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Real Ear Measurements: The Basics

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Hello everyone. My name is Dr. Amanda Wolfe and I'm excited to be here with you today to provide an overview of relayer measurements and share how you may implement them into your clinical practice. Please type in any questions you may have in the Q and A and my colleague will be happy to answer them. Handouts are also available as well for future reference.

And please don't forget to pass the multiple choice exam to obtain your CEU credit. And here are some risks and benefits that are associated with every Audiology online course. While what I'll be discussing today is pretty generic, please keep in mind that the applicability of this course may vary by the clinical, geographical and cultural context. Along with the other items listed on this slide, we have three learner outcomes for today's session. Participants will be able to explain the benefits of utilizing relayer measurement in the clinic, explain how to make appropriate adjustments to the hearing aid based on a real ear measurement, and identify one key learning to implement in the clinic to improve patient outcomes.

Several surveys have shown that only about 30% of hearing healthcare professionals are conducting real ear measurements on a routine basis. As for the 70% who aren't performing them regularly, several factors have been cited as to why. The most common, of course, is equipment availability or cost. Another common barrier is lack of time during appointments. Adding in one more procedure in your typical protocol may not be easy at first, but in some cases, taking the time to run real ear measurements may end up actually saving you time because you can visually see what the hearing aid is producing in your patient's ear, leading to faster fine tuning or more efficient counseling.

And some professionals have said that even when they match to real ear targets perfectly, they still get the same reports from their patients, so they don't really see the benefit in bothering to perform them at all. And then of course, there are those who are just plain unsure of how to perform them, which is why some of you are here today.

While I do not want to discount those real world barriers, we know that performing REM contributes to higher patient satisfaction since it tailors the fitting to those individual ear differences and has actually been noted as part of best practice guidelines when verifying hearing aid performance from organizations like the American Academy of Audiology and the American Speech, Language and Hearing Association. Real ear measures really can make the difference, and there is research to support the idea that patients do report greater perceptual benefit when their hearing aids are adjusted according to measures as compared to when they were fit with the first fit algorithm. Specifically, patients who were fit with hearing aids using a comprehensive protocol that included relayer verification reported increased hearing aid use, benefit and satisfaction. They also report reduced listening effort, improved speech understanding, and they came back for fewer follow up visits and the cherry on top. They were more likely to recommend their hearing healthcare professional to friends and family members than patients who did not receive Relayer Verification and Relayer measurements don't need to take a lot of time either.

If using an integrated system within your fitting software like REM Target Match and Starkey's Fitting software Profit, you can perform these measurements quickly and easily and get on with the rest of your appointment. REM Target Match allows you to verify hearing aid fittings using your relayer equipment and the Profit software. It provides a quick and easy streamlined process for automatically matching relayer targets to provide an accurate and efficient fitting experience. There are several advantages of integrated REM Target Match within Profit which include it's a fully integrated workflow via the REM Target Match wizard within Profit. It allows for simultaneous binaural relayer measurements, it automatically matches to Target for both The E Stat 2.0 proprietary fitting formula and standard prescriptive formulas and it does this all in under four minutes.

It also features a live display of measurements relative to target so you know what's going on and you can also manually fine tune the curves afterwards to better suit your patient if needed. This is also

compatible with multiple popular relay systems. Whichever method you choose to run your measures, either traditionally or through an integrated tool like REMTarget Match, the goal is the same right to verify the audibility of a speech signal and the output of the hearing aid, but the real ear measurement may be used to fit the specific needs of your different patients, with the ultimate goal being to promote patient benefit and success by making the appropriate adjustments and troubleshooting any complaints. Troubleshooting complaints can be if they come in for a follow up and report they aren't hearing well. After you've made adjustments, you can run real ear measures and see what the hearing aid is actually doing in their ear and determine audibility from there.

And as we all know, with amplification, we want to ensure first that soft sounds are audible, average conversational speech is comfortable, and loud sounds are not uncomfortable. Some professionals who are unsure of the value of REM say that the patient report is really all they need to verify audibility and comfort. And yes, behavioral reports are very important. However, we've all had those patients right who either are not strong advocates for themselves or who are just not very good at verbalizing their experiences with Hearing aids. Brillear measures offer you an objective verification of the response, which can be used in conjunction with your patient's report.

