Grand Rounds - Hearing Aids, presented in partnership with Purdue University

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- [Christy] Hello everyone and welcome back to the Classroom. Thank you for joining us today on AudiologyOnline. We are delighted to host a new group of experts as part of our Grand Round Series for 2019. Each year, we invite world-renowned institutions and universities to come on and present with us their most difficult and challenging cases as part of our Grand Round Series. If you didn't catch the first Grand Rounds of this year, it was with Boston Children's Hospital where they discussed difficult pediatric cases that they've seen. Today we will hear from the clinicians at Purdue University. So just a little bit about them. We have Dr. Lata Krishnan, who is a Clinical Professor in the Department of Speech, Language, and Hearing Sciences at Purdue University. She received her BSc. in Speech and Hearing from the University of Mysore, India, and her MS in Audiology from Rush, as well as her Ph.D. in Hearing Science from Purdue. She provides graduate and undergraduate clinical and didactic student education and clinical services to patients of all ages at the M.D. Steer Audiology Clinic. Dr. Krishnan has special interest in early intervention and intercultural competence and developed and leads a short-term study abroad program for the department.

Also presenting today is Dr. Jennifer Simpson, who is the Clinical Professor and Director of Clinical Education in Audiology in the Department of Speech, Language, and Hearing Sciences at Purdue. She earned her bacherlor's in Communication Disorders at Western Washington University, and her master's at the University of Colorado at Boulder, and her Au.D. at the University of Florida. Dr. Simpson provides clinical education to graduate students in the large on-campus clinic as well as teaches in the classroom. To wrap up, we have Dr. Jillian Hubertz, who is a Clinical Assistant Professor in the Department of Speech, Language, Hearing Sciences at Purdue. She provides clinical education to Au.D. students including diagnostic and intervention services from infancy throughout adulthood and also teaches the Audiologic Diagnostic course. Her special interests include early intervention and clinical education. I will now pass it over to Dr. Krishnan who will begin today's Grand Round with why we should perform real ear verification. Over to you Dr. Krishnan.

- [Lata] Thank you Christy, and good morning everyone. Thank you for being here. So we're here today to talk about real ear verification and share some cases with you. I want to first start by acknowledging Gus Mueller for inviting us to do this Grand Rounds online presentation, and then of course the Purdue University Audiology Clinic patients who choose to come to our facilities for services that they require. The outline of our presentation, we're gonna talk about why this topic was chosen, we'll talk a little bit about manufacturer first fit versus prescriptive methods for hearing aid fitting. We will make sure everyone is oriented to the SPL-o-gram, and then we have a case on troubleshooting, we'll talk about frequency lowering, and then we will have plenty of time for questions and discussion as well. Before I start, though, I also want to say that I don't really consider myself an expert in real ear measures, however, I've been doing them for my entire career, so that's 32 years, and have seen how it has evolved from when we first started using pure-tone sweeps as our stimulus, and then we switched over to a composite noise, we were doing insertion gain measurements, and we switched over to direct SPL measurements in the ear canal, and today we're using speech as our stimulus.

So that really is my expertise is that I've been doing this for a long time. Then I did have the opportunity for the past two years to teacher our graduate level hearing aid scores, and that was greatly beneficial as well to help me in this area. So let's first start about why this topic was chosen. So evidence-based practice is a buzzword in our profession as well as, I would say, most health care professions, and it's been this buzzword for the last few years. So real ear measures provide the evidence to verify the hearing aid fitting, to verify if sounds are audible to the patient, to verify that they are comfortable, and to verify that they are within tolerance for the patient. Both the American Academy of Audiology and the American Speech, Language, and Hearing Association, do have guidelines and recommendations which specifically say that real ear measures should be performed when fitting hearing aids. There's been plenty of evidence for performing real ear measures, and I'm not going to include all of it, but

just touch upon a couple of things. So studies have shown reduced number of patient followup visit if the hearing aid fitting is both verified and validated, which means verified using objective measures, and validated subjectively with a patient questionnaire of some sort. Also has been shown that patients have improved perceptions of their devices. So they think their devices have better quality, better value, they have more positive attitudes or emotions towards their devices and wearing their devices, and they're willing to pay more. This was true for three different groups of patients: those who were experienced hearing aid users, those who had purchased hearing aids and kept them in the drawer, and those who were first time hearing aid users. So despite the evidence that we have, in our profession, real ear measures are little used. Only about 30 to 40% of professionals use real ear measures. 30% say they use it always or almost always. Only 50 to 60% who have the equipment use it. So they might have the equipment and they're still not using the measurements, and up to 30% may not understand the purpose of real ear measures. All of this is from this study in 2010 by Gus Mueller and Erin Picou.

Sadly, the numbers have not changed over the years. So these are from surveys start, that were done in 1995, and then at several years in between, and then the last survey was in 2010. When we talk to people about why they do or don't use real ear measures, those who use real ear measures do find that acceptance of the devices is improved, returned are reduced, and the value, what they're paying, what patients are paying for hearing aids is substantiated. But those who don't say the equipment is too expensive, perhaps they were not trained in doing real ear measurements. All that matters is that the user likes the sound quality and is happy, that's sufficient, and then that the first fit in the manufacturer's software is sufficient in programming the hearing aids appropriately for any particular patient. I'll come back to a couple of those here in the next few slides. So here we are at Purdue University, and for the first two years of the program, our students are on campus and we do all of our hearing aid fittings, 100% of them, based, verified using real ear measures. Then in their third year, students start going off campus, and what we have noticed over many years is that

very few of our off campus sites are doing real ear measures. So in the last couple of years, we decided to survey our third and fourth year students, and this was published in Audiology Today last year. So for our adult patients off campus, the students reported that 41% of the places where they were were always performing real ear measures, and 23% were never doing it, and 23% didn't even have the equipment. With the pediatric off campus placements, we were doing a little bit better, to 58% were always doing real ear, but sadly 11% never, and 26% didn't have the equipment. Which I would argue perhaps is not, not best practice at all to be fitting a child without having the equipment for verifying the output of the hearing aid in the child's ear. So the article ended with this plea that, "use data to drive decision-making in your work, "use evidence-based, clinically-relevant research "to shape your care of patients. "Your patients and your profession are counting on you." We said this because we've, as I said, I've been doing this for 32 years, but we know that the people doing real ear measures are the same 30% to 40%, and other people are not doing it. I said I've come back to this because some of the students, we had open comments also we asked our students, and we did have students saying that there were sites where there was equipment.

