of 47 total participants responded to this question). Patients were asked to report on the value and convenience of Synchronized User Adjustments.

Subjective reports obtained in the field trial with private practice and university audiologists indicated that the SurfLink Programmer was easy to install and use and was faster than other wired and wireless programming methods. One audiologist reported that programming with IRIS Technology is one of the most convenient advancements in hearing aid technology.

Synchronized User Adjustments and Binaural Spatial Mapping

Through the Inspire fitting software, an audiologist can configure IRIS Technology to meet each patient's needs. Synchronized User Adjustments in Wi Series devices maximize convenience for the patient. Performing bilateral volume or memory changes can be accomplished with the single push of a button. When asked about the convenience and value of Synchronized User Adjustments, participants in the field trial reported that Synchronized User Adjustments add both convenience and value to the fitting (Figure 3).

About the Authors:

Elizabeth Galster, Au.D., is a Research Audiologist with the Clinical Product Research team at Starkey, which conducts clinical research trials on emerging technology and fitting processes. Galster's previous research focused on evaluation of signal processing algorithms, directional microphones, and speech understanding in reverberation. She has also worked clinically with the Veterans Administration. Galster holds a bachelor's from the University of Iowa and an Au.D. from Vanderbilt University.

Matthew Burk joined Starkey in 2008. As a member of the Clinical Product Research group, his research interests include hearing aid test methodology and wireless hearing aid technology. Prior to joining Starkey, Burk was a research scientist at Indiana University with an emphasis on auditory training and rehabilitation. He holds a bachelor's degree from the University of Minnesota-Twin Cities and his master's and Ph.D. from the University of Wisconsin-Madison.

In addition to Synchronized User Adjustments, Wi Series devices also utilize Binaural Spatial Mapping, which coordinates digital signal processing algorithms between the patient's two devices. Ear-to-ear communication coordinates the performance of InVision Directionality, as well as the Wind and Machine AudioScapes, ensuring that the algorithms are optimized for any given acoustic environment. Algorithm performance with Binaural Spatial Mapping is optimized, not necessarily synchronized. Internal research has indicated that synchronized digital signal processing algorithms, in which settings between the two ears are identical, are not always optimal (Banerjee, 2010). This data, along with that of Hornsby & Ricketts (2007), indicate that there are situations in which asymmetric settings for digital signal processing algorithms can be advantageous.

Based on this evidence, Starkey developed Binaural Spatial Mapping. The Binaural Spatial Mapping system uses data, including estimates of signal-to-noise ratio (SNR), from both hearing aids to determine optimal settings, whether symmetrical or asymmetrical, for speech understanding and comfort. When no speech is detected in the patient's environment, InVision Directionality and the Wind and Machine AudioScapes are designed to improve listening comfort by reducing background noise through the gain reduction settings of the ear with the poorer SNR. As soon as speech is detected within the patient's environment, the algorithms optimize the SNR in order to maximize speech understanding for the patient. This optimization may result in asymmetric hearing aid settings in order to optimize hearing aid settings for the patient's environment.

Figure 4: SurfLink Remotes.

SurfLink Remote

In addition to Wi Series hearing aids, Starkey has introduced the SurfLink Remote. This small, lightweight device allows patients to control their hearing aid settings using a straightforward keypad. LED indicators confirm patient adjustments and switches, allow patients to make monaural or binaural adjustments, and lock the remote control when not in use. An additional benefit of the SurfLink Remote is that it requires no charging; a single battery is designed to last the life of the product.

Recognizing that professionals must tailor hearing aid fittings to the needs and capabilities of their patients, SurfLink Remote is available in three different configurations as displayed in Figure 4: Basic, Intermediate, and Advanced. As such, the professional can select the remote control option that is most appropriate for a given patient: Basic for the patient who wants to make simple volume adjustments or Advanced for the savvy patient who wishes to manipulate multiple hearing aid settings. Additionally, a remote control can be modified in the clinician's office as a patient's needs change simply by changing the faceplate of the remote control.

