Managing Severe Hearing Loss

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- - [Don] Hello, everybody. This is Don Schum, I'm the Vice-President of Audiology at Oticon here in the U.S. And what I wanna do in this seminar is talk about managing patients with severe hearing loss. In the fall of 2019, we at Oticon have released a new line of power and Super Power products available to you as clinicians, and we think it's very important to really understand what it takes to be able to provide really good solutions for patients with this amount of hearing loss. At Oticon we have a long legacy of building excellent power and Super Power and Ultra Power products, dating back for several decades. And because of that, we have spent a lot of time over the years to really dig in to what this patient population is like, what their perception is like, what their needs are, what their preferences are. And we believe we build this into the products that we produce for them. But in order to get the most out of the products, we think it's really important to really understand a lot about what's going on with severe hearing loss.

So that's what we've done with this seminar. So let's go ahead and get started. We'll start with a discussion of learning objectives for this course. And the first thing that we will be covering is to dig deeper into the nature of severe, and to severe to profound hearing loss. Once you get down to that point of audiogram, things can be very different than patients with mild to moderate or moderate hearing losses and the difference is in the impact of this amount of hearing loss on perception is big. Or can be potentially very big for some patients. And so understanding the nature of these hearing losses to some degree, I think, is the first point to sensitize yourself to know that the fittings might be done a little bit differently. The second thing I wanna talk about is the way patients with this amount of hearing loss evaluate the benefit of amplification. Because they have this amount of hearing loss, because they might have very extensive damage, you might not be able to verify the impact of the fitting necessarily using the same sort of techniques that you would use with people for less, with less hearing loss. And because of that, you may feel like you're not really sure

what's going on. But patients with this amount of hearing loss can tend to be very specific about what they need or don't need from their amplification. So unlike a typical first-time user with mild to moderate hearing loss, who's just entering the world of amplification, and really doesn't know what to expect. When you talk about patients with this amount of hearing loss, the situation can be very different. Where they may have a long-standing history of what they, of using amplification, and then they may have some very specific ideas about what works and what doesn't work for them. And the criteria that they'll use to make a judgment of the value of a fitting might be different than a more typical sort of patient you would see. And then the third thing that I wanna do is to spend a significant amount of time walking through a few case examples that really put to test a lot of the thinking that we have put together around treating patients with severe and severe to profound hearing loss.

So let's go ahead and get started. This is the agenda that we will go through today. I won't spend time to read it line by line for you, but basically we wanna talk about the nature of the patient and the hearing loss first, talk about how we put together our line of Power and Super Power products, plus our new capabilities in the CROS area, and then get into, okay, how do you match these technologies to the needs of the specific patients, especially by going through some case examples. I wanna start with a discussion of why. Why do we need to do a show like this? And one of the reasons why I think it's important to spend the time to actually talk about severe hearing loss is that it, in my opinion, it's starting to become a little bit of a lost art. Back when I came up as a very young audiologist in the mid-1980s, when patients with severe hearing loss, almost exclusively wore acoustic amplification. That was really what the only option was. CIs, cochlear implants, were just coming into reality in the clinical marketplace. They were mostly research devices. They were not particularly, very sophisticated in terms of the signal processing that they do, definitely compared to the way they work now. And so, if you fit hearing aids, you fit a lot of patients with severe hearing loss, that was just part of our caseload at the time. As implants have become

more and more sophisticated, as the effectiveness of implants have been proven time and time again to be very, very sizable for patients in this hearing loss group, so many of these patients have moved into the range of using CIs. And so because of that, this idea of kind of being good at fitting patients with severe hearing loss, that's been a little bit of a lost art in our field. Now, not all patients with this amount of hearing loss can be implanted. That's part of the reality, is that sometimes the patient may choose not to be implanted. Maybe sometimes they have a medical condition that won't allow them to tolerate the surgery to be implanted. Maybe for some other physiological reason they can't be implanted, but they still need some help. So these patients are there. And they need to be treated. And so if they are evaluated and can be implanted, then there's every reason why that is a very good treatment option for them.

But since not all these patients can be implanted, we need to look at what some of the options are for those patients in the non-implantable segment. As I said, in the fall of 2019, we released some new products. Oticon Xceed, at the one, two, and three levels. Oticon Xceed Play, and our Oticon CROS or BiCROS solution. In the Xceed product family, we have both a Super Power, which is based off of a 13-size battery and an Ultra Power, which is based off of a 675-size battery. We have the same type of products, the same configuration in our Play line. And Xceed Play, that's our pediatric line. These products are physically, physically are the same size, they just have some different capabilities based on being an adult product or a pediatric-based product. And finally, we've released a CROS transmitter that's designed to mate with all of our products that are on the VLOCS-S platform and above. So that includes Open S, one, two, and three. Oticon Xceed one, two, and three. Oticon Play one, two. And Oticon Xceed Play one, two. So all of our products that we've released this calendar year in 2019 can now be compatible with our CROS transmitter. And we will spend some time in this show talking about that capability and how to make that up for patients. Now, if you want a full detail on all the products that we've released this fall, what I would do is suggest that you dial in to a companion show that is given by my colleague Kelly Stall

about our fall 2019 releases. And she will get into all the details about these products. I'm sort of assuming that you may have already listened to that show, or that you will listen to that show. So I'm not gonna go into the details of the products, but more really focus on how to use them to solve specific problems for cases, for specific problems that specific cases will present to you as a clinician. So let's talk about the physiology of severe hearing loss. And a few of the observations right away that I wanna make and that we'll dig into more is that the variability is very high. And because the variability is high in these patients, one of the first things that you have to basically accept if you're gonna fit patients with severe hearing loss is that you need a more adaptive fitting mindset. Meaning that just putting the audiogram in our Genie fitting software and getting some prescribed settings and putting those in the patient is not necessarily gonna be a solution for each and every patient. And that's true anytime you fit hearing aids, but when you're in the group of patients with severe to profound hearing loss, that variability, that need to make adjustments based on individual needs and preferences and perceptual performance is much greater.