So they of course said, "Let's take out the equipment, "let's start using it," and they were sometimes teaching their preceptors how to use the equipment and how to set it up and so on. Then there were also sites where the students clearly said that the person said, "Well, I've been doing this for 30 years "and I've never done real ear and my patients are happy." So we did hear those from our students as well. Okay, so having set up that sort of background information, let's talk a little bit about manufacturer first fit versus prescriptive formulae. So what's the difference? So the manufacturer first fit is what you see on the screen in the software, and I just have one example here of a screenshot. It is the manufacturer's proprietary algorithm. It is a simulation. So it is not an actually measurement. It is a simulation of what the manufacturer thinks or expects is going to happen in the patient's ear. There's no real evidence unless the manufacturer has published some sort of paper about their

algorithm, and it's not verifiable because we don't know what the algorithm is since it's proprietary. Prescriptive formulae, on the other hand, and the two most commonly used ones are the National Acoustics Laboratories and the Desired Sensation Level Methods, they are a real ear measure. So they are not a simulation, it's an actual measurement in the patient's ear. They are evidence-based. So there's a series of published papers over many years that started in the 1970s I want to say, at least for NAL, and the procedure has evolved over the years as more evidence has been collected. They are verifiable because they are published papers and we can duplicate those outcomes.

Also, other differences of note are that manufacturers' first fit settings are typically within about 10 dB of the prescriptive formulae only 36% of the time. So only 1/3 of the time are we actually within, 10 dB of the ballpark where we think we ought to be. Generally, there's not enough gain for soft inputs, so manufacturers tend to start patients out softer than where we think they need to be for optimum listening or hearing, and that's largely due to wanting the patients to be comfortable with wearing the hearing aids. Generally, there's a roll-off for the high frequencies, so there's not enough high frequency gain, and sometimes there's too much gain for loud inputs. The most important difference, though, that practically relevant for clinicians, is this study by Leavitt and Flexer in 2012, where the aided QuickSIN scores were done with hearing aids programmed using the prescriptive method and hearing aids programmed using the manufacturers' first fit. The QuickSIN scores were significantly better when they were fit using a prescriptive method, meaning that we're fitting today's fancy digital hearing aids, but not gaining the best outcomes with those if we just use the manufacturers' first fit. Okay, so we're gonna talk a little bit now about the SPL-o-gram, just to be sure everyone is oriented to it. So here's a picture of what we might see on the screen. The SPL-o-gram is just an audiogram, but in Db SPL instead of in Db HL, which we are used to seeing on the audiogram. It is inverted, so we are more like a normal graph with zero here at the bottom instead of being over up at the top. So there's zero, and then we go louder as we go up that y-axis. What we see on the x-axis

of course is frequency, just like it is on an audiogram. What we're seeing here, the little dashed line at the bottom, or dotted line at the bottom, is normal hearing, average normal hearing. So remember this is a Db SPL graph, so that's essentially your minimum audibility curve. Then what we're seeing over here is the mean level of conversational speech. So it is the speech spectrum mean. Then if we look at this whole shaded area, that is the spectrum. So that's called the longterm average speech spectrum, often called LTASS, and you'll notice that from the mean, because speech intensity varies over time, we are about 12 dB above and 18 dB below, and that encompasses the entire spectrum of speech. So here is a typical audiogram that you're used to looking at, and if we were to convert that or, oh, before I get to that, so the box there shows you the area of speech that is inaudible to this patient given their audiogram. Now, if we look at the SPL-o-gram, that's the same audiogram over here on the right side, and if we look at the inaudible area, now you see that a large portion of the speech spectrum is inaudible to this person.

So if I go back here, that gray portion is your speech spectrum, and this entire portion of it is not audible to this patient. So I'm on the slide which is showing you the SPL-o-gram, and then on the left hand side, we were talking about the prescriptive targets. So we have the NAL-NL2 targets shown up in the hash marks, and then you'll see that LTASS, which is the gray shaded area. Then what I've put up there is also the green shaded area, so that is the amplified LTASS. So this is with a hearing aid on, and so what you can see from this is that the hearing aid clearly isn't providing much amplification for this patient, because the amplified speech is also inaudible to them 'cause it's all below their audiogram. Then over on the right hand side, what I've shown you is what a good fitting would look like. So in the top you'll see the patient's audiogram is over here, and then in this case you'll see that the pink shows soft speech, the green shows average conversational speech, and the blue shows loud speech, and then the yellow or gold is the maximum power output. You'll see that all of the speech is audible to this patient 'cause all of it is above their audiogram. The other thing of note on the SPL-o-gram is that you can also look at what we call the speech

intelligibility index, which is shown here in this column. You can see that speech, 94% of the speech is audible to this individual when they're aided. So that orients you to the SPL-o-gram. We will now share a couple of cases with you. So the first case is an adult, his name is, we'll call him Mr. Frank. So Mr. Frank is an 80-year-old retired airplane pilot, and he actually flew from Indiana, or from Florida to Indiana to get a second opinion on his hearing aids, and he did this because his sister-in-law is my patient. His story was that he purchased his second pair of hearing aids which were receiver in the canal style about four years ago, but he has not worn them for over a year because he said he doesn't perceive any benefit with speech understanding. He says it's the same with or without the hearing aids. He also said that he was told by the office where he was fit that the hearing aids were maxed out and set as high as they could go before feedback.