So it really can be an invaluable tool with which to use for your patients.

Now you may be wondering, well, when using Railer measurements, how do I know that soft sounds are audible, average sounds are comfortable, and loud sounds are loud but not uncomfortable. Independent fitting formulas have been developed by independent research labs that generates required characteristics called targets that are based on your patient's audiogram. These are very well researched and will give your patients a nice starting point since they all prioritize audibility. NEL NL1 stands for the National Acoustics Laboratory Nonlinear Version 1. It was created for nonlinear hearing aids and it really maximizes speech intelligibility and keeps overall loudness at a level no greater than

that perceived by a normal hearing person.

NEL2 came out of the same laboratory and is a Revised version of Nel1. This formula provides less gain than Nal1 and is a loudness equalization approach, meaning intelligibility is assumed to be maximized when all bands of speech are perceived to have the same loudness. And the modifications from NAL1 were based on patient comfort findings DSL is a prescriptive formula out of the University of Western Ontario and stands for Desired Sensation Level. It originally started as a pediatric formula but has since been updated to include adult targets. It is correlated with data on preferred listening levels and the goal really is to normalize loudness and provide maximum audibility.

And lastly, nalr, which stands for National Acoustics Laboratory Revised. It's a prescription that indicates how to fit linear hearing aids. So the goal of NALR is to amplify speech so that all frequency bands contribute equally to its loudness. Now, typically, a prescriptive fitting formula generates its targets by measuring the required amount of gain to amplify a defined speech spectrum to a desirable level. Then the goal would be to match the measured hearing aid response to those specified targets.

Now, there is limited data to suggest that one of these rationales consistently outperforms others when applied across multiple types and degrees of hearing loss. Some patients may be fit with a certain fitting formula when they first start wearing hearing aids and their brain just acclimates to those gain settings, and that is the fitting formula or gain settings that they prefer the remainder of their hearing journey. Some professionals also have their own favorite fitting formula based on what they learned in school or what they think they've had the most successful within their clinical experience or with what their patients are most comfortable with and most successful with hearing aid manufacturers often have their own fitting philosophy that results in their own proprietary fitting formula. Starkey's as an example, is called estat 2.0. Now we designed this formula to really emphasize audibility and increase acceptance of Starkey hearing aids by customizing it to our proprietary compression architecture.

When designing the original version of ESTAD over 10 years ago, we based it on an average of targets from the standard fitting formulas, NALR and NAL1. The value of proprietary formulas is their ability to optimize fittings and deliver sound quality with consideration for the manufacturer's approach to signal processing. ESAT 2.0 provides more gain for soft sounds than its predecessor and more gain at higher frequencies. If you feel more comfortable using a standard fitting formula that I just spoke about, just be sure you select it in your fitting software so it matches what you select in your real ear equipment. For ease, Starkey offers an easy way to switch fitting formulas if you so choose to switch and use something other than estat.

So now that we've reviewed some background of real ear measurements and introduced how they may benefit you and your patients, let's start talking more about how you can actually integrate these measurements into your practice and get into a little bit more high level information about how to actually run them. Let's go over the three stages of the patient journey and where you can start to set up your patients for success by running rem. Those three stages are the hearing test, the hearing aid fitting, and the follow up visits. It's important to remember if you or your practice is contemplating purchasing or using REM that they can be useful for multiple types of appointments. So right from that initial hearing evaluation, you'll want to keep your end goal in mind.

It's a good idea to find your patient's uncomfortable loudness levels so they can be entered into the relear system to help generate fitting targets. If you don't do this, it's fine. The system will likely use average values. As we fast forward to the hearing aid fitting, this is where performing the measurements will establish a measured baseline for you and at the follow up the measurements may help in troubleshooting patient complaints, help you with fine tuning the hearing aid and patient counseling. We'll talk about how to integrate real ear measurements in your fitting and follow up in more detail later today.