Clinical evaluation of the Advanced SurfLink Remote demonstrated that 15 out of 20 patients would purchase the remote control for use with the hearing aids (Figure 5). The five patients who responded "No" simply preferred not to carry a remote control. Anecdotally, patients reported that the Advanced Remote was very easy to use, and clinicians noted that it was more user friendly than other remote controls currently on the market, requiring less training and counseling time with patients.

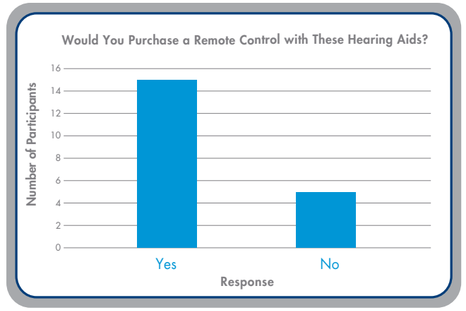


Figure 5: Subjective data collected during the Wi Series field trial (20 of 30 patients who used a remote control in this study responded to this question). Patients were asked to report on the value of the SurfLink Advanced Remote.

SurfLink Media

Starkey also offers SurfLink Media, pictured in Figure 6, as a convenient solution for streaming audio from a television or other media device directly to Wi Series hearing aids. This frees patients from the typical relay devices that require frequent recharging and cumbersome pairing routines. These relay devices used in the transmission of the audio signal create an intermediate step that may delay the audio signal and may send a lower fidelity signal, degrading the overall media experience. Therefore, Starkey's IRIS Technology enhances patients' experiences by eliminating the need for this relay device.

Figure 6: SurfLink Media.

SurfLink Media can function automatically: when a patient enters a room and turns on the television, the audio stream will initiate without any user action. After turning off the television in one room, Intelligent Media Mobility allows a patient with multiple media streamers to move to a different room and automatically begin listening to music streaming from a separate SurfLink Media device. Of course, these are optional settings; if the patient prefers to manually initiate audio streaming, this option is also available in Inspire 2011 fitting software.

The media streamer is easily installed and offers multiple connection options for use with a variety of media devices, ranging from televisions to personal media players. Installation requires only two steps:

1. **SurfLink Media must be connected to the television or media device using a cable, such as a standard RCA cable.**

2. **SurfLink Media must be plugged into a power source or wall outlet. Both patients and professionals have reported SurfLink Media to be very easy to install.**

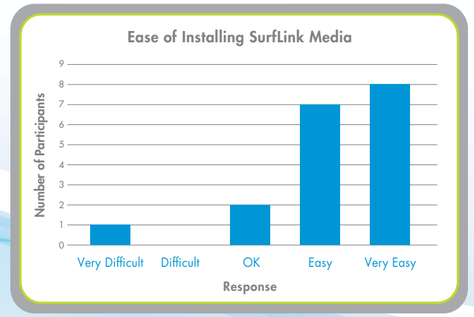


Figure 7: Subjective data collected during the Wi Series field trial (18 of 30 patients who used a media streamer in this study responded to this question). Patients were asked to report on the ease of installing SurfLink Media.

Figure 7 displays patient questionnaire data regarding the ease of installing SurfLink Media. Most patients in the field trial found the installation easy or very easy and appreciated that multiple connection options (for example, RCA and optical cables) are available. Additionally, multiple patients in the same household or living center can seamlessly connect to a single SurfLink Media unit without requiring pairing of the hearing aids to the media streamer.

Summary

Wireless technology has changed the way people interact with their environment. IRIS Technology, available in Wi Series hearing aids, makes it possible for hearing impaired patients to take full advantage of the benefits of wireless technology. Wi Series is the only wireless hearing aid system to offer ear-to-ear communication, wireless programming, and wireless streaming without any relay devices. Starkey continues to develop innovative hearing solutions and is committed to providing the functionality and form factors that patients demand.