This is Mr. Frank's audiogram, and you can see that it's a fairly typical sloping, high-frequency sensorineural hearing loss, with very good word recognition scores, 96 and 88%, but some difficulty hearing in noise with that QuickSIN score which is 9.5, and maybe I can find my pointer to show that to you. So here is that QuickSIN score at 9.5. So when we tested Mr. Frank with the hearing aids that he came in with, no changes made, here's what we got. What we can see here is that he is getting audibility for these low-frequency sounds, but remember that's where his hearing is entirely normal. Then he's getting not much audibility and not even close to the targets here for sounds in the one to say three or 4,000 Hertz range at all. So what we did for Mr. Frank is we decided we would just try, oh, and so I just wanted to point out here before we show you what we did, is that this is what we mean when we say that what you see on screen here is just a simulation. 'Cause things can look very perfect here on screen, but when you measure in the real ear, they can be very different. So now I'm gonna put up what we did. So after we adjusted Mr. Frank's existing hearing aids, which were supposedly maxed out et cetera, this is what we got. Again, you'll see here with my pointer, that the soft conversational, loud speech, we have improved his audibility quite a bit, and if you look, his speech intelligibility index, which aided was in the 30% range

is now in the 55% range, and for loud speech it's even more. So we have improved it. We could improve it even further, probably with frequency lowering given his high-frequency hearing loss, but I'm gonna let my colleague talk to you a little bit more about that in just a few minutes. So when we did this, Mr. Frank's immediate reaction was everything was very loud. He was overwhelmed, and we counseled him a fair bit and we offered him the option of coming back for a followup visit in a week, in two weeks, but he was flying back to Florida and he said he would think about it. So we followed up with him by email, and his response was that he was thrilled with the hearing improvement that is possible with these hearing aids. So we did not fit him with new hearing aids. He's doing fairly well with the left ear, speech clarity is good, non-speech noises are a bit sharp but tolerable, and in the right ear, he did say some of the non-speech sounds are uncomfortably loud. Then he ended with that he was facing a dilemma. He said, "I'd like to get new hearing aids, "but I'm having difficulty "with trusting another audiologist." So that was a very telling statement which should give us all pause for thought.

I'm gonna move on now to a second case, and this is a child, and we will call her Fay. She was a six-year-old, or is a six-year-old painfully shy kindergartner, and she was late identified with her hearing loss when she was about five years old. She did pass her newborn hearing screening, but over the past year or two almost, between four and a half and age six, she has had multiple ENT appointments prior to the diagnosis of her hearing loss. She was so shy she couldn't be tested at the ENT office, and they ended up referring her for a sedated test to confirm her hearing loss. She ended up being fit with hearing aids by a local hearing aid dispenser in the town where she lives, and then she was referred to us actually by her school, by the deaf and hard of hearing teacher at her school because she was still having difficult hearing in class, even with the hearing aids. This is Fay's audiogram, and you'll see that she has a low-frequency hearing loss rising to normal hearing in the range of four to 8,000 Hertz. She came in wearing open ear hearing aids. So even before we did anything with the hearing aids, we had some concerns, because an open style is not what we would fit for a low-

frequency hearing loss, and perhaps not what we would fit on a six-year-old as well. The hearing aids were also not FM compatible and they didn't have any T coils. So there was no way to provide her addition assistance in the classroom with those hearing aids. We did attempt to verify the fitting, and here's what we got for each ear. I'm going to just have you focus on this black circle on the left ear where you'll see that we are over-amplifying those high frequencies. This is as expected, because open-ear hearing aids emphasize high frequency sounds, that's their purpose. So here we are, giving her too much volume or too much gain for high-frequency sounds where her hearing is normal or close to normal. The other thing you'll notice here is that we're not giving her enough gain for the low-frequency sounds where she has the hearing impairment, or more hearing impairment. Again, probably perhaps because of the open fitting. So we did get Fay new hearing aids, and here's what we did. I'm comparing the old and the new fittings.

So on the left side is the old and on the right side is with her new hearing aids. You can see the difference here where the inadequate gain is no longer there. She's getting adequate low-frequency gain over her, and the excess gain here in the high frequencies has been reduced. I just have another slide to show you the right ear as well. So this is the same thing again. The inadequate low-frequency gain, now we have adequate, and the somewhat slightly excessive high-frequency gain we've reduced. So to end Fay's story, we did get a report from the deaf and hard of hearing teacher at the school, and she had performed something called a CAST, which is the Contrasts for Auditory and Speech Training Levels, and we'll just point out these three things which she, which Fay did much better with the new hearing aids. So her recognition of narrow vowels, so for example, differentiating between heat versus hit, she was doing a lot better. Also doing a lot better with consonant voicing features, so comparing Ss, and Ns, for example, and recognition of final consonant differences. So if we were talking about tip versus tick, for example. So that is the story of Fay, and those are the two cases to help you sort of understand the difference between manufacturers' first fit versus using a prescriptive formula. I'm now going to hand it over to my colleague,

Jennifer Simpson. Jennifer is a, also a Clinical Professor here at Purdue University, and she has 20 years of clinical experience working with patients of all ages, and I'm going to hand the mic over to her.

- [Jennifer] Good afternoon everyone. This is Jennifer, and I'm gonna talk a little bit about how you can use real ear measures to troubleshoot maybe some problems with hearing aid fittings, and share a case with you about that. So as we all probably are aware that a real ear's probably most used for verification at the initial fit of hearing aids, but often then it's not used again. But there are some instances where maybe using that again would help the audiologist figure out a problem or solve a problem in the best way. So one example would be when a patient has feedback issues. You may use the feedback manager after you've done the initial fitting at a different appointment, and the patient is happy and the feedback goes away, but you really don't know what has happened in that patient's ear canal or what changes actually have happened to the hearing aid to make the feedback go away. So you could run real ear and see if you're still meeting targets or close to targets, and that sounds, especially in, probably in the high-frequency range are audible to the patient, which is of course our goal when we're fitting with hearing aids.