And so if you're going to fit someone with that amount of hearing loss, you basically just have to accept the fact and get your head around the idea that you're going to have to spend more time in that fitting to perhaps search more and more to find the fitting that works well for that patient. It's important to recognize about some of the changes in the marketplace these days is the idea that oh, hearing aids can be fit over the Internet, they can be fit over the counter, all those sort of discussions that make hearing care professionals wonder about what their role is in the future. But when you are working with a clinical population like severe to profound, that's exactly where the need of highly trained clinicians comes into play. Because, because of the need to do a much of adaptive fitting, this isn't something that can happen over the Internet. This is not something that can happen over the pharmacy or over-the-counter at some big box store. This is the sort of thing where the clinician really needs to understand the nature of the hearing loss, the way the technology works, and really work hard to make

that, everything come together. The other topic that we're gonna talk about when we talk about the nature of severe and profound hearing loss is residual capabilities thinking, and I'll describe what I mean by that in a few moments because we're gonna talk about pirates. And it turns out that I'm recording this show on National Talk Like a Pirate Day, and that's actually a real thing, you can look it up. So it seems particularly timely that we talk about pirates on National Talk Like a Pirate Day. But, let's aside pirates for a few minutes until I cover a couple other topics. One of the things that we have to remember is that as audiologists, as hearing care professionals, and when we talk about patients, one of the first things that comes out of our mouth when we're talking from one clinician to another clinician about the patient is we describe the patient based on the audiogram.

Oh, I have this patient with this type of hearing loss or this amount of hearing loss. And I have this particular question, you know, dah dah dah dah dah. That's kind of the currency that we use, that's kind of the language that we use is we talk about the audiogram. And the audiogram is a reasonable, a reasonable look at a patient's hearing impairment, but it's only part of what's going on with that patient. Remember what hearing impairment is, it's a physiological change in the way the auditory system works. The audiogram is one reflection of that, but it's a limited reflection of that. And so understanding what could possibly or really be happening inside the person's peripheral auditory system is essential, especially when you're in this, dealing with this group of patients. And so understanding that it's a change in physiology and the change in physiology is gonna cause a change in perception, that becomes very important and a key to keeping in mind when you're dealing with this patient group. We talk a lot when we talk about hearing loss about hair cells. Inner hair cells and outer hair cells. And so much of our legacy in using multi-channel, non-linear products over the years as a field has been driven by a consideration of a model of hearing loss that pretty much just is talking about hair cell loss. About how up to mild to moderate loss, you're talking about mostly outer hair cell loss and not inner hair cell loss. Once you

get above about a moderate hearing loss, then you're talking about more inner hair cell loss. And then that's where the dynamic wave starts to change and you get all those sort of considerations going on. But when you talk about patients and you get down to severe and severe to profound hearing loss, it's important to realize that there's a lot of other things going on in the auditory system that could change, other than just hair cell loss. So, when you ask the question what else has to go right, there's a lot of physiology that has to be working right for hearing to happen. It's not just that the inner hair cells bend and fire and send a signal up the eighth nerve, but all the other supporting structures, all the other physiology that has to be going on to make sure that the inner hair cells can fire appropriately. Remember, the inner hair cells sit within a certain chemical bath. They sit, it's part of this two chamber system in the inner ear. And you have the different fluids in there. The endolymph and the perilymph. And they have to have different chemistries, the potassium and sodium content has to be different those in order to create the electrochemical environment that is necessary for hair cells to fire. Inside the inner ear, you have these membranes, you know, that have to be intact for all these mechanisms to work. You have stria vascularis over on the wall of the inner ear right over here providing blood flow to all the structures of the inner ear. And the inner ear is very sensitive to having very good, healthy blood flow in there.

So if the patient is dealing with any amount of restriction to there, it could really throw off the physiology. You can have an underdeveloped cochlea, where it's not having the right amount of turns in it to really fully process the amount of traveling wave that you need to have the full frequency bandwidth of hearing. You have to have nerve structures, you have to have this connection between the hair cells and the nerve fibers that lead into the eighth nerve and go up to, up into the central auditory system. Those have, all that structure, all that physiology has to be working right. When you deal with some of the etiologies that will cause severe or profound hearing loss, you could be talking about things that go well beyond just hair cell loss. Hair cell loss, in and of itself,

is not a good thing at all because those are this primary sensory fibers, the inner hair cells. But you could have changes in any other of these structures. You could have meningitis cases where you get ossification within the inner ear, you could have patients with long standing mender's issues, where you had repeated ruptures of those membranes. You've had fluid, the fluid chemistry within inner ear can be thrown off or you can have scar tissue on those membranes that don't allow the membrane to work in its normal manner. You can have a whole host of things that can go wrong in these ears, and they can all be part of the complication of the perceptual condition of these patients' ears. A couple things that I believe are key to keeping in mind when you're talking about severe and profound hearing loss, as I just said, multiple structures are involved. I think one of the other keys is how long they've had the hearing loss.

So you could have two patients with the same audiogram, you could have someone who's had that audiogram for 40 years and they started wearing hearing aids when they were a kid and they change their hearing aids every three or four or five years. And so by the time you see them as an adult, they could have had 10 sets of hearing aids on them. And the way their physiology works, the way their perceptual system works, the way they've learned to get information from that altered physiology, can be very different than someone who, let's say, had a sudden or rapidly progressive hearing loss, and now they're left with a severe hearing loss, poor word recognition, with this very recently disrupted auditory system that's been disrupted in some sort of unique way for that patient. That could be a very different listening experience, a very different perceptual experience, for that patient. And so the audio, there's a very good example where the audiogram doesn't tell you everything you need to know. Okay, let's talk a little bit more about patient performance. And as I said, there's a lot of variability when you talk about this group of patients. This is data out of Holland back in the '90s. And what they did is they took a look at speech discrimination score, word recognition score, as a function of average hearing loss measured in quiet. And so, when we talk about average hearing loss, this is average of 5.12. And one of the things that you

notice is when you measure speech understanding or word recognition performance or speech discrimination performance you need quiet environments, but up to or through about a moderate hearing loss. So up through, let's say 60 dB, 65 dB. There's not a lot of variability in patients with this amount of hearing loss in terms of their core speech understanding performance in quiet. You can see some variations, but at least in this data set, you see all the patients with that up through moderate hearing loss be somewhere at 80 percent or above. Well once you get above let's say 70 and you're in the 70 to 80 dB range, then you see the variability go way up. For example you have this person here who has an average hearing loss of around 90 dB who has a speech discrimination score better than 90 percent. Whereas you could have another person with the same average hearing loss way down here at about 10 percent. And the hearing loss, the performance is all over the board by the time you get into the severe hearing loss category.