But before we go any further, I really wanted to pause and make sure we're all on the same page regarding terminology, if you're just getting started with REAR, there is a lot of information out there. And if you even do a basic search on the Internet, you'll be quickly, quickly inundated with a slew of terms you need to be aware of. In fact, it's kind of like a sea of acronyms when it comes to the topic of real ear. So before we get to how you will perform them, you need a basic understanding of the terminology associated with these measurements. Almost all real ear acronyms begins with the letter RE for real EAR and are followed by two more letters that describe the type of measurement being made and how the measurement is displayed as far as a GAIN response or gain Gain or response.

Excuse me. If you notice on the slide before some acronyms ended with R and some ended with G. Those correspond to whether we are referring to hearing aid response or gain. The term response or also known as output indicates you are observing the absolute measurement of SPL generated in the ear canal and is expressed as db SPL. As we all know, the amount of amplification is called GAIN and is expressed in decibels.

A gain curve indicates you are viewing a measurement that is relative to the level of the input signal, so the input level has been subtracted from the output level. Practically speaking, out of all the acronyms I just showed you, you will likely mostly perform REAR in the clinic, which is a measurement of the SPL in the ear canal created by the hearing aid when it is turned on and adjusted to a comfortable listening level and placed in the ear. REAR can be measured at varying intensities, but it is recommended that it is definitely run at an average speech level like 65 db SPL to ensure that the response is analyzed for the intensity that it will normally be used for an REAR relay. REAR Gain is the REAR minus the input signal the last term I'd like to review is the Speech Intelligibility index or the SII. This is a measure ranging from 0 to 1 that is highly correlated with the intelligibility of speech.

The SII score is a way of quantifying the likely intelligibility of speech based on the proportion of speech cues that are audible and usable for a listener. Basically, an SAI of zero implies that none of the speech information in a given setting is audible or usable to improve speech understanding, and an SI implies that all of the speech information in a given setting is both audible and usable for a listener. So as the SII value increases, speech understanding generally increases and small improvements in SII score yield big improvements in actual word recognition scores. But at some point we reach kind of a ceiling. So the SII score that is associated with maximum audibility with relear is about 70%.

So if you're wondering what SAI to shoot for during your relayer measurements, it's worth trying to get close to 70 for a conversational speech level because up until that point, any improvement in SII will have a positive impact on word recognition. But if you really try to push it past 70, word recognition scores will kind of hit their ceiling or level out. Now, while the SII is a great tool for you as a professional, it is important to keep in mind a few things. One each fitting formula prescription has been designed and evaluated to provide comfortable loudness and good speech recognition and fitting higher than the gain targets in order to get a higher SII may make sii, excuse me, make may make things too loud. Also, as hearing loss becomes more severe, your SII expectation needs to go down.

Also, think about real world context and how speech recognition in the real world will likely be better with contextual contextual cues, facial cues, et cetera. So take SAI with a grain of salt and think of it as a starting point. Don't get too caught up with increasing gain to reach a specific value. So now that we have some terminology under our belt, let's talk about the basic setup steps of real ear equipment to ensure you get the most accurate measurements. First, you'll want to calibrate your machine.

Calibrating the probe tube removes the acoustic effects that the probe tube and the microphone introduce during relayer measurement. So by calibrating, we're essentially making the probe tube and the microphone acoustically invisible. This step is typically performed without the patient present and

involves aligning the external microphone with the pro microphone to compensate for any differences between the two. A stimulus is then played and a trace will appear on your screen that you can compare to what is likely in your user manual to see what that calibration curve should look like. Some Calibration Some real ear equipment will have you calibrate before each patient, and some will store the calibration where you only need to do it once for the week, for example, room setup and patient positioning is also very important.

Your relay measurement system user manual will likely recommend positioning the patient directly in front of and facing the speaker at a distance of about 18 to 39 inches. Ideally, the room you have your relay equipment in should be conducive for acoustic measurements as much as possible. This means that the room needs to be quiet with minimal hard reflective surfaces. Also, the equipment and thus your patient should be as equidistant as possible from walls and other large surfaces to minimize standing waves. That said, I completely understand most of our environments, so do the best with what you can.