Another example would be if a patient complains that the hearing aids are too soft or too loud in their world or the places that they go. You could use real ear measures, again, after the initial fitting, to actually see what they're talking about and looking at the input, what input you're using to measure the output of the hearing aids in the ear canal. So you may need to figure out, what are they exactly talking about? Are the hearing aids too soft when an input level is a soft input level, or maybe they're not hearing average sounds or loud sounds well enough, and again, also too loud. What sounds might be too loud? Sometimes that's actually hard to understand just by talking to the patient, that you might need to use real data to figure out what kinds of sounds or what level of sound is actually too loud. Then you can make adjustments using the real ear and still making sure that you're in the range of meeting those targets

and that sounds are audible to the patient. So another example would be checking the function of hearing aids with a pediatric patient, and this is very important, because often pediatric patients just are not mature enough or have the language to tell you exactly what's happening. Even if they are a young student or a child, they might say it sounds okay, but you need to verify that. So besides just verifying fittings at the very initial fit, doing that later is always a good idea. So this is a case study, and we're gonna call her Anna. She's an eight-year-old female, and she was diagnosed with a mild sensorineural hearing loss in both ears at another clinic. She was then referred, of course, to an ENT, because she was a late-diagnosed hearing, she had a late-diagnosed hearing loss. I did find out that she did pass her newborn hearing screening when she was born, but of course this was diagnosed later, and probably either late onset or progressive hearing loss. The ENT ordered a CT scan and that came back normal. So the child was cleared to pursue hearing aids.

At that point, she was referred to Purdue for a hearing aid consultation. So when she came into the clinic the parents shared that Anna is an excellent student academically, she does very well. She's very friendly, she has lots of friends, a nice social group. She sits in front of the class because she chooses to, she likes to be close. There's no major medical concerns. The only thing was that she has about three to four diagnosed and treated ear infections per year, most of her life, but only one in the last year. In the past year, Anna had noticed more difficulty hearing speech at home and school, and especially in noise. She had told her teachers and parents that. So this is the audiogram that we performed at Purdue, which actually ended up being very similar to the one done at another location. But since it had been over six months by the time they came to see us, we repeated the audiogram. Otoscopy was clear, so clear ear canals, and I could see her tympanic membranes, normal tympanograms in both ears, and again, a mild sensorineural hearing loss in both ears. Word recognition was excellent if you can see that, it's a little blurry, 96% in both ears, and DPOAEs ended up being low amplitude or partially present, which makes sense with a mild hearing loss. So we moved on to talking about fitting for Anna. So we ended up choosing BTE

hearing aids with a remote mic, and she chose black, red, and white swirl earmolds to go with the hearing aids which is always exciting when a young child kind of takes that on and likes to have fun with the colors. Anna was excited about her hearing aids, and when they were first fit, she had a fantastic reaction, thinking that she just basically had bionic ears and could hear so much better. She did mention right away that she just thought something sounded funny, but she couldn't describe it any better than that, or even identify if it was on one side or the other or somewhere in the middle. So of course our initial counseling, because she's young, hasn't worn hearing aids, and she's not describing it well, is that we said, "Well, things'll sound funny at first, that happens. "Things are gonna sound really different "and it's gonna take a little while "for your brain to get used to it." So we performed real ear measures next, thinking that we're just going through the process, and again, your oriented to the SPL-o-gram here, and what's going on there. I will say this is the right ear, and everything looks good. It's close to meeting targets or in the range of meeting targets, all sounds are audible in the right ear, and her, the index here is all in the 90%. So the right ear looks good, so no problem there, and then we went to the left ear, and right away of course, it's not meeting targets.

Let me just get that little cursor here, right there. So none of the inputs are meeting targets. So you have a soft speech sound, an average speech sound, and a loud speech sound there not meeting targets at all, and of course it just looks like the hearing aid's not working. So Anna was right, something was wrong. So we actually performed real ear again, and just repositioned the probe tube, but there was no change in those results. The right ear was, well, we didn't do the right ear again, but the left ear was the same, and it just didn't look like something was working. So we ended up taking the hearing aid and the earmold apart, and the hearing aid seemed to be functioning okay, which we thought that was true when we checked it prior to the fitting, too. Then we checked the earmold closely and it ended up being that there was glue adhered to the entire bore preventing the sound from passing through, but it was clear, so you really had to look at it carefully to see what was going on. We then

retubed the earmold which isn't hard, and Anna reported that it sounded much better and nothing really sounded funny anymore. So then we did real ear again, and now we're closer to meeting those targets and definitely in the range where everything is audible. I guess the lesson to this story is that without doing the real ear, it's possible to have let that child and her family go with the counseling and the message that things will sound funny or different when really she needed some help to make that hearing aid actually work. So I am going to pass the microphone on to my colleague, Jillian Hubertz. Jillian actually is a Purdue audiology graduate, and for the past five years, has been working up in Northern Indiana in a busy ENT clinic before she joined our clinical faculty here about a year ago. So thank you Jillian, I'm gonna pass the mic.

- [Jillian] All righty, good afternoon everybody. Today I'm gonna be talking to you about verifying frequency lowering settings. We'll go through a protocol and I will have a couple patient examples for you. So frequency lowering may be something that you're already familiar with, and it's a technology that we use to provide audibility of high-frequency sounds when conventional amplification is insufficient. So oftentimes, we run into this scenario because our patients oftentimes have a high-frequency hearing loss. However, hearing aid technology doesn't always do an adequate job of providing the audibility that's necessary. So that's really where the creation of frequency lowering technology came from. Now there's different methods and each manufacturer uses their own proprietary feature, but the different methods of frequency lowering that exist are frequency compression, frequency transposition, frequency translation, and frequency composition. So the methods really relate to how that algorithm is repackaging the high-frequency input into a lower-frequency range where the patient's audibility is better. Now these methods can either be static in nature, in the same, whenever you turn the feature on or off, or they can be adaptive and change depending on what input is coming in. So I wanna be sure to start with a disclaimer that I am not an expert on frequency lowering techniques or methods. I am truly a clinician that was motivated to figure out how to apply frequency lowering in a more evidence-based based way, and really to improve my confidence with when I use this