And I think that this is a very good reflection of that, the fact that the audiogram doesn't tell you everything you need to know about the altered physiology. There could be a lot of different things going on for these patients, depending on the etiology, depending on how long they've had the hearing loss, depending on how the structures, the remaining structures are working, such that you just don't know how well that system's gonna work until you actually test it. And you can test it using on your headphones in your booth and get an idea of what their perceptual performance is, but also more importantly, it depends on what they're gonna get out of their hearing aids and what sort of adjustments they're gonna need, and what sort of absolute performance they can get out of their hearing aids, driven by the fact that each and every one of them is gonna have a different physiology that they're left with. This is similar data, but this is for speech understanding in noise, so this is using the QuickSIN. This was measured by Pam Souza, back about 10 years ago or so. So she tested a group of patients with mild to moderate hearing loss, and those would be in the blue dots, and then a group of patients with severe hearing loss. And again, what

you see, now that you move into noise, you see a little bit more variability in the patients with less hearing loss, but you still see a much greater range of variability when move in the severe hearing loss. So whether you're looking in quiet or you're looking in noise, variability is one of the big keys in understanding what to expect out of this group. One of the cues that humans use to understand speech are temporal cues. There are two, there's two fundamental cue sets that we use when we're tracking speech. One is spectral cues or frequency cues. Every phoneme kind of occurs in a different frequency region, but there's also temporal cues. And temporal cues are the rhythm of speech. The super-segmentals. The phoneme to phoneme differences in level. The way even within a phoneme, the level may go up and down and change over time. Frequency cues or spectral resolution is one of the first things that goes when you have hearing loss.

You just, your ability to tell the difference in two different, in the frequency of two different sounds is one of the first things that gets affected by sensorineural hearing loss. And that's usually thought to be related to the fact that as you lose outer hair cells, which is one of the first things that happens in mild to moderate hearing loss is that you start losing the fine-tuning of the inner hair cells. And that seems to be what the job of the outer hair cells is, is to modulate and sharpen the tuning of the inner hair cells. So that's one of the first things that goes. So what ends up happening is as you lose frequency resolution, you have the tendency to then focus on the cue that still works well for you, and that's temporal cues or temporal resolution. Temporal resolution is a more robust skill set that seems to be a little bit more resistant to loss when you have hearing loss. But eventually you can lose all your temporal resolution, too. And so you talk about people with classic profound hearing loss as corner audiogrammed, even temporal resolution might be very, very poor in those patients. But in this range, especially for patients with severe hearing loss, they probably have shifted their use of cues in speech much more towards using temporal cues and not frequency cues. And the reason why that's very important is that there's a lot of things

that we could do in non-linear hearing aids to disrupt temporal cues. 'Cause remember, what is the job of a non-linear hearing aid is to change the amount of gain you apply to a signal based on its input level. Well if you have a lot of speech, which changes in level all the time, if you are too aggressive with the way you use compression, especially faster-acting compression, by design what you're trying to do is get rid of temporal variations in the signal. But that could be a primary cue set for someone with this amount of hearing loss. And so I'll talk about the design of our new Super Power product Xceed and Xceed Play, both in Super Power and Ultra Power, where we specifically have done some things in those products to try to preserve the temporal information in the speech signal. As promised, given that it's National Pirate Day, I wanna talk about pirates, and so you can give an R.

Now, if you're listening to the seminar and there're other people in your office or in your home or on the train with you, you probably wanna do it in a little bit of a soft voice because you don't wanna stand out too much. But the reason I wanna talk about pirates, is I want you to think about what it takes to put a peg leg on a pirate. So let's say the pirate's been out on the Seven Seas and had a run-in and he loses a leg. So your job is to get a peg leg for the pirate, and because he's a pirate, you don't wanna screw up your job because you'll be walking the plank. So you wanna do a good job. So how would you go about fitting a peg leg to a pirate? I want you to think for a moment about that. And probably what you'd do is have the pirate lay down and you would measure the length of his good, remaining leg and you would measure the length of the leg that has been attacked, and you would find out the differences, right? And then you would cut a piece of wood that is equal to the length of the difference between the fully intact leg and the leg where it's missing a part of it. That's the way you would fit a peg leg. There's not very difficult to do. It's a pretty straight-forward process. But I want you to think about whether or not that's the way prosthetic devices are fit these days. And the answer is, of course, no. When modern prosthetic devices are fit to a patient, there's a very big focus on not necessarily just what is lost.

Obviously you want to replace what is lost with something that's the right length, right? You don't want the person tilting one way or the other. But much more fundamentally, these professionals will look at the remaining physiology that the patient presents. So that patient, let's say the patient has lost half of a leg due to whatever, that patient still has some bone structure and some muscular structure, and now there's even some neural structures that can be tapped into in order to create a good solution for the patient. So, very much the thinking is what we refer to as residual capabilities. That the job of somebody fitting modern prosthetic devices is to understanding the remaining physiology that the patient has and figuring out a way that you can use technology to get the most out of that remaining physiology.