References

Banerjee, S. (2010). Hearing aids in the real world: Typical automatic behavior of expansion, directionality, and noise. *Journal of the American Academy of Audiology*. Advance online publication. doi: 10.3766/jaaa.22.1.5.

Cox, R.M., Alexander, G.C. & Xu, J. (2009). Development of the device-oriented subjective outcome scale (DOSO). Poster session presented at the annual meeting of the American Auditory Society, Scottsdale, Arizona.

Hornsby, B.W.Y. & Ricketts, T.A. (2007). Effects of noise source configuration on directional benefit using symmetric and asymmetric directional hearing aid fittings. *Ear and Hearing*, 28, 177-186.

FREEDOM!

In our society we have many freedoms, unless you consider programming hearing aids. Since the early 1990s when programmable hearing aids were introduced, hearing care professionals have had to deal with programming cables, programming boots, and the storage of all these accessories. Many improvements have been made, but we are still stuck with tangled cables, confusing boots and broken flex strips. Each of these obstacles results in intermittencies that happen just when you need a quick and flawless programming session. Couple these problems with the fact that the patient is tethered to the computer or a neck worn harness with limited range, and we don't have much freedom during our programming sessions.

Starkey's SurfLink™ Programmer and Wi Series™ hearing aids have changed our fitting routine, giving us much more freedom. Programming Wi Series hearing aids is seamless — real-time detection occurs as soon as the hearing aids are powered up or when your patient walks into range. The range for high-speed programming is at least 20 feet and often greater. Now we can sit with our patients in a natural, comfortable environment and have them move about during an Inspire® programming session. The patient is free to open and close doors or experiment with anything in range to determine if the settings are comfortable and appropriate. The connections are robust thanks to Adaptive Frequency Agility, which eliminates interference by hopping to free frequency bands as needed.

Wi Series SurfLink Programmer:
Easy enough that adults can do it! No engineering degree required.

Watch the video to learn more:
http://www.youtube.com/watch?v=l0xNw2KZEFQ

Illustrations showing how Starkey's SurfLink Programmer works with Wi Series hearing aids.

> **"Starkey's SurfLink Programmer and Wi Series hearing aids have changed our fitting routine, giving us much more freedom."**

Patients also have the added freedom of providing input into the fine-tuning of their hearing aids with SoundPoint. Using an iPad® and the SoundPoint application, patients simply move their fingers around the screen to change the sound quality of the hearing aids. Whether it is music or the speech of a significant other, the patient can go to the source of the desired sound in the office and optimize the sound quality to his or her preference. It is the wireless programming and the wireless networking of the computer and iPad that make this new freedom possible.

Imagine a busy day in the clinic and a packed schedule with three appointments showing up at the same time. One patient is late, one on time, and one 30 minutes early. All you need to do with one patient is to add a memory, or perhaps move him or her from experience level 1 to level 2. If the patient is in programming range while in the waiting room, simply select his or her hearing aids from the "Get Started" screen in the Inspire software and make your simple programming changes. All that is left is to stroll out to the waiting room and let the patient know that you have made the change and that a follow-up appointment can be made at the front desk!

Now that's freedom!

What is a QR Code?
Short for Quick Response, a QR code is a two-dimensional barcode that allows someone with a smartphone camera to quickly scan and decode its contents — be it text, music, a URL or other data — quickly.

How do you use a QR Code?
Download a QR Reader or QR Scanner to your smartphone. Many Android, Nokia and Blackberry phones come with QR code readers preinstalled. QR reader software is available for most mobile platforms.

Social media is word-of-mouth marketing, but on a new level. It is important for most businesses to participate in this new marketing world, but execution is key. There are three vital factors to your social media success: strategy, relevancy and commitment. Utilizing social media can strengthen relationships, encourage conversation around your practice, make your business more accessible, and relay information more quickly — it's essentially free advertising!