with patients. So prior to investigating the literature that existed, I would turn frequency lowering on for a patient with a steeply sloping or a severe high-frequency hearing loss, not really knowing what that feature is doing for the patient, or I might turn, if the feature was on by default, I might turn it off if my patient was complaining of some lisping or slurring of speech. So I was really motivated to figure out, how can I apply this feature with more confidence and actually knowing what it's doing for the audibility for the patient. The good news is, I was pleasantly surprised with how approachable this was. So it was very easy to find the literature. The protocols already exist and there's tools that already exist. Really, the more practice I had with verifying this feature, the quicker I was able to perform these measures. So the first thing to start off with is which of our patients are candidates for frequency lowering. So these candidacy criteria that I'm gonna go through are listed from a protocol created by Glista, Hawkins, and Scollie in 2016. So when they're discussing candidacy factors to consider, they included considering the degree and configuration of the hearing loss. So typically, the more severe degree of hearing loss, the more likely your patient is going to be a candidate, as well as if they have a high-frequency hearing loss. If they're, especially if it's a steeply sloping high-frequency hearing loss, your patient is more likely to be a candidate for frequency lowering. Another thing to consider are your hearing device factors.

So to start off, does the hearing device have a frequency lowering feature within the software? Also, what is the output bandwidth of your hearing aid? Some hearing aids are limited in terms of how much high-frequency audibility they can deliver, and so in those cases, you might be more apt to need to resort to a frequency lowering feature. Another important thing to consider is when the high-frequency audibility is insufficient with conventional amplification. So this is something that we can verify electroacoustically, and also just asking our patients, "Is the sound audible to you?" But more specifically, we'll be discussing what the maximum audible output frequency is, or the MAOF, because this is what we use to determine electroacoustically if the patient is a good candidate for frequency lowering or not. Another factor of course is

our patient report. So it's very important to know, you know, what sounds are, is our patient having difficult with, are they having difficulty with women's voices, children's voices, other high-frequency speech sounds? Then once we use frequency lowering, we wanna verify how those sounds are being perceived. So first we'll start with talking about what is that maximum audible output frequency? So the MAOF is the highest frequency where the output of the hearing aid intersects with the patient's threshold. So I will show you right here where the MAOF is. So this is the highest frequency that is audible to the patient. So in order to find this, what you will do, you have the patient's thresholds within your verification equipment, and then you will run the average speech signals so that you can see the LTASS. So at that LTASS, you're seeing the average line, which is in bold, and then in the shaded areas where you're seeing those peaks and valley of the longterm average speech spectrum. So this highest point, this is the, let me outline this here for you, because oftentimes we talk about an MAOF range. So the lower limit of the range is where that average line intersects with your patient's thresholds, and then the upper limit is where that MAOF where I was pointing to before, so that's where the peak of the LTASS intersects with your patient's threshold. So then that's giving you this MAOF range. So this is a suggested target range for placing the frequency lowered signal to improve audibility of these, of the high-frequency speech.

So like I said, verification guidelines, protocols, and tools already exist, and there are several tools out there, some are more general in nature. So despite what manufacturer you're using, what frequency lowering feature you're using, or really what kind of verification equipment you have, you're able to follow these protocols to successfully verify your frequency lowering settings. Some are more manufacturer-specific, so you can always look that up based on what manufacturer you're fitting, and if you can cannot find those manufacturer-specific guides, if those aren't already published, you can always contact your manufacturer trainer to get more information about those settings. But the protocol that I was using was by Glista and colleagues. So the first step of the protocol is to verify the shape and gain of the hearing aid fitting without

frequency lowering. So again, making sure that we're meeting those prescriptive targets so that we can determine what is audible to the patient. The next step is to determine the candidacy for the frequency lowering. So that's going through the previous factors that I discussed, most importantly identifying the MAOF range, and playing a high-frequency speech signal such as a calibrated S to see if that sound is falling within the MAOF range with frequency lowering turned off. If that is not audible to the patient, or if, based off your verification, it's not falling within that range, then it's more likely that your patient is going to need to use the frequency lowering technology. Once you've determine that they're a candidate, you'll enable the frequency lowering typically starting at default setting and determining the audibility of that S signal, and then you may need to adjust the settings of the frequency lowering feature to optimize the fitting. The whole goal of fitting frequency lowering is to use the minimal amount of frequency lowering necessary to make the high-frequency speech signal audible to the patient.

Lastly, you wanna make sure that you're providing post-fitting supports, so of course not just leaving the patient where they're at, but determining in followup appointments, determining if the patient is actually seeing, or perceiving these high frequency speech sounds or if they're having any sort of abnormal sound perception. Now, I used this protocol in conjunction with the manufacturer-specific guide. I found that the manufacturer-specific guides were helpful in informing me about the different parameters of their frequency lowering features since it is proprietary. I was able to learn more about what I should be adjusting to make sure that the settings are optimal for the patient. So we'll get into a couple cases here. So Case Number One is Mark. He's 76 years old and he's had known hearing loss for the last five to six years. He has used a hearing aid for the past five to six years. But he was coming in to see, coming in to our clinic for an evaluation and a consult because he has not been satisfied with his hearing aid performance. He notes that his hearing aids are helpful in limited, simple environments, but in any degree of background noise, he is not able to follow conversation and finds minimal benefit from his hearing aids. One of his hearing aids

stopped working, so instead of obtaining a new hearing aid, he wanted a second opinion to see if there was anything out there that would help him. So you see his audiogram. He has nice, normal hearing through 1,000 Herz, and then it drops to a severe sensorineural hearing loss in both ears. His word recognition was excellent in both ears, and his QuickSIN showed a moderate SNR loss. So that's reflecting his complaint of understanding speech and background noise. Mark did decide to pursue a trial with amplification, and those were ordered and he was fit. At his first followup is when we verified the frequency lowering settings. So this brings up a good point that ideally you will be verifying your frequency lowering settings at the hearing aid fitting. However, since I was just in the beginning stages of investigating frequency lowering verification, I was not able to do that at the fitting, and instead, I did it at the first followup appointment. I would say if you're a clinician that works in a busy practice or if your patient's requiring more counseling up front, that maybe you save verifying frequency lowering for your first followup appointment. I thought that worked out very well for Mark because he was already a previous user, so we didn't have a lot of content to go over in his first followup, so we were able to spend more time with this frequency lowering verification.