Because that leg is not coming back. We're not regrowing legs, right? We are using technology to allow the patient to get back as close as possible to normal function with the remaining physiology that they have. Now, I want you to think about how we fit hearing aids. And I want you to think about, what is the only measure you really have to make in order to fit a hearing aid? And of course, that is the audiogram. And what is the audiogram? The audiogram is a measure of how much leg the person has lost, right? The audiogram is a measure of how much the sensitivity levels in the ear have changed. And that's something you need to know. Like I said, you need to know how much pure tone hearing loss a person has because you have to be able to compensate for audibility. But as I said earlier, the audiogram is not a complete description of the remaining physiology that the patient has. And when you're talking about patients in the severe to profound range, that remaining physiology is very important. That's what we get to work with. I think it's very important for all hearing care professionals, especially when you're thinking about severe to profound hearing loss, to really use this residual capabilities way of thinking. To remember that we are trying to figure out how to make best use of the remaining physiology that the patient presents. Because we can't regrow hair cells. We can't make the peripheral auditory system work in a normal way anymore. It's broken. The hearing that the patient has when they walk in

your office is the hearing that they have when they walk out of the office. What we do is get to change sound in such a way that the remaining physiology that the patient has can get the best use out of that sound. We can't change that remaining physiology, but our job is to get the most out of that remaining physiology. And to me that's a very good mindset to have when you're talking about dealing with patients with severe to profound hearing loss. Okay, let's then talk about how a patient will judge the value of a hearing aid, especially patients with this amount of hearing loss. And I think the only thing that we know for sure is that for a patient to make a judgment that the fitting works well for 'em, it has to be on a dimension that's meaningful to the patient. When you talk about patients with this amount of hearing loss and you think about the amount of variability that they show, you really are not sure what they could possibly get out of their remaining hearing.

And because of that, the patient will tend to be the driver of telling you whether or not the hearing aid fitting is doing anything worthwhile for them. Sometimes, it'll show up in a standard audiometric measure like speech understanding and the sound field and quiet or noise, which is something that a lotta clinicians would then be very comfortable with. But sometimes you may not see a change or improvement in that level because perhaps the patient's auditory system is just so compromised that speech understanding without visual cues is just not something that they're ever gonna get. But the patient might have judgment based on their ability to identify environmental sounds or the idea that they can combine the auditory signal with visual cues or a lot of other dimensions that might not necessarily fall in a standard clinical practice. And these patients, especially these patients who've had this hearing loss for a long period of time, they can be very, very specific about what they feel that they need out of hearing aids. In fact, one of the challenges about dealing with these patients is when you try to change the hearing that you have on them, sometimes they get very resistant to change because they have everything that they hear comes through that hearing aid, and they're very dependent on the auditory signal that they

get through that hearing aid. And if you do anything to change the sound of that hearing aid, they can become very reactive to it. It used to be a big, big issue when we moved into the era of multi-channel non-linear, to take patients who had longstanding, just very powerful linear hearing aids, and move them into a non-linear fitting. And those transitions could be very, very hard. That's become less and less of an issue these days, but I just got an email from one of my colleagues yesterday asking for my advice on how to help a patient who has one of our more powerful, old products from 16 years ago, who's in the severe hearing loss range, who's having trouble adapting to the new Power products. And it's like, you know, that's a classic sort of example where a patient will get so locked in to a sound quality that they're used to hearing that moving them to a different hearing aid can be very difficult. And so part of this adaptive thinking that I think you need to have in terms of the mindset of dealing with the patient is understanding that these criteria can be different. Here's a list of some of the criteria that could matter to patients, especially in this hearing loss group. And there's gonna be a lot of different things that could be, really, the key to what they will use to judge the hearing aid fitting.

And so if you have a very strict protocol in your facility or in your mind about what has to get better for the patient to be a successful hearing aid user, I think when you're dealing with this group, I think you have to kind of loosen up those reins a little bit because sometimes what is important to the patient might not necessarily strike you as a clinician of the immediate sort of dimension you would think of as being most important to judge the criteria of a good hearing aid fitting. Okay, I wanna talk a little bit about how we put together these products. Like I said, I'm not gonna go through a whole description of the products that we've released because there is a separate show on AO to do that, but I just wanna point out a couple things about the design to help further this discussion about getting good fittings for patients in this group. And one of the things that we've done and we've done this for a number of years, several generations of Super Power products, is to have a specific fitting rationale designed

specifically for patients with severe or severe to profound hearing loss. And we call that fitting rational DSE, which is called dynamic speech enhancement. And it's designed specifically to help patients with severe or severe to profound hearing loss to get what they need out of the hearing aid. One of the things that happens with these patients if you don't have a lot of experience in dealing with these patients, is you've gotta get the loudness correct. These patients have a lot of hearing loss, and especially if they've had a history of use of linear hearing aids. They oftentimes get very tied to a certain loudness perception out of the hearing aid. You gotta get enough loudness out of the hearing aid. In the early day when people started trying to use multi-channel non-linear hearing aids to fix severe hearing loss, they failed. And they failed because they typically were using a lot of fast-acting compression. And when you use a lot of, especially fast-acting compression, you can really muddle the signal.

And for patients with severe hearing loss who really needed to hear that punch out of the signal, they just weren't getting that. The second issue is you need to try to give them whatever audibility you can. And so one of the reasons we very much try to use non-linear with patients with this amount of hearing loss is to try to get what we can to fit in the remaining dynamic range. But you have to do that in a very careful way in order for it to work well for patients. And the third point is the point I made earlier, is that you wanna make sure that you protect temporal cues in the signal because like I said, these patients typically have very poor frequency resolution. So you wanna make sure that if they've kinda shifted their perception to really be dependent on temporal cues that you do the best job possible about, the best job possible in protecting these cues. So if you kinda take a typical sort of non-linear approach to treating patients with severe hearing loss, because these patients typically have a relatively reduced dynamic range, in most cases, not in all cases, but in most cases, then there's this tendency to try to give them too much compression. You're trying to get a lot of sound to fit in that remaining dynamic range. And because of the resolution of their system, because of what they've grown up listening to, because of the need for loudness, that just might

sound like too much of a muddled signal for them. So what we do with DSE is we try to make sure that moderate speech inputs are presented within the patient's dynamic range in a more linear fashion. And here's a case where linear is good. Okay, when we talk about linear, you need to differentiate between linear as an engineering term and linear hearing aids as an old technology. Linear hearing aids are an older technology. But the idea of being linear, in the engineering context means that the output of a system directly reflects the characteristics of the input. Meaning that the speech signal, there's a lot of information embedded in the speech signal, especially in the temporal cues, like I said. And you wanna make sure that if you, you wanna process that information in a linear way so that those temporal cues are maintained. Like I said, compression can minimize those temporal cues. And so what we do is instead of trying to get the entire dynamic range of speech to fit within the patient's dynamic range, we do the best job possible of making sure that moderate speech is presented in that remaining dynamic range in a very linear fashion.