THE Social Media MIX

All About Your Practice

Tips for using social media to grow your business

1. **Develop a strategy** — understand what you want to accomplish.
2. **Deliver relevant content** — information should be timely and useful.
3. **Be consistent** — update regularly and communicate using a consistent voice.

Get Started!

Create a Facebook fan page for your business

1. Visit **www.facebook.com** and log in to your account.
2. On the left-hand column of your homepage, click **Pages**.
3. Click **Create a Page**.
4. Select the type of page you want to create (i.e., Local Business, Brand or Product, etc.)
5. Begin customizing your page — upload a profile image, invite your friends, and post status updates.

Create a Twitter account

1. Go to **www.twitter.com** and create an account.
2. Find friends, get Twitter on your phone and customize your homepage.
3. Join the conversation and start tweeting!

Create a YouTube channel

1. Go to **www.youtube.com** and click Create Account.
2. Log in to your new account and select **Channel** under the drop-down menu in the upper right-hand corner.
3. The top navigation bar allows you to customize your channel.
   - o Control your channel's Settings.
   - o Select your Themes and Colors.
   - o Manage your Videos and Playlists.
4. Click **Upload** near the search bar to start the uploading process.
5. Manage your videos and account under the drop-down menu in the upper right-hand corner.

Now what?

You've developed a clear strategy and set up your accounts. Now it's time to join the conversation.

Create a social media content calendar. You can do this in a simple Excel spreadsheet with columns including content theme, goal for the week, audience and fan/follower count. This is a good way to track page growth and keep your content organized.

Gather content. For Facebook and Twitter, set up Google alerts and link to articles relevant to your readers. You can also post items like health tips, product information, and news about upcoming events at your clinic.

Increase traffic to your practice's YouTube channel by using Facebook and Twitter to link to your YouTube channel.

Start posting. Begin with one to two status updates per week on Facebook — just stay consistent. You should be tweeting at least once per day on Twitter. Tweets are short and sweet and can be no longer than 140 characters. YouTube can be home to videos like patient testimonials, video blogs, product information and even a welcome video to educate your subscribers about your practice.

There is huge opportunity using social media — Facebook, Twitter and YouTube are great places to get started. There are other social sites that can help grow your business including LinkedIn, Vimeo, flickr and Quora. You can also start a blog on your own website. Do some research, find the avenues that make the most sense for your business, but most of all, get started!

QUICK FACTS:

YouTube has exceeded two billion views a day.

Facebook has more than 500 million users, and an average user spends 55 minutes a day browsing the site.

Twitter has more than 110 million users and generates one billion tweets each week.

In the hearing industry, the integration of social media is growing. Starkey has found success using outlets like Twitter, Facebook and YouTube to develop communities for both professionals and consumers.

Visit the **Starkey for Hearing Care Professionals** Facebook fan page and follow **@StarkeyLabs** on Twitter to read the latest industry news, access fitting tips, enter exclusive contests and connect with other hearing care professionals and students. Subscribe to the **Starkey Laboratories, Inc.** YouTube channel for current information including hearing aid instructional videos, product testimonials, instructional podcasts and content from the Starkey Hearing Research Center (SHRC) in Berkeley. And, you can follow the SHRC on Twitter at **@starkeyresearch** to get updates from Brent Edwards, Ph.D., Vice President of Research. Finally, consumers can "Like" **Starkey** to get up-to-date information about hearing loss and new products on Facebook.

The Starkey Hearing Foundation has been extremely successful at creating a strong connection with its audience via social media. The Foundation has more than 2,570 followers on Twitter and 350 fans on Facebook; follow **@starkeyhearing** and "Like" **Starkey Hearing Foundation** to read about the Foundation's latest missions and activities.

NEW TO THE FIELD?

It's a Great Time to be in the Hearing Industry

Barry Freeman, Ph.D.
Senior Director of Audiology, Starkey Laboratories, Inc.

There has never been a better time to be in the hearing industry. Whether you are a student trying to figure out which path you should take, an established audiologist or an independent hearing instrument specialist, demand for your services will increase over the next 30 years as the U.S. population grows and ages.