So going through the protocol, we'll start with verifying gain settings using the NAL-NL2 targets, and that's what you see in the green shaded area here. Next what I did, I identified the MAOF range by looking where that bold line is intersecting with the threshold and then finding where the peak is intersecting with the threshold. So you do need to have the full L test spectrum up to identify this range. You can see in the right ear, this MAOF range is actually more narrow for this patient than the left ear. So next what we're going to do, we're going to run the calibrated S stimulus with frequency lowering turned off, and that's what you see here in the magenta line. So right here is where that S stimulus is peaking, and then this is the upper shoulder. So based on the verification, you can see that that is not falling within this MAOF range, so it is not audible to the patient. Also, when I asked the patient if it was audible, he said he could not hear any stimulus. So next what we need to do, we'll run the S stimulus with

frequency lowering turned on at default setting. That's what you see with the blue lines here. So in the left ear, we're still not reaching audibility, even with frequency lowering turned on at default. Over here in the right ear, though, we are having some audibility of the peak. This is a zoomed in version so you can see that closer with the range identified. So no audibility over here, and the patient also said that he could just faintly hear the S sound in the right ear, however, we've having good audibility within the verification, and the patient also noted that he was able to clearly hear that S stimulus. So this is telling me that we need to go ahead and make some additional adjustments in the left ear, but the right ear is sufficient. So here what you see in the orange line is when we increased the strength of the frequency lowering. So the frequency, or what you see with the S signal in blue here, I felt like that was falling within the correct frequency range, but it just wasn't audible enough for the patient. So that's when we increased the strength, and now you can see we've improved audibility, just with the peak, not so much with that upper shoulder. But again, we're trying to find that lowest setting where it is audible to the patient. The patient also noted at this setting that the S sound was much louder and clear and more similar to the right ear. So I felt like this was a great setting to have the patient at since it was feeling balanced between the ears.

In terms of outcomes, Mark has been very happy with his hearing aid performance. He's noted improvements in conversations with his wife, he's doing better in environments with background noise, but he still is noticing some struggles. His aided QuickSIN score did show an improvement from the moderate SNR loss to a mild SNR loss, but he's still falling within that mild range at a 6.5. So we continued to counsel about using good communication strategies and how those background noise situations may be a struggle. So Case Two will be talking about Charlie. Charlie was a 65-year-old patient that came in to see us after failing a hearing screening. He has worked in noise, so he's been exposed to noise in the past, although he said that he has been consistently using hearing protection for the past 15 years. He notices difficulty hearing conversations in simple and complex environments. So his audiogram

here is showing you nice normal hearing through 2,000 Hertz which then slopes to a moderate hearing loss in both ears. His word recognition was excellent in both ears, and his QuickSIN was showing us a moderate SNR loss. I will say, based off his audiogram, he, to me, was not an initial candidate for frequency lowering technology. I wasn't quite sure if I knew the configuration with it being a high-frequency hearing loss that that might make him a candidate, however, I wasn't sure about the severity of the hearing loss. Charlie did decide to pursue a trial with amplification, and at his first followup, we verified if frequency lowering would be a good technology for him. So again, our first step, which is to verify gain using prescriptive targets, you see in the left ear across all frequencies, it is audible for Charlie in that left ear. So we really didn't even need to identify an MAOF range, because all frequencies are audible. In the right ear, however, we were able to identify that MAOF range, so again, finding where average intersects with the threshold and the peak intersects with the threshold. So our next step would be to run the S stimulus with frequency lowering turned off. That is shown in the magenta here. So on the left side, audible to the patient, to the right side that's falling within that MAOF range as well. So you have the peak and the upper shoulder. So I'm seeing audibility in both ears.

The patient's also noting that he's hearing a crisp, clear S sound in both ears. But out of curiosity, I was just wanting to see what difference could we see with frequency lowering turned on. So at default settings you can see, and it's kind of hard to see because they're very similar. So the blue line is frequency lowering on at default settings, and it's pretty much identical to frequency lowering turned off. There is a slight improvement, so you see it's a steeper slope here at the very highest frequencies, however, I'm not seeing a significant difference of audibility in the MAOF range, and also the patient could not perceive a difference between the two. So this is immediately telling me that frequency lowering is likely not necessary for this patient. But again, out of curiosity, because I, becoming more familiar with verifying these settings, I wanted to see how changing the settings would alter the acoustics of the hearing aid. So I increased the strength of frequency lowering. You can see that in the

orange line here, and again, the audibility is still there, it's just a steeper slope. So it's kind of packaging that high frequency information into a smaller area. But again like I mentioned, frequency lowering was not used for this patient because he didn't seem like a clear candidate at this time. In terms of outcomes, Charlie had noticeable differences with his hearing aids on. So he noted improvements in family conversations, with watching the TV. But just to wrap up, I wanted to share these frequency lowering verification resources, because I found them extremely helpful, and they were laid out in a very digestible way than any clinician could easily start applying these when they're verifying hearing aids. So the ones that I used were the Glista, Hawkins, and Scollie Update on Modified Verification Approaches for Frequency Lowering Devices, but then the other two are also applicable in general to frequency lowering technology. This is something that not only applies to adults, but also to children as well. Now, there are more specific to manufacturer guides and tools that I found and used. This is not a comprehensive list, because I really only searched for the manufacturers that I was fitting at the time, but I do know that the frequency lowering fitting assistants do cover the majority of manufacturers. So that is all for the frequency lowering verification. So I'm gonna pass the microphone back.