And the idea being, then moderate level speech is what the patient listens to most of the time. And so we wanna make sure that most of the time they are getting a signal that really works well for them. If they happen to be in a softer sound environment where someone's using soft speech or they're a little bit different from the patient, these patients will then just have to turn it up using a volume control wheel. But remember, they're very experienced hearing aid users often. They typically don't have a problem with making adjustments on the fly. They're used to being able to have to do that. And so you don't wanna sacrifice and use a lot of compression because you don't want the patient to ever have to touch the volume control. That's just unreasonable with these patients. It's hard to get that point in time. But if you tend more to think about it in terms of protecting moderate level inputs, then you can get a sound quality out of the product and a perceptual effect out of the product that could be much more effective. The way we do that with DSE, is that you take a look at the primary knee point. So, in this case, this is the primary knee point of the product is around 65 dB.

For most multi-channel, non-linear hearing aids on the market, especially our products like OPN-S one, and two, and three, and other products that we've had on the market, we typically have that primary knee point down around 45 dB or so. 45 dB SPL or so. With severe to profound hearing loss, we move that primary input up to around 65 dB. And what that allows us to do is to take the full dynamic range of moderate level inputs, and that goes from about, oh about 30 dB up to about 60 dB. So this gray area is the dynamic range, the speech banana of moderate level inputs. And by moving the primary knee point up to 65 dB, then that full range of moderate level inputs still falls within the linear part of the input-output function of the hearing aid. And so we accomplish that linearity for moderate level inputs by moving that primary knee point up. We then set the gain for louder speech. So this area between where the gray area ends and where the blue area ends are the upper level, the peaks of louder speech. We move those peaks up right to the, right below the MPO of the hearing aid. And so we do the best job we can of getting as much extra room out of the patient's dynamic range and put the louder speech levels up there.

But patients are not in really loud speech as often as they are in moderate speech. Nowhere near as often. And so we do have to use compression there, and so we have a non-linear section to the hearing aid, but it's a relatively short compared to what we would do for patients with mild to moderate or moderate hearing loss. And so it's a very specific fitting rationale, like I said, we call it DSE or dynamic speech enhancement. And it's specifically designed to give the perceptual treatment that patients with this amount of hearing loss typically need. Another feature that we have in all of our products, and becomes very relevant in the power and Super Power products, is we have our approach to frequency lowering, and we call that speech rescue. And the idea being that if you had, you know here's the phonemes in the typical speech banana, and here's someone with severe hearing loss, and the idea being able to have enough gain in the very high frequencies to make those signals audible, that's a little bit tricky. Of course, you know, it's just physically very difficult to

do that. And so we do have frequency lowering available. We use a frequency composition approach. And when we use frequency composition approach, we contrast that very significantly to frequency compression. With frequency compression, you're taking the full bandwidth of the speech signal and you're basically squeezing it down into the mid frequencies. With frequency composition what we do is we identify certain frequency areas up in the very high frequencies that are most likely to be inaudible for the patients and we replicate those areas down here in the mid frequencies where they can be audible. But when we do that, we don't get rid of the very high frequencies, because you never know what the patient might potentially be able to get out of that information. But the idea is that we wanted to take that information up there and make it available in the better functioning, and at least more audible, mid frequencies. And we call that approach our frequency composition. We've been using now for several years in products. It's available in almost all of our products, but we don't really necessarily see a big use for it until you get it down to this amount of hearing loss.

And so, and again, the idea is to try to use a more gentle hand in the way we treat the speech signal. Again, we believe that there's a lot of very important information embedded in the speech signal in a natural way, and we don't wanna do anything that's too dramatically disruptive on that speech signal. And so our approach to frequency lowering is designed to be a much more gentle hand of doing frequency lowering. Okay, now that we've talked a little bit about the way we put together our power and Super Power products, let's talk about triaging patient needs a little bit. Trying to understand which products make most sense for patients. Here's a partial list of some of the things to keep in mind. And it's not just the audiogram. Of course the audiogram matters. You need to know what the audiogram is 'cause you're gonna want to make sure that you're providing enough gain to make things audible, et cetera. But there's a lot of other things that could affect the way the patient's gonna respond to amplification. And here's a partial list of what those other factors could potentially

be. As I go through the cases, I will touch on each of these other factors and how they could possibly impact the way you're thinking about using the range of devices we have to do fittings. So let's talk about our devices a little bit. This gives you the fitting ranges of our miniRITE line of products. So the OPN-S one, two, and threes. And one of the things I wanna point out is that because they're RITE products and you can change the speakers, we have different speaker levels that you can put on the 100 and the 105 speaker levels. And what's important to notice is that this gives you a pretty good working dynamic range. You get down to 100 or 105, which is why the speakers are named that, as you might have guessed. But the point being that we already have products in our product line that can work on some of those patients who are just kinda getting in to the severe hearing loss range. And the reason that's important is that, well one of the things that is very important to patients these days is to have rechargeable hearing aids. So our miniRITE R is our rechargeable hearing aids. And if they have thresholds, let's say down in the 75 to 80 dB range, you might very well consider using the miniRITE products instead of going right to the Super Power products because you could still fit those patients.