As you know, hearing loss is a major public health problem. In fact, it is the third most common chronic condition in the U.S. populace. Hearing loss is underdiagnosed and undertreated despite the fact that the knowledge and skills of clinicians make treatment effective. Even publications of the America Medical Association are encouraging physicians to routinely screen patients for hearing loss and to refer those patients that fail the screening to a hearing care professional.

Research Overview

Research on the field of audiology that I conducted with Ian Windmill, Ph.D., looked at the supply and demand dynamics in audiology, specifically in the next three decades (Freeman & Windmill, 2011). In that time, the population of the U.S. is expected to significantly increase, particularly in the 65 and older segment. The population of 65- to 84-year-olds is expected to double, while the population 85 and older will nearly triple. Knowing that at least 30 percent of people ages 65 to 84 and 50 percent of people over age 85 have significant hearing loss, the increase in the number of people in these age ranges will lead to increased demand for hearing-related services.

In addition to the population adjustments, changes in health insurance will also influence demand for hearing care services. Legislation passed in 2010 included provisions to provide insurance to an additional 32 million Americans, and, according to the Center for Disease Control (2004), increased health coverage is a factor that leads to increased use of health care services — meaning hearing care as well.

Some of the demand for hearing care services can likely be met by improvements in productivity due to advancements in technology; improvements in business efficiency; and the use of adjunct personnel such as assistants. However, those strategies alone will not be able to keep up. In fact, the research concluded that there would need to be an immediate 50-percent increase in the number of people entering the field and a lowering of the attrition rate to 20 percent to meet demand in the next 30 years. The attrition rate of people who voluntarily leave audiology at some point after graduation is approximately 40 percent — that was an unexpected variable.

Recent Developments

The U.S. Department of Labor Jobs Almanac refers to audiology as the best and fastest growing health care profession in the country, and audiology spent three years on *U.S. News & World Report's* Top Jobs list from 2007 to 2009. In 2011, audiologists claimed the top spot as the least stressful white-collar job in a survey conducted by CareerCast.

Technology has given audiologists the tools to diagnose and manage patients like no other time in history. Audiologists have the ability to evaluate an individual's hearing, determine the cause of hearing loss and set a course for treatment — whether that is medical or surgical correction, or hearing aids that can improve the patient's quality of life. Systems for the verification of a hearing aid fitting are available in programming software; feedback has been virtually eliminated from most hearing aid fittings; voice indicators and self checks are available for patients; application of nanotechnology assists in the management of problems such as moisture; wireless connectivity is available to improve the lifestyle of our patients; and online apps are available to assist practitioners in the evaluation, management and consultation of their patients.

Conclusion

As the population grows and ages, the demand for hearing care services will continue to increase. It is truly a great time to be in the hearing industry.

About the Author:

Barry Freeman is Senior Director of Audiology at Starkey. Prior to joining Starkey, he was chair and professor in the Audiology Department in the Health Professions Division at Nova Southeastern University (NSU), Ft. Lauderdale, Fla. Freeman earned his bachelor's degree in business and economics from Boston University, a master's degree in audiology, and his Ph.D. in hearing and speech science from Michigan State University.

Freeman has taught audiology on the faculties of Syracuse University and Vanderbilt University. Prior to joining NSU, Freeman was in private practice for twenty years at the Center for Audiology in Clarksville, Tenn. Freeman was president of the American Academy of Audiology in 1996-97 and served on the Academy's Board of Directors for six years. He continues to serve on professional committees and is a member of the Board of Directors of the Accreditation Commission for Audiology Education. He received the Distinguished Achievement Award from the American Academy of Audiology in 2006.

FOR STUDENTS:

Audiology Career Paths

Today, there are more opportunities than ever before for students and young professionals in the field of audiology. Following are some of the most popular options:

Private Practice

Private practice audiologists work in a wide array of clinical settings where they independently bill for services and/or have equity ownership in the practice. These practices vary from providing services to adults and/or children to creating diagnostic and treatment programs for persons with auditory or vestibular disorders.