- [Lata] Okay, hello again everyone. So I just want to share one additional case to wrap up and hopefully help you all go home and start thinking about performing real ear measures more frequently if you haven't been doing so. So I said I've been a clinician for 32 years. This case is actually from about 20 years ago, or 18 years ago when I was quite recently, had moved here to Purdue. We'll call him Mr. Price. So I saw him in April of 2001, and he had purchased CIC hearing aids at another clinic, but he came in to see us for a second opinion and he was saying, his primary complaint was feedback in the right hearing aid, and he said he had been back to the other clinic several times, but the feedback was just persisting. So here's Mr. Price's audiogram, and as you can see again, it was a fairly typical sloping audiogram, and really mild to moderate, so not very significant. His word recognition scores were relatively good, and that's where he was. So now you'll notice that these graphs look very different from the ones we've

been showing you so far, because this was from 2001, and these were insertion gain measurements. Unfortunately at that time, I didn't do pre- and post-, so this is after our fitting. But regardless, the thick, solid, the thick line here is the target, and then the thin line is the actual measurement in his ears. So you can see that we were generally achieving pretty good audibility for him, or matching target for him almost out to 4,000 Hertz over there. I chose to take directly a quote from the chart note from that date which was April 18th, 2001, and say that, which says that, "Real ear measures indicated "that the feedback was caused by too much gain "at the high frequencies. "Programming was adjusted to reduce the gain "and alleviate the feedback." This was the student's note from that date. Mr. Price is now 97 years old, and he continues to be my patient. He, in fact, still drives himself to the clinic. So we're wrapping this up, hopefully, with emphasizing that real ear measures are not really a new or fancy technique. We have known about them for years, we have known about their effectiveness for many years. In fact, when I was finishing up my master's program, or when I was in my master's program, is when our clinic at that time where I was, we had just started dispensing hearing aids, and there we were with our, you know, some of you perhaps are familiar with our old Restronics real ear system.

So I've been doing it from the get-go, and I don't think I know how to fit a hearing aid any other way without real ear measures. I don't think I have ever fit a hearing aid without doing real ear measures. Yet even despite this and despite knowing their effectiveness, we continue to have fewer than 50% of clinicians using this evidence-based technique for successful hearing aid fittings. I'll add her that I have been leading a study abroad program to India, and now we have the primary institution that I partner with, has started doing real ear measures for their pediatric fittings. So because of my sort of, I don't know, dogged determination let's say, I've been there three times and I gave them a talk on real ear measures with cases, and they now purchased their own equipment, and they're fitting their pediatrics using objective verification. So I end by saying, is it time for us to make a change now? We're trying to make, or at least I personally feel like I've made a little bit of a global change with this institution in India,

but really, is it time to make a change now in the U.S.? So that concludes our presentation with the cases, and we will be happy to answer any questions that you would like to ask us now. I believe you have to type those in and we'll be able to see them as they come in. Thank you very much for your patience through the technical issues as well.

- [Christy] Wonderful, thank you so much. We're gonna go ahead and open up the floor for any questions or comments that you might have for doctors. If you could just let us know if it's pertaining to a certain case, just let us know the name of the case or maybe even the presenter's name that you are wanting to have it queued for, and we will get them in queue for them. While we are waiting for the questions to roll in, let's go ahead and do a fun poll. So we have a poll here. Hello everyone, while we're waiting for questions for our Purdue University experts, I wanted to go ahead and take a poll. The first poll is, we just wanted to see, how many of you perform real ear measurement in your clinic, and if so, how often? Do you do it on certain cases? We just like to know where you're coming from. Thanks so much.

- [Lata] So we're doing a couple of polls here of the audience, and the first question was do you perform real ear measures in your clinic? Looks like, based on this audience here, you are all very well versed with real ear measures, 'cause 83% have said yes, and 16% have said no, they don't do real ear measures. So for those 16%, we really hope that this was a useful presentation. We'll be happy for you to reach out to us if you, if we can be helpful in any way in terms of helping get set up or questions and things of that nature. Our second question here is, if you perform real ear measures, how often? I'm trying to look at the results here, but I'm having a hard time seeing those. So I'm not quite sure how to.

- [Christa] Hi Dr. Krishnan. In terms of the answers to how often, it looks like it's always.

- [Lata] Miss doing real ear measurements because it works. So they used to work someplace where they doing it, and now they're not doing it anymore, because they're not dispensing hearing aids. So that's a positive comment as well. I really feel like what we wanted to do with this is reach out to the people who are not doing the real ear verification and make a convincing or persuasive argument as to why it's important. So if anyone in that group has a question or needs some help. I don't know, what do you see?

- [Christy] Let's pull up a second poll. These polls are so useful because it just reiterates the findings that the presenters were discussing earlier, especially about real ear measurement and how many of us are doing it clinically.

- [Lata] Okay, so, so we have the results on a second poll question which is do you verify frequency lowering, and on this one, we have 75% saying no, and only 23% saying yes. I'm going to pass the mic over to Jill to see if she'd like to comment on that.

- [Jillian] I'm wondering if we can add to the poll maybe an open question about why you don't verify frequency lowering, because I do see the majority of participants are not. I will say, I used to be in that majority of being a clinician that was not consistently verifying my frequency lowering. So I'm hoping that today's presentation helped, if you feel like verifying frequency lowering is an intimidating thing, I hope you find some help from the protocols that were listed in those resources to feel more confident with your fittings.

- [Lata] Okay, hello. So we have a couple of questions that were typed in. One of them was in regards to, with the low-frequency hearing loss, how do you make sure that the low-frequency amplification isn't masking the high frequencies? That's a really good question. I don't think we do that using real ear verification necessarily, but we do that

behaviorally by testing speech and noise for example. So we could do like a BKB-SIN test, which is like a QuickSIN for pediatrics, and then the CAST, which was the testing that was done by the deaf and hard of hearing teacher at school. That's just done face-to-face in the classroom, and so something like that, or there's a functional listening evaluation which can be done in the regular classroom as well. Those would be methods to check to be sure that there isn't too much low-frequency amplification. I guess I would certainly also think about the fact that these prescriptive formulae have been evolved over the years, and surely that's a consideration that they took into when they were formulating those equations, et cetera. So that would be my answer to that question. Do you have anything that you would like to add, Jill or Jenn?