Now part of the decision making is going to be on how stable you feel those thresholds are. If they've that audiogram down at 75 or 80 for 10 years, and you think there's nothing about their etiology that would expect them to move, then you do have the capability of getting that amount of power out of a 312 size miniRITE product. And that sometimes is one of the subtle little things that sometimes clinicians forget is that these miniRITE products, although they're small and sleek, they also can have a significant amount of power, if you put the right receiver on them. So that's one thing to keep in mind. We also have had a BTE. A BTE-SP, that goes, I'm sorry, these are the, oh yes, these are the BTE fitting ranges. And what you notice is with our, hang on one second. I wanna make sure that I'm being very accurate. No, I'm sorry, these are the fitting ranges for the new products that we have. Our Super Power and Ultra Power products. What I forgot to show you, what I forgot to show in slides is we also have a BTE power

plus that goes down to about the 105 level. So we do have a little bit smaller body size for the BTEs. But these are the fitting ranges for the Super Power and Ultra Power, the new Xceed product line. And what you see is that they do go down to 110 or 120 in terms of fitting range. So they do extend the fitting range significantly compared to what we have the miniRITE line, and so not all severe hearing losses are the same. You can have someone with a severe hearing loss with kind of like, flat 75 dB, 80 dB hearing loss, and that's gonna be very different than somebody who has thresholds at 80 and 90, up to about one K, and then drop down into the 100, 105 level. That's kind of a different class of severe hearing loss. And so taking a close look at the audiogram and understanding how stable you think the audiogram is gonna be is important. This, what you see now here on the screen are the, the SPL output for, maximum output of the products and the full-on gain for the products. And this happens to be for the Ultra Power products. And what you see is those peaks jumping up at one K at a very high level. When you build Super Power products, in order to get that loudness punch that, especially the people with severe to profound and profound hearing loss needs, you really need to be focused on getting that one K peak right. Because so many of these patients have grown up wearing linear based products that have that very strong one K peak. So in order to get very good maximum output levels and maximum gain levels, you need to make sure that typically that gets down in that mid-frequency one kilohertz range. Because before you do anything else, you have to make sure that you get the loudness right for these people as I have said before.

And so that's why the shape of the frequency response looks as it does, and what you know is that when you're dealing with receivers that can give you that amount of output at one K, you're naturally gonna see a roll off in the high frequencies. And that's why I think it's important to really think carefully about whether or not you wanna be using the RITE product line or the power plus product line versus going right to the Ultra Power, Super Power products. Because you have a different type of frequency response when you're dealing with that amount of gain and output in a hearing aid. So

just something to keep in mind when you're kinda trying to size up your patient compared to the fitting range that's available on the product. It's not necessarily just their thresholds that you have to consider, but it's kind of the whole picture of what you expect out of these patients. If they have some usable hearing out there in the high frequencies. Let's say maybe out to two or three, or even four kilohertz, you wanna make sure that you're picking the right product to get as much as you can out there in the higher frequencies. Oftentimes when you're dealing with patients with severe and severe to profound hearing loss, the idea of getting any audibility out past about 1500 or two K is just pretty much unreasonable that you're gonna get any good audibility out there. But like I said, if you're talking about somebody with maybe 80 dB thresholds, 80, 85 dB thresholds out at two K and three K, or maybe even four K, then the idea of getting audibility out there is kind of, sort of back in play. And so you don't wanna rule that out too quickly. Another product that we did release this fall is our CROS. Our CROS transmitter. And as you know, the CROS transmitter is designed to take, you know, when a patient has a dead side to their hearing, is it takes sound coming in that dead side and send it over to a hearing aid over on the good side.

And this hearing aid in a CROS set up is just basically passing the signal through without any additional gain, other than just overcoming the insertion loss of using that product. In a BiCROS situation, of course, that hearing aid functions also as a hearing aid for the hearing loss that the patient has on that side. The, many hearing care professionals have strong opinions one way or the other about using CROS. Some use it a lot, some typically have found that they don't feel there's a great need for it. They just, you know, they've had trouble getting patients to really accept it. And that's really up to you as a clinician about how you wanna see CROS. In general, it feels to me that the acceptance of CROS on the part of the patient will come down to the perceived need on the part of the patient. Whether they feel that they're having so much listening difficulty that they're willing to wear devices on both ears in order to defeat the head shadow effect. I do wanna talk about asymmetrical hearing loss a little bit right before I

get into the case examples. And the thing about asymmetrical hearing loss is that it's important to remember that perceptually what we're going after is trying to have a single, unified image. And that single, unified sound, perceptual image you get from the patient, that's almost always takes place. Occasionally you'll have some sort of disjointed, sort of signal, and that is usually extremely, extremely disruptive for a patient. So when we're talking about getting a good fitting in someone with severe, with asymmetric hearing loss, it's about trying to get to that single, unified image. And that can become very tricky when you talk about some of these cases with asymmetrical hearing loss. And the reason I bring that up is that it relates to both the idea of fitting CROS, but oftentimes when you talk about patients with asymmetrical hearing loss, they've had, based on the nature of their etiology, they also may have a loss of, they might have severe hearing loss. You know, it's just the nature of the way these things work out. You can get asymmetries for patients with moderate hearing loss, of course. But a lot of the etiologies that create significant asymmetries often create significant threshold loss.

And so I oftentimes will talk about asymmetries at the same I'm talking about severe hearing loss because there's a lot of crossover between the two. When you talk about asymmetries, it's important to remember the type of asymmetries that are out there because you have the situations where both ears need hearing aids, but just one ear is functioning better. Then you have the situation, the kinda the classic CROS situation where you have one ear that's absolutely normal and then one aidable. I'm sorry, I'm sorry not the classic CROS where you have a dead ear and a normal ear. That's not on the screen. But then you have one dead ear and one aidable ear, the kinda classic BiCROS situation. And then you have this idea, one normal ear and one aidable ear. And that is trying to create a good solution for those patients can also be one of the more tricky sorta situations you run into. One of the things that I wanna point out is a basic observation about the decision to recommend CROS or BiCROS. And basically when you make that recommendation to a patient, you have basically told them that

your ear, your poorer ear is totally unusable. We're gonna bypass that. We're not gonna put sound into that ear. Any sound that occurs on that side of the head, we're gonna move over to the other side of the head. And so, you know, that's the basic idea behind CROS. But I think it's very important to remember that that is the assumption that you're making. Because the one thing that I believe is true in this area, is that I think there's a lot of clinicians who will make that judgment before they can really be sure. I wanna give you an example. So this is an example out of the literature, Feldman and Oviatt, back about 20 plus years ago, where they had this patient with this sloping hearing loss in the left ear who had a history of using amplification on that ear. And then the patient had this flat, severe hearing loss with no measurable word recognition under headphones on the right ear. And supposedly this patient had never been given the opportunity to wear a hearing aid on the right ear. They had only been wearing a hearing aid either on the left ear or a BiCROS set up. But these patients decided that since they really didn't know for sure, they wanted to see if that ear could participate at all in terms of perception, even though there is no measurable word recognition under headphones in that ear. There's a lot of clinicians out there who simply would not have tried that. But these clinicians decided to give it a shot.

