Earmold Acoustics, Size Does Matter!
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- [Christy] At this time it is my pleasure to introduce our Guest Speakers who will discuss Earmold Acoustics: Size Does Matter! Our first presenter is Ozden Uslu, who is the Technical Director of Microsonic Earmold Labs. He oversees product development, quality and regulatory compliance. In his 10 years plus work at Microsonic he has implemented 3D design and 3D printing technologies, developed numerous processes and represented the company in global hearing healthcare industry. We also have Dr. Brian Fligor, who is a Board Certified Pediatric Audiologist and owner and Staff Audiologist at Tobias & Battie Hearing Wellness of New England in the Boston, Massachusetts area. He is also long time Chief Audiology Officer at Lantos Technologies in Wilmington. Thank you both for being with us today and at this time I will hand the mic over to you Ozden.

- [Ozden] Hello everyone, this is Ozden. It's a pleasure, it's a privilege to deliver this course to you. Today we're gonna talk about earmold acoustics, more specifically size restrictions and some limitations. So at the end of this course we hope that you will be able to identify earmold components, describe various hearing aid options based on physical limitations and also select the appropriate earmold venting based on acoustic mass. Okay, today around 85% of hearing aids sold in the US alone are BTE or RIC devices. Whether they are paired with universal domes or custom earmolds, acoustical concerns are similar when it comes to delivering the sound in the canal. So after putting that much effort into your programming, your planning to meet the insertion gain targets, so the question is that will you be able to achieve that target consistently? So while everyone knows that universal domes are less expensive than custom earmolds. Custom earmolds are prepared for better acoustics but also custom earmolds play an important role to deliver the sound as intended consistently since they are placed in the ear at exact same depth with the same angle every time they are placed in the ear. So if you think about it, you cannot achieve the same result with a universal dome since they are not made specific to the patient's ear so as they're inserted, they may be inserted at a different depth or with a different angle so the result will not be consistent. Okay, so with a custom shape the consistency is guaranteed but acoustical consistency is not the only aspect for patient satisfaction. So if your patient is consistently annoyed with his or her hearing, the target is not achieved. So, again, customization of an earmold does not only refer to it's physical conformance to ear. Earmold configuration for desired acoustical performance also depends on our choices, such as BTE versus RIC, or tubing or receiver size, tubing or receiver type, proximity to eardrum as well as venting. So with so many aspects to consider, so many components to consider, you may have difficulty to find enough room to fit desired components in an earmold so we have limited space. So for desired earmold acoustics, size does matter. So let's go over the components that go into an earmold. So what goes in in an earmold? The first critical item in an earmold is the sound bore where we place either a tube or a receiver, depending on whether you fit a BTE or RIC device. For BTE tubing, you can go either with a number 13 tubing or slim, or some say even a thin tubing. For tubing you also need to consider some sub components such as tubing connectors, elbows, tube locks or anchors.

For receivers, okay so they're not one single size. So they come in different sizes. So for receivers you also need to consider their sleeves, connectors or adapters. The second critical item is venting. Although it's optional, it's a critical feature for earmold acoustics. Even when you choose no venting option on the order form, you have a great impact on the final acoustics. Other typical components are pull cords and engraving serial numbers. These are optional items although they are very common. Okay so how size matters? So before we go over the essential components, let's talk about the rest of the earmold, which is I would call wall thickness. We need wall thickness to separate the items from the outer surface. So when I say wall thickness I'm talking about these two areas in here. So you need to leave some room for wall thickness as well. So wall thickness, typically, on each side of an earmold is about 1mm. So 1mm on each side, that will make 2mm that is reserved for wall thickness alone. So how about the critical components, the essential ones? So you can go with a smaller receiver size, which is 3.3mm and 4mm, or medium or large receivers which are between 4mm to 5.5mm. If you are going with a BTE option, then just a tube alone, thick or heavy wall, whatever you call that, it's roughly 3.3mm. So I'll insert a number 13 tubing while we have much cosmetically appealing option, which is slim tubing, or thin tubing, even that would require 3mm space in an earmold. How about venting? Okay, so no vent here. Okay, no, it's not gonna occupy any room in the earmold but conventional venting would require additional 1.2 to 2.4mm space in an earmold. If you choose an open fit style, that would require minimum 4.5mm to minimize the occlusion effect, or 50% of the overall diameter of the ear canal. For that, acoustic mass would be a better descriptor of vent characteristics. If you don't have enough room for conventional venting, you have another option. We call this, in earmold labs we call that external venting, it's also known as a trench vent. The size equivalency is like a small vent. This vent is placed on the outer surface of an earmold. The equivalency can be achieved by matching desired acoustic mass thanks to 3D design and printing technology. So I kept talking about this acoustic mass. I'm gonna leave you with Brian, he's gonna go over acoustic mass. Brian?