Once your patient is positioned, it's time to insert the probe tube, which is used to measure the response of the hearing aid at the eardrum. I always recommend, even if you've already done it, redo your otoscopic exam before inserting the probe tube. This will help you get the lay of the land as far as the ear canal is concerned and make sure that there's no cerumen to take care of before putting the probe tube in, as it just takes a very small amount of cerumen to plug up that that probe tube. You will then hang the external microphone over the ear and the probe tube will be attached to this little box here. And then now you'll need to insert the probe tube in the ear between 2 to 5 millimeters from the eardrum to avoid standing waves.

To help you with insertion, the probe tubes that ship with your equipment should come with the black marker to help you kind of get the distance that you're going to need for each patient. Once the black

marker is measured, you can insert the probe tube in the ear. And generally that black rubber piece should be sitting right at the intertragal notch or a little deeper. I'm also sure to hold the probe tube in place with my other hand when I'm inserting the hearing aid into the ear so the tube doesn't accidentally slip in further and poke the eardrum, because that's not very comfortable. After the measurements, be sure to dispose of the probe tube as they should only be used once.

Next, you'll need to choose your speech stimulus. So here are the most popular speech stimuli available. The International Speech Test signal, or the Ists, was developed from recordings of six female talkers reading the same passage in different languages. The segments of speech were then spliced together and filtered to match the average female spectrum. It also has certain dynamic properties that make it very similar to reality speech.

The ICHRA stimulus comes from the International Collegium of Rehabilitative Audiology and is a distorted speech signal which is a random type noise modulated by real speech. Simply, the Caret passage is about a 10 second audio recording of a man talking about a carrot and then some other items after you choose your speech stimulus that you'll need to put into your machine are your patient's audiogram, how you have it coupled, the hearing aid style. So just be sure to double check everything just to make sure your machine has the most accurate data with which to work with. And it's also a good idea to go into your programming software and turn a few hearing aid settings off. While Rayleer measurement system should be compatible with all forms of hearing aid processing, it is recommended to limit signal processing during testing.

So for Arriar, I set the hearing aid to omnidirectional mode. I turn off noise reduction features, even the feedback canceller if possible. Pretty much any adaptive features your hearing aid manufacturer has turned on should be turned off. This is really just to ensure that while unlikely, the hearing aid isn't going to be doing something to the stimuli that would alter the response and give you inaccurate data. You

also want to ensure the input levels from your fitting software match or are approximated to the levels you wish to measure with your real ear equipment.

So, as an example, we're looking at profit here. Profit's default response curves are at levels 50, 65 and 80 db spl. Therefore, when using a relayer system, we would want to run each curve at these same levels or at a level that closely approximates. Typically, we want to measure multiple levels to ensure soft speech is audible, average speech is comfortable and loud speech is loud but not uncomfortable. So running an MPO curve, a maximum power output curve, will also help ensure the hearing aid output will stay at or below the patient's ucls.

If you didn't measure ucls again, that's fine. The system will just use average values and the final setup step I always recommend doing is just instructing your patient about what's going on. Tell them to remain quiet and sit still. I always let my patients know they'll be listening to a speech signal as at different volume levels and all they need to do is sit still and look straight ahead. They don't need to repeat anything back or even understand what is being said.

I also let my patients know that if any time something gets too loud, they just need to raise their hand and I'll stop the measurement. I've had this occur from time to time during the loud measurement and maybe during the MPO measurement. So you can either change the level of the loud stimulus so it's a bit softer, or just choose not to run it at all depending on your clinical judgment. So the steps we just reviewed will need to be done at every time, every time you do relayer, regardless if it's at a fitting or a follow up. So now let's talk through the steps of the measurement for the initial fitting of course, keep in mind what I'm going to review today are just suggestions.

As you get more comfortable with doing rem, you can adjust your protocol to fit your needs and your practice. At the initial fit, program the hearing aids and ensure a comfortable physical fit inside the ear. Then it's time to collect your responses. Once you start your measurement, you will see the hearing aid

response curve and the generated targets from your chosen fitting formula. So the targets would be like these little cross crosses here and then the curves would be the purple green curve there and the blue curve.

So the goal would be to adjust the hearing aid response via your fitting software to get it within three to five decibels of that target. Sometimes this may not be possible though, so just do what you can. So, for example, if you're increasing your highs and you start to get feedback, maybe stop increasing gain and use your best clinical judgment to help determine audibility. Your relayer equipment will also likely calculate the speech intelligibility index for each input level. Remember, ideally, for that conversational speech level, you'll want about a 70% SII.