And it turned out that these are the aided results both in quiet and in noise wearing a hearing aid only on the left ear, and then wearing bi-neural hearing aids. And one of the things that you notice is a significant improvement, both in quiet, and especially in noise, by adding a hearing aid to that ear that otherwise was considered to be unusable for the patient. And to me, it only takes one good example to make the point that you really don't know an ear is unusable until you actually put a hearing aid on that ear. And so when we talk about some of these case examples in a few moments and you talk about the idea of using CROS or BiCROS, I think it's absolutely essential that you don't get locked in to some sort of decision making criteria or matrix that you might have to say, oh I just don't believe that ear is usable. Because if this ear was usable, then there's probably a lot of ears that have never been given the opportunity

to use amplification out there that are also potentially usable. All you lose is a little bit of time. Fitting a hearing aid on an ear that is very questionable, all you're losing is time. It is a totally reversible solution. It's not like you're implanting and everything. It just takes the time to give the patient maybe a week or two of trial use with a hearing aid to find out if there's anything that you could potentially get out of those hearing aids. Out of that ear. Hearing aids on that ear. In a lot of these cases of asymmetries, you'll end up wanting to fit two ears, but you don't necessarily have to fit two ears at the same time. And one of the techniques that I've found to be very useful is that when you're dealing with significant asymmetries between two ears, that you might consider fitting the hearing aids on different days. The reason I suggest that is that if you have a significant amount of asymmetry between the ears, and I'll give you an example in a few moments, that you might find that you know that that ear is gonna be the dominant ear that the patient listens thorough. That's gonna do the heavy lifting of perceptual tasks for that patient. The other ear might be useful, but you definitely don't want the other ear to compete with that better ear. So one technique that you might find is to really fit that better ear first and get a really good fitting. Give the patient maybe a week or two to get used to that fitting and then add the second ear. Because then, you kinda decrease the amount of confusion that the patient might develop in terms of what they're hearing. If you take two hearing aids and put them on a significantly asymmetrical auditory system and the patient doesn't like the way it sounds, the patient might have a really hard time of deciding exactly what it is about the sound that is really throwing them off and that they don't like. But if you fit the better ear first and then the poorer ear, you can kind of improve the decision making process for the patient. They won't get quite so confused about that. So it's just a technique that you might consider. And when I walk through these cases next, you'll get some ideas of how that could be applied. So let's take a look at a few cases. We already walked through this case where we talked about the idea of not giving up on an ear just because it has a lot of hearing loss and there's a lot of asymmetries, and I think that's a very important aspect of thinking about these cases when you go through that. Like I

said, there's a list of issues to consider. It's not just the thresholds, but it's a lot of the other aspects that are going through that will affect the way you think about doing some of the fittings. So let me give you a few cases and just give you some of the ideas that I have about how you might approach these cases. So the thing about it, is that there are clear candidates for Super Power and Ultra Power, without a doubt. Patients with audiograms down in the 90 dB range, where you just need to get a lot of power into the ear. And then clear candidates for CROS, someone who's had an eighth nerve resection on one ear, who has a lot of listening needs who wants to be able to have sensitivity to that truly dead side, then that might be something where there's a clear candidates. And there are clear candidates for BiCROS. Patients who have that truly dead ear on the one side and need a hearing aid on the other ear because that's the only ear they listen to and there's a lot of hearing loss. But there's a lot of gray areas, and some of these cases that we're gonna be seeing will show up some of those gray areas. So here's a patient who came in with this kind of flat, severe-ish hearing loss. Limited dynamic range, as you can see. And the patient is 24 years old and been wearing hearing aids all her life. Her last set of hearing aids was 10 years old. And everything seemed to be loud and rackety.

And the solution for this patient was to move this patient from a primary linear hearing aid into a multi-channel, non-linear hearing aid. Because this patient, given her age, and given the fact that her, the resolution in her auditory system, it's still reasonably good. 54, 58 percent word recognition with those amount of threshold loss. I mean, there's still some usable hearing going on in that ear. But moving that patient into a non-linear hearing aid is really what worked for that patient. Because the patient basically was fit in the past with more of this, there's a lot of threshold loss, and so we have to put a lot of power into that ear. And that was considered to be loud and rackety for the patient. She said when she was younger she had, she was the type of teenager who didn't wanna use her hearing aids, and if it was just because she was just getting a lot of linear power out of the hearing aid that was too much for her, that

was what was going on. But it, to me, the tip-off in this case was the very low UCLs in those ears that she just really needed a multi-channel, non-linear approach. And so this would be a case where perhaps, even some of those RITE products these days would still make sense for that patient. One of the questions is whether or not you wanna fit Super Power or Ultra Power on patients. Remember Ultra Power gives you about 5 dB more gain in output than you would get with the Super Power. And to me, one of the keys in making that decision comes down to what happens above one K? So for example, in this case over here on the right side of your screen in the blue audiogram for the left ear. You see this drop off above one K, and to me, it's probably pretty unrealistic to think that there's any reason to provide much amplification up here in this region. The threshold to support it's even unmeasurable at four K. Whatever is out there, even if you can establish a threshold, it's probably very, very limited residual capability in that ear. And so this would be a patient where you kinda shift into this low-frequency, dominant, classic Ultra Power fitting. I think that can be contrasted quite significantly to this patient where you see measurable, reasonable thresholds out here. All the way out to four kilohertz. To me, this region from one kilohertz to four kilohertz is the key. But you can probably reach that with a non-linear approach with patients and probably give them some good speech recognition.