- [Brian] Thanks Ozden. So this is Brian Fligor and do wanna say thank you so much to Ozden and the folks over at Microsonic for asking me to chime in with this presentation. I don't have an affiliation with Microsonic, I just happen to use them as one of my earmold labs of choice in my private practice in downtown Boston at Tobias & Batties here in Wellness. We fit a lot of BTE hearing aids, a lot of RIC hearing aids. We fit probably about 30% custom products from IICs through ITEs with the majority of our devices being RIC hearing aids of course, like most everybody else. I think what's a little bit different about my practice is that we decided that, by default, we would fit custom coupling for all hearing aids unless there's a specific reason why we can't achieve a good outcome with the custom and then we may go over to an open dome or whatever other approach. But just across the board we do custom, custom molds on our RICs, obviously on our BTEs, if the person isn't a candidate or doesn't want a custom product. So we use Microsonic for a bit of this. In full disclosure I have a longtime relationship with Lantos Technologies and I'm not representing them today but I'm affiliated with them and my love of custom does, in part, go hand-in-hand with the work that I've done with them. So I do use the Lantos scanner, as does the rest of my staff, with all of our patients. We scan every single person and our products are primarily made from Lantos care scans and so the reason why Ozden asked me to participate in this talk was to get down into a little bit of the clinical interface between what the Earmold Lab is doing and what the clinician is doing and this came, in part, from a good number of conversations I've had with Ozden, with Monica Major and with folks at Microsonic surrounding how to best accomplish a good fit for the patient given the space limitations that we have. As Ozden eloquently went through, there's minimum requirements for some of these things. We can't look at an individual's audiogram and say well, they've got a moderately severe hearing loss and then the manufacturer software says that'll call for a high power receiver and I'm gonna need to put, say, a fully recessed earmold on that. There may not be physical space. You won't know that until you actually see the size of their ear, which is something you can't know unless you do an earmold impression or you do a Lantos scan and measure out the physical size.

So this all boils down to things like how do we make this device actually perform the way that we want it to, the way that the software predicts that it should in the individual's ear? It all comes down to how that device is coupled to their ear canal. Whether it's a full shell mold or it's something that's teeny tiny and recessed very deeply down the canal, it all boils down to do I have adequate gain? Is that speaker pointed in the correct direction toward the ear drum or is it pointed at the wall of the ear canal accidentally, because they have a sharp bend that we didn't know about 'cause we didn't go deep enough with our impression? And in all of this, does their hearing in the low frequencies cause them to have real difficulty accepting anything other than as wide open a fit as possible because their own voice is trapped inside their head? Well, this comes down to this overall technical term called acoustic mass, or also known as acoustic inertance, inertance, if I could say that correctly. So what is acoustic mass? Well, according to the Acoustical Society of America, acoustic mass is that at a frequency for which inertial forces are dominant, the quotient of sound pressure by the resulting in-phase volume acceleration during sinusoidal motion. It's unit is in pascal per square seconds, sorry, pascal per cubic meter per second squared or, more easily, kilogram per meter to the fourth. And that's my face as I'm reading that saying what? Much more simply put. Acoustic mass is the amount of, for lack of a better word, impedance of air moving from one end of the tube to the other end of the tube. Think of this as trying to blow through a straw, that's actually an exercise for people learning how to sing, so you build up your diaphragm muscles and you get good breath support and you blow through that straw, it's a small tube and it's fairly long. Now, compare that to blowing through a paper towel roll that it may be just as long as that straw but it's much wider, it's much larger and it's much easier to breath out. There's less impedance, okay.