Academia

Audiologists who work in college or university settings are primarily involved in teaching academic and clinical practicum courses and preparing students to become professionals. They teach clinical courses, provide services to patients while serving as clinical preceptors, participate in clinical research, and supervise and direct research projects that culminate in doctorate of audiology degrees for their students.

Hearing Aid Dispensers and Audiology Aides

The expected growth in the demand for hearing care professionals will also provide opportunities for hearing aid dispensers and audiology aides. Today, there are many opportunities for audiology aides to work as "extenders" for audiologists, taking over many of the technical and administrative duties required to keep a practice running smoothly.

Hearing aid dispensers, whether working independently or within a practice partnering with audiologists, have shown that business expertise and practical knowledge have a place in a successful practice. Some of the most successful practices are audiology/hearing aid dispenser partnerships where each member has the opportunity to contribute, creating a synergy that benefits patients and the practice at the same time.

Hearing Care Industry

There are many opportunities for audiology careers in the manufacturing industry. The technology side of audiology is a fascinating, fast-moving arena. The advanced design applications lead to continually improved patents and products used in hearing and balance specialized equipment, hearing aids and all their associated products such as earmolds, assistive listening devices, etc.

Audiologists are employed as hearing specialists and consultants to industry and manufacturing to help bring products and devices to the marketplace. Private industry audiologists work in customer service positions, marketing, education and training, research and product development, as well as a variety of sales positions.

Government Services

Audiologists working in government services such as at the Department of Veterans Affairs or Indian Health Services provide diagnostic and treatment services to qualified individuals. The Veterans Administration is the largest provider of hearing aids in the United States through hearing services provided to veterans. In addition, the Veterans Administration trains students and supports clinical research to promote the highest level of patient care and education.

Industrial Audiology

Loud and excessive noise in the workplace contributes substantially to employee hearing loss. The industrial audiologist plays a major role in working to eliminate hearing loss caused by industrial noise exposure. Many industries employ audiologists to conduct hearing conservation programs within their companies including periodic employee hearing tests, development of noise reduction plans, and the issuing and maintenance of effective hearing protection.

Medical Centers and Hospital Services

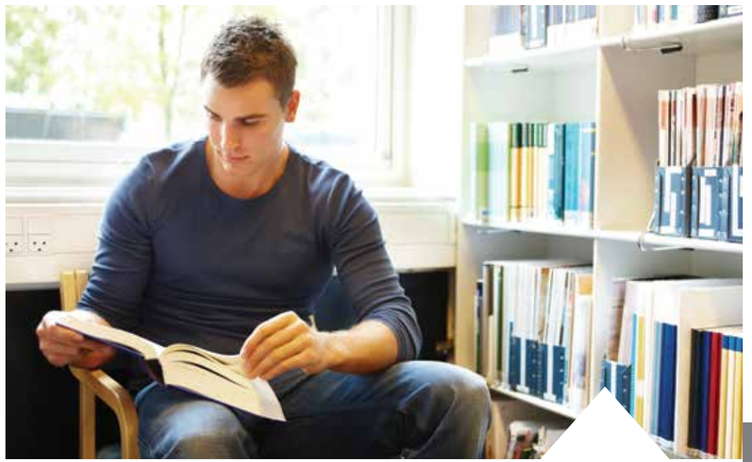
As part of the health care team, audiologists provide the diagnostic, management and treatment services to inpatients and outpatients with hearing and balance disorders. They serve on teams that provide services including pre- and post-operative hearing evaluations for otologic, cochlear implant and cranial-facial anomaly patients. They may also provide inter-operative monitoring and participate in fall prevention programs. The hospital-based audiologist receives referrals and works with a wide variety of medical and other health specialists. The audiologists may be involved in newborn infant hearing screening programs, as well as teaching residents, nursing and medical students, and other hospital personnel about various aspects of hearing and hearing and balance disorders. Audiologists in medical settings often may be involved in dispensing hearing aids as part of their clinical services.