So this is probably more of a Super Power type loss. Or Super Power type fitting where you really are still thinking that there could be enough good resolution in that hearing to get some good speech perception up in that mid- to high-frequency region. And so just don't let the thresholds jump you into, oh I need to get as much power as I possibly can. Because you can easily kind of overpower these losses and not really pay attention to the fact that you might wanna treat that more classically, like a moderately severe hearing loss, where you can't expect something out of the mid- to high-frequencies out of a ear like that. And again, keep in mind the fitting ranges of these products that you're not getting quite as much fitting range out of the Super Power than you are with either, than out of the Ultra Power, but you could still get

some reasonable gain out of those products to reach those hearing losses. Here's a classic patient to wear CROS. This is a patient that I saw where I fit a CROS. And the reason I fit a CROS for that patient is he had a high demand on his hearing. He was a police officer in a small little town in Iowa and he was allowed to continue at his job as long as he wore his hearing aids and he really felt a better sense of security wearing a CROS transmitter on his unusable ear. I tried that ear. There's just nothing I can get out of it. And so I fit him with a CROS and he was happy with it because at work he just felt more secure having the sensitivity off to his left side that he felt that he needed to feel good doing his hearing. One of the things about kinda classic CROS fittings that I would have you consider is the way hearing aids work these days, CROS hearing aids, definitely our CROS hearing aids, is that you fit the transmitter on the unusable side and it goes to a regular hearing aid over on the usable side. And even though the patient might have quote normal thresholds, that doesn't mean that they wouldn't appreciate a little bit of mild high frequency gain over on that ear. 'Cause remember, everything they hear is only going through one ear.

And even though they're getting sounds transferred from their dead side or their unusable side over to the usable side, they're still at an auditory disadvantage. And as long as the hearing aid is over and it's a hearing aid it's over there, there's no reason why you can't experiment with giving a little bit of mild gain in the mid to high frequencies just to see if the patient likes that little bit of extra audibility over there to get some sense of sound coming in that ear. And some sense of communication effectiveness that's improved by giving a little bit of mild high frequency gain. There's no perfect place where speech is supposed to fall in a dynamic range. So this idea of giving gain in the presence of normal hearing thresholds, think about it when you're driving down the road in your car and you're listening to the radio and then there's an announcement that you wanna really about concert tickets or sports scores or something like that. What's the first thing you do? You turn it up a little bit because you really wanna hear what's going on. And so you might think of it, what I refer to as a

mild BiCROS fitting in this patient, because they might want that little bit of extra audibility up there in the high frequencies. Okay, couple more case examples before we wrap things up. Here's a patient with a classic BiCROS, or I'm sorry, there's a patient who some clinicians might immediately think BiCROS. They may take a look at those thresholds and say, I could put a hearing on there, but oh, look at that word recognition, eight percent. That's an unusable ear. This patient wore a hearing aid on that right ear. I fit a patient, this patient with a hearing aid on the right ear and she did fine. Getting this mixture of this hearing aid on the poor ear with normal hearing on the right ear was a little bit tricky, but we were able to find that and basically ended up not having to give as much gain on that right ear as originally the thresholds would have called for in order to get that mix of the normal ear with this amplified ear. But the idea that eight percent word recognition means that the ear is unusable, that's simply not, that was not tenable. And so she was a very successful hearing aid user because she had high demands on her hearing. Here's another case of asymmetry. Just a kind of a classic not BiCROS situation, but just a classic two hearing aids on the same side.

The thing about this patient is even though the thresholds in this right ear are still within the range of let's say a RITE product, the etiology was unknown and was a little bit unstable. And so one of the things you might be a little bit concerned about is that if you fit, let's say a RITE product, and those thresholds drop anymore, that now the hearing aid might be underfit for the patient and under powered for the patient. So this is a patient where you might think about maybe going to the Super Power product simply to protect against any further drops in the thresholds. That is totally dependent on what you think the etiology is and what you think the future for that patient is going to be. Here's another patient with a pretty, with a significant asymmetry, but even in the better ear, the word recognition in quiet was very poor, especially given those thresholds. But again, this is another patient who was successfully fit bilaterally with hearing aids. This is a patient where I used that approach of fitting the better ear first and then the poorer ear second. It helped to really clean up the case. These thresholds

were relatively stable, and so I was okay in fitting a regular-type of product definitely on the right ear. On the left side I went to a more powerful product over there because I was little bit concerned about the thresholds. Fortunately for that patient, the thresholds didn't move any more from that point, at least in the time that I was managing the patient, and so this is another case where two hearing aids worked out fine. Definitely not a BiCROS sort of situation at all. And then finally, this is a patient who's probably a classic Ultra Power product patient. This is a patient who there's really not a whole lot you can expect out above one kilohertz. There is a little recovery in thresholds in the very high frequencies for that ear, but I was a little bit concerned about that. You take a look at the word recognition scores, which are, you know, pretty low given that he has, or she had hearing up past one kilohertz, but not a lot. So this is a patient who ended up wearing more of like an Ultra Power style product, just because that was probably all she had left in her auditory system.

She was one of those patients who for example in that Dutch data, where just even on their quiet, there just wasn't a whole lot you can get out of this patient's auditory system. So there truly are patients who are in this group. Of course all of these patients that I've shown you are potential candidates for implants, of course, or most of them were. It's just that these patients, for whatever reason, especially at the time period that I was involved with these patients, simply, implants were not an opportunity. But that is something that could be worked out for any of them. So, hopefully, then, by walking through these cases, talking about these hearing losses, talking about the needs of these patients. Hopefully, maybe you got a few extra ideas that you maybe haven't had before. As I said, if you really wanna know a lot more about the details of our power product line, our Super Power and Ultra Power product lines, as I said, you can pick it up on our companion AO show about these releases. You could always talk to any one of the personnel at Oticon live to kind of get an idea more of what these products are about. These patients with this amount of hearing loss can be very satisfying to work with if you can get a good fitting. These are exactly the sort of

patients who are very dependent on very well-trained, well-informed, creatively-thinking hearing care professionals who can really take a look at the remaining capabilities that these patients have and try to get the most out of that for them. So, hopefully you have a lot of success with fitting these patients. As always if you have any questions or comments, you can contact me. My email is on the slide. D.schum@Oticon.com. And with that, I just wanna thank you for your time.

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