In the extreme example, consider having to blow, or breath, through a garden hose. That's a lot of air to move and it's actually moving through a fairly small, constrained space relative to the length of that hose. So a straw may be very small, like about 5mm all the way across, and a garden hose may be three or four times as wide but it's so much longer that the combination of the length as well as the diameter dictates how much impedance there is in air moving from one end to the other end and that could go either direction. So here's two audiograms of patients of mine. On the left hand side is the hearing of a person with unfortunately good hearing sensitivity in the low frequencies, normal hearing sensitivity in both ears through 1500Hz I did use open domes on this guy, they were migrating out of his ears. I was planning on putting him in custom anyway 'cause I thought that we could accomplish better hearing for him with custom. Comfort was a huge issue for him and he was rejecting the custom earmolds until we devised something that was a better acoustical fit for his ears as well as a better physical fit for his ears. It required getting a little bit creative, and this is some of the work that Ozden and his crew did with me, we had to get a bit creative with the physical form of the earmold that we did. Essentially what we were trying to accomplish was an earmold that's acoustically transparent below 1500Hz and this is something that has very low acoustic mass. The lower the acoustic mass, the higher in frequency before you start to have insertion loss caused by the earmold itself. So if we have a really tiny, tiny vent in the earmold, you get a roll off from ambient sound at lower frequencies and as you go higher, sorry, as your acoustic mass gets lower, your roll off goes up in frequency, as you get even higher, it rolls off again. So this is what we're gonna be talking about here today is thinking about just how much acoustic mass, or how little acoustic mass, do we want to try to achieve in this earmold? And we're going to attempt to describe this as a way that we could prescriptively determine where is that roll off going to be in that individual's ear, okay? So in this individual, so this person who's got a moderate sensory neural hearing loss and she slips way down to profound here, we're looking to have adequate gain before feedback in this person. But even people with profound hearing loss down to the low frequencies, often times still can tell that they are plugged up, that sensation of being fully occluded where they feel a little bit better if you put a "pressure vent". We do want higher acoustic mass in those instances but not infinite acoustic mass.

So Ozden and his team built some test systems, test earmolds for me where we had different sized vents that were of different length as well as different diameter. So in this case, the canal length, so this is a receiver in the canal earmold, you see the receiver, actually the little cutout area here in the CAD rendering of this earpiece and here's the wire coming out so the output is up at the top and the outside of my ear would be pointing downward, and then here with a yellow on either side, that is the actual vent and so this is what Microsonic would define as a "large vent" but with a long canal. This large vent with a long canal gives us acoustic mass of 4107kg/m4. That's a weird unit. The best way I can describe this is for those of you who may recall some things related to your physical science, stuff called density. So for any given physical volume, how much does it weigh? So, for instance, how many kilograms, so the weight per cubic meter, or how many grams per cubic centimeter would kinda be right along the same idea. So that's the kilogram per meter to the third and now this is looking at it over the course of distance per meter, kilogram per meter to the third, so density, as a function of the physical distance as you go down, down, down, down,

down. So it's some weird number with a weird unit but just treat it as any other number that, hey, we understand frequencies so here's acoustic mass. So here's what we did. Ozden's team did the modeling and they reported to me, from their modeling software, this number. This comes up as they're doing their modeling and to us it's a little bit of voodoo, but it's something that the software does provide and we can use this number to dictate where on that audiogram I want that frequency roll off to begin, where my insertion loss starts, okay? I want insertion loss to be nothing right up to about 1500 or so and then I want it to slope off.