Military Audiology

Military audiology provides hearing loss prevention, diagnostic and treatment services to members of the uniformed services and their families. Military audiologists serve as specialists in hearing conservation programs to ensure that active duty soldiers are provided with proper ear and hearing protection. Most military hospitals also have audiologists providing clinical hearing services, hearing aid evaluations, fitting and distribution to active duty members and their dependents. Active duty soldiers are required to undergo a hearing evaluation prior to entering service and at the time of discharge through services provided by military-based audiologists.

Educational Audiology

Audiologists work in primary education delivering a full spectrum of hearing services to children in educational settings. Nearly all states mandate hearing screening programs in public and private schools; these services are organized and supervised by audiologists. Educational audiologists are involved in monitoring and adjusting children's hearing aids and making sure that they are compatible with the school's FM systems. In-service programs regarding hearing issues are often taught by the educational audiologist, who is also part of the specialty team dealing with those children identified with auditory processing problems.



*Windmill, I. & Freeman, B. (2011). "Demand for audiology services: 30-year projections and impact on academic programs." *Journal of the American Academy of Audiology*. (In press).

Invisible Hearing Aids Drive Consumer Demand

Invisible hearing aids can be an important part of a practice's advertising mix, since invisible messages have proven to attract more responses and a high percentage of new users. Starkey has established itself as the market leader in small and invisible hearing aid solutions — holding large shares of the market in completely-in-canals (CICs) and nearly all of the market in invisible-in-the-canals (IIC).

Starkey is dedicated to growing the marketplace by finding new and current users interested in new technology and passing along those patient leads to licensed practitioners. With this in mind, Starkey is continuously focusing on lead-generation programs to drive patients to independent hearing care professionals.

Hearing care professionals affiliated with Starkey have found that promoting IIC products has proven to be an effective lead-generation tool to create interest and bring new patients into a practice. Following is a snapshot of Starkey's national campaign and its results.

IIC and AMP shown actual size.

2010 IIC Campaign

Overview

The IIC campaign ran for six weeks in 2010 on TV and online. TV channels included FOX, CNN Headline News®, Hallmark, Game Show Network™, Weather Channel® and MSNBC. Online, the campaign focused on search engine pay-per-click ads, Facebook, content networks and image ads.

Results

The invisible message resonated, generating more than 130,000 unique visitors, and solid conversion to leads from lead forms and calls to our call center.

The IIC campaign also provided important consumer insights, including that one product at a high price is not enough — we need to provide options. Patients are interested in small, invisible and affordable hearing aid options. So, in 2011, a year-long national campaign was launched, including flights of media surrounding AMP™, wireless hearing aids, IIC and more.

2011 AMP Campaign

More than one and a half million people with hearing impairment use personal sound amplification products (PSAP), and 75 percent of those have hearing loss equivalent to that of hearing aid users. Most of those people would have lived with their hearing loss without PSAPs. This is an opportunity for hearing care professionals fitting AMP.

AMP advertising has been successful for hearing professionals in many markets. Real-world results since the product's release show that advertising makes the phone ring and that those calls are comprised of a higher rate of new patients. This gives hearing professionals the opportunity to provide good counsel and better hearing to new patients who wouldn't have otherwise come into the hearing professionals' offices — whether they fit those patients with AMP or with other products that are better suited to their hearing loss and lifestyle needs.

NEWS & VIEWS

AudiologyNOW! a Huge Success

Starkey's booths were flooded at AudiologyNOW! in Chicago, Ill. Thousands of people experienced Starkey's latest innovations, including Wi Series™ — now available in three technology levels — SoundPoint, Starkey Invisible Solutions, and Starkey Pediatrics. Attendees also spent time interacting with apps and connecting with other hearing care professionals.