Okay, there was a second question about doing real ear measures with open fittings, and whether we should control for the sound bleeding out from the open fitting. I guess my answer to that is, we actually want to measure what's happening in the patient's ear, so we don't want to close the open fitting, and if we're using a vented earmold, for example, we don't close the vent, because the purpose of the real ear measure is to measure exactly what's happening in the patient's ear. So if there's too much sound bleeding, of course you'll have feedback, so you might have to adjust or take care of that, and then most important, I guess with an open fitting, is with the equipment that we use for the speech mapping, don't skip that equalization step, and remember that the hearing aid has to be muted when you're doing that equalization step. So that is essentially the calibration for the sound leaking out and potentially affecting your measurements in the ear. So that's the step, and it's, the equipment really prompts you to do that, but what you have to be sure is that the hearing aid is muted when you do the equalization step before you go on to the next step. So another thought that we just had is that perhaps with the RIC, you're not meeting the targets and you think that it's actually sound bleeding out, it may be that the RIC was just not an appropriate choice. In fact, I have actually had that experience multiple times with patients being fit with open fit RIC hearing aids at a different clinic. All I have done is add earmolds to

give them the low-frequency gain that they need. So add the earmold, and they get the low-frequency gain that they need.

- [Jillian] Okay, another question we had come in was about the calibrated S signal. if you don't have that in your verification equipment. That is accessible, the calibrated S and SH. I'm trying to find exactly where that's at, but the group that's working on the DSL method, so the Scollie, Glista group, they do have the calibrated S and SH on their website in a WAV file format. So depending on what verification equipment you're using, you could add that in. I'm not finding the source of that right now in my handouts, but I will add that as a link later so that you're able to find those calibrated signals.

- [Lata] We have another question which is do you incorporate these verification tools when teaching your students? The answer is yes, 100% of the time. So students, our courses, the graduate level course, the first hearing aids course covers this content, but then the course has labs. So the students do labs on not just sort of what we do in the clinic, but way beyond and much more. Then they start doing it on patients immediately thereafter. So if they're a second semester, first year, second semester student, they're starting to perform real ear verification on every fitting. I'll also add that in addition to initial fittings, I do real ear verification pretty consistently at reassessment. So if a patient's coming back two years, three years down the road, their hearing aids are still good, but we do their reassessment, and perhaps they only have five or 10 dB changes in their audiogram, but we've got to verify to be sure that the hearing aids are still providing them with the gain that they need two or three years hence. Then oftentimes on hearing aid check appointments, for, if patients have certain complaints, the only way I know how to address them is sometimes perform real ear verification to see what it is exactly that's making them have that particular complaint. Of course since ours is a teaching clinic on the university campus, we have a student with us for our appointments about 95% of the time. Okay, I just want to share another comment from a participant who said that his father was, his or her father was fit with

hearing aids at a clinic that didn't perform real ear verification and was very unhappy and went back and then now went to a different clinic where they did perform hearing aid, or real ear verification, and quote, his father is, "Happy as a baby eating cake." So thank you for that comment. Next question is how often do you schedule hearing aid checks for your pediatric and adult patients? So I think it varies. We have six clinical faculty in our clinic and it varies a little bit between us. I schedule for my adult patients, after the initial fitting, we have a hearing aid check in two to three weeks, and then depending on what's going on at that point, perhaps a second hearing aid check. Some patients, most patients that's all, and some patients need even a third appointment. Then subsequent to that for adult patients, I usually just say annual hearing aid checks. For our pediatric patients, when they're an infant, we see them every three months, every three months until such time as we have, when we start getting behavioral test responses that are consistent, then we maybe step back to six months, and then when they're school-age, five years old and up, I see them for a hearing aid check every six months and then an annual assessment. So basically I see them twice a year, and one time it's the full assessment and hearing aid check, and the second time it's just a hearing aid check. Okay, it appears that there aren't any further questions. I'm going to hand the mic over to Jill, because she's going to, she has a link that she might be able to help, share, that will help some people, and then we'll have some closing comments.

- [Jillian] All right, so back to the question that was asked previously about finding those calibrated S and SH signals. You can find that at www.dslio.com, and then through that website, you will be able to find those WAV files. Again, you can always contact your equipment manufacturer or representative to help you with that.

- [Christy] Thank you so much for everyone's participation in those polls. We're gonna leave the floor open for another few moments to anyone who has any questions or comments for doctors Krishnan, Dr. Simpson, or Dr. Hubertz. If not, I'll hand it back over to Dr. Krishnan for any closing comments. Thanks so much everyone.

- [Lata] So thank you so much everyone for signing in, listening, asking questions, being patient through the technical difficulties. One poll question I should have thought about was, how useful was this presentation or how useful was the information for you. I think perhaps it's too late at this point to do that, but I don't know if AudiologyOnline perhaps has a system for obtaining feedback from participants hopefully that will be shared with us. We really enjoyed preparing for this and it's always interesting to have cases to share. Generally, I save interesting cases all the time because we are in a university and we are teaching students, and so we're really happy that we got to share it with a larger group and a larger audience, thank you very much.

- [Christy] Thank you so much for your time and thank you to our experts at Purdue University. Doctors Krishnan, Simpson, and Hubertz, we thank you for your time and expertise in putting together this great presentation of various and difficult cases. I hope these examples will help you in your day-to-day practice, and to get you thinking out of the box clinically. It is clear the value of real ear measurement, and we hope this will give you the confidence to implement this with your patients if you are not already. We have listed the link to the resource in this Classroom that was provided by the presenters, but if you need it directly, please do not hesitate to reach out to us. If you enjoyed this course, we hope that you would provide your feedback as this is most valuable for our presenters when planning their next presentation. We are so excited to have this Grand Rounds series every year, and we hope that you'll tune in to our final Grand Rounds webinar which will be presented by the folks at the Pittsburgh Veterans Affairs Hospital Thank you so much and have a great day.