Keeping in mind realistic expectations that context out in the real world is probably going to boost their speech understanding. So don't try to get, you don't really need to try to get above 70 or try to get 100 for every input level. Now, when you get to your NPO curve, you'll get just the response you're not going to match to target. So I don't have an illustration here, but basically the system will elicit a loud sweep of beeps across the frequency range. And here you want to ensure that you're not exceeding the UCL of your patient.

And again, you would just instruct your patient to raise their hand if that stimulus gets to be a little too loud.

So let's look at an example here. Let's say your patient's primary motivation for getting a hearing aid is to hear her grandchildren hear better. So during the initial hearing aid fitting, you program the hearing aids and you match to a prescriptive target. But then afterwards, the patient reports that it's too loud and too tinny. So your first response may be to reduce gain until she's happy with the sound.

But then if you run really or again, you may see something like this where perhaps you decreased gain too much and her SII decreased dramatically, indicating that her audibility may suffer.

So you have a few directions to take in terms of counseling and adjustments. You can use the rear screen to visually show your patient that her grandchildren's Voices won't be audible at the volume she is requesting. You can encourage her to try higher gain settings in real world environments while providing her with a volume control so she knows she can turn it down if need it. Or perhaps you can find a middle ground and so provide adjustments. Just not be so aggressive and encourage she try those.

You could also try giving her two memories with different gain settings, one with lower gain and another with higher gain. Then you can encourage her to flip back and forth and compare how she does when she's around her grandchildren. Or you can keep things simple and keep her at those lower gain settings and then at each follow up appointment just increase her gain slightly so she's closer to that prescriptive target. So this scenario really lends itself well to showing how important hearing aid counseling is along with doing relayer verification. But know that doing relayer isn't the end all be all.

You still need to take your patient into account when wanting to set up their best success with their hearing aids.

So the time between the hearing aid fitting and the first follow up visit is always interesting because your patients actually had time to wear the hearing aids. Maybe you matched the target at the first fitting and didn't make any adjustments. Or maybe you made adjustments away from target based on your patient report. Either way, the follow up is generally focused on ensuring good sound quality while not losing sight of audibility. It's really that balancing act.

This is the point where we want to take those realer measurements, then take a step back and think about how they fit into the overall scheme of things. So you want to make sure that you have your questionnaires for your patient, you know how they're expressing themselves when they're talking about wearing their hearing aids. Because as hearing professionals we want to make sure that not only is speech audible, but that our patients are satisfied with their hearing aids at the end of the day. So let's look at a scenario where realer measures may be useful. Your patient comes in and reports sound quality issues.

So this first curve is what you measure at the fitting. You make a few adjustments and realize the sound quality improves when you reduce the high frequency gain. Like this may remind us that we're not really looking at the full picture here when we're doing realer. Sometimes maybe this person has dead regions that has caused the higher gain to cause distortion in the acoustic signals. So again, we really need to remind ourselves that while realer measurements are very useful, they're not really the only thing that we need to be taking into account.

They're just another tool in your toolbox that can be used to set your patients up for success. So at this point, we know the value in using Realer measurements, and we know that every patient is unique. Just because we're making speech audible, it doesn't mean that the patient is going to be able to interpret it. But if it's not audible, then there's no chance they'll understand it. So we're working on this balancing act of making speech audible, but also making it sound good.

And we also need to balance the time we have for the fitting. Right. We also need time for counseling. So it's not only a science, but also an art. So there's a few takeaway messages I want you to have today.

I would say that the most important thing to keep in mind is why you're doing real ear measurements. How do you want to use them? How do you want to make them meaningful? And remember that

verifying audibility is so important, but it can also just be the starting point in the fitting process.

So you really have to keep in mind these three things. Real world performance, sound quality, and again, matching everything with your validation measurements.

Thank you so much. I know this was a quick and short course, but I want to thank you again for spending your day with me. We do have other more comprehensive relay courses on audiology online if you're interested in learning more. I really do appreciate your time and attention. Thank you so much and have a great day.