Tickets to Starkey Live! 2011 went quickly, and House of Blues® Chicago was filled with more than 2,000 guests for The Blues Brothers' energy-packed show — starring Dan Aykroyd and Jim Belushi.

The University of Minnesota-Twin Cities and Gallaudet University were the recipients of scholarships in the amounts of $5,000 and $2,500, respectively, in the Trivia Challenge.

Keep up with Starkey's latest news at StarkeyPro.com.

Innovations Editor, Dennis Van Vliet, Au.D., drew a crowd with his deep ear impression demonstrations which were broadcast on a big screen.

Wi Series App Now Available

The Wi Series app is the latest of many mobile apps developed by Starkey to give you and your patients access to today's latest hearing resources anywhere.

This app is designed to provide education about new methods for hearing in historically difficult situations, while providing current wearers much needed information to maximize their experience with this innovative technology. The app:

- Provides demonstration videos to help explain how Wi Series hearing devices wirelessly connect to various media devices, as well as to your programming computer.
- Includes interactive audio comparisons to illustrate how this advanced technology can help wearers in noisy environments.
- Connects to online videos and manuals.
- Has a hearing professional locator feature.

Hearing Innovation Expo: *Don't Be Left Behind*

Join us for the Hearing Innovation Expo, a new global event for independent hearing care professionals next January 4–7 at the Cosmopolitan™ of Las Vegas. Presenting the latest innovations in hearing science and technology, patient care and business practice, the Expo will feature hearing industry thought leaders, world-class scientists and Fortune 500 executives, delivering new and exciting content relevant to today's cutting-edge hearing industry professionals.

The Hearing Innovation Expo is sponsored by Starkey Group and is not associated with any professional organizations.

Capacity is limited to 2,000 attendees interested in supporting the American business model and entrepreneurial spirit with a focus on best practices in patient care. Contact your Starkey Group Representative for more information.

Extern and Practice Opportunities

Starkey has a resource for students looking for externships or practice opportunities. Visit the Student & Faculty section on StarkeyPro.com for more information. For clinicians who offer fourth year externships or are looking to bring an audiologist into your practice, contact us at practice_opportunities@starkey.com to have your practice listed on StarkeyPro.

Jerry Ruzicka on Winning NRA Country/ACM Celebrity Shoot Team

Starkey President Jerry Ruzicka was on the winning team in the inaugural NRA Country/ACM Celebrity Shoot, hosted by Blake Shelton at Nellis Air Force Base near Las Vegas in April. Ruzicka shot at the clays course with Navy war veteran and Wounded Warrior Project board member Andrew Kinnard, Gary LeVox of Rascal Flatts, and Congressional Medal of Honor nominee Dakota Meyer. The shoot was a 13-station, 50-target sporting clays competition. 19 teams competed — each with a celebrity captain.

In addition to the competition, Ruzicka fit a number of the event's participants with SoundGear by LaPierre, a new shooting protection product from Starkey that is 100 percent digital and enhances environmental awareness while protecting the shooter's hearing from gun blasts. SoundGear combines instant-fit convenience with the comfort of a customized device.

The winning team (from left): Gary LeVox, Andrew Kinnard, Dakota Meyer and Jerry Ruzicka.

Starkey Honored with Edison Awards Bronze

Starkey is proud to announce that its SoundLens invisible-in-the-canal hearing aid was the recipient of a 2011 Edison Bronze in the Science & Medical – Handheld or Miniaturized Devices category. Awards in all 12 Edison Award categories were announced in April during an evening that also included the presentation of prestigious Edison Achievement Awards to Alan Mulally, CEO of Ford Motor Company, and John Hendricks, Founder and Chairman of Discovery Communications.

Other notable 2011 Edison Award winners included Apple®, The Coca-Cola Company, Colgate Palmolive Company, ConAgra Foods®, Gillette, Johnson & Johnson, Lockhead Martin, Medtronic, Starbucks, The Walt Disney Company and 3M™.