So in this instance, so for earmolds that had a really small, sorry, a really small vent. They had really high acoustic mass, we're talking up into the 1400 to 1600kg/m4 and the cutoff frequency was down very low in frequency, it was down around 250, 300Hz, so that'd be really good for a severe hearing loss. Then, as we go lower in acoustic mass, the cutoff frequency started rolling up higher, and higher, and higher, and higher, okay. In fact I was able to get, at least in my ear, a couple of my earmolds rolled off at around 6000Hz. I did this measure, I did this with a verifit too, probe mic measures, we can all do this. You just put the probe mic down the ear canal without an earmold in place and you run your 85db MPO sweep. So you get nominally 85 decibels and then you have your ear canal resonance as when you get that probe tube down there, about two to three K, four K, you get this bump in how much unaided real ear gain is, your real ear unaided response, REUR, you get that ear canal resonance, now you stick this earmold in place, hearing aid's off but you've got the earmold in place with the receiver in there and now what you're measuring on the other side of this with a probe mic, you're measuring how much sound is coming through this vent, or coming around the earmold itself, flanking the earmold. So at that, what you can do is you can measure, well, is it rolling off, am I starting to get some insertion loss at about 500Hz, am I starting to get insertion loss at about 3000Hz, or at 6000Hz? Well as the acoustic mass went lower and lower and lower as in this channel, this sound channel, the vent effectively got larger and larger and larger, analogous too, as this got easier to blow air through like a paper towel roll as opposed to the garden hose, the roll off frequency got lower and lower in frequency. Turns out that even with only a few data points was able to construct an equation for this, and again, not necessary for us to do out the equation ourselves but I can tell you, if you say huh, do you know what I want? I want my cutoff frequency to be 1500Hz, I could plug 1500 in here and then solve for X and that'll tell me, hey, what do I want my acoustic mass to be? And I actually did that recently for a patient of mine who is a professional musician who has otosclerosis but wants to protect his better hearing ear, well both ears, and I requested a certain sized external vent, or trench vent, on a pair of life plugs for him and so it was from this equation that I'm able to predicatively determine where is sound gonna come through unimpeded, where's it gonna be acoustically transparent and where am I gonna start to have some insertion loss? Okay, so I think on this one, it's time for me to turn it back over to Ozden. Ozden, why don't you take this away because we're going right back over to the other aspects related to the components that go into the construction of the earmold?

- [Ozden] Well thank you Brian. Thank for explaining such a weird unit in such a simple way. Okay at Earmold Labs we have a responsibility to provide you the most comfortable earmold, that's what you expect. So the expectation, of course, is not or should not be only for physical comfort, also for acoustical comfort. So if we can sort this acoustic mass situation by working with you, by working closely with Audiologists, I believe we can provide much better acoustical comfort. So that being said, we have talked about essential components so far which are sound bore that we place, receivers or tubing as well as venting. So other than that we have two more components. We have a pull cord that we have to place, we have to prepare a hole which is roughly 1mm in diameter, and also engraving. Okay so how on earth engraving would occupy space in an earmold. So because of a number of manufacturing challenges, we cannot just simply print on an earmold. The numbers, the series numbers, the names, left or right indicators, you name it, they have to be engraved into an earmold. So when I say engraved, I'm talking about roughly 0.5mm depth from the surface. On some it feels that distance may go as deep as one full millimeter. Okay, so the receivers, tubing, wall thickness, venting, pull cords and everything else. So let's talk about the minimums. So no matter what you do, you cannot get rid of wall thickness, right? So you need a wall thickness of 1mm on one side and another on the other side. So you have 2mm right there. Even with the smallest component option, which is a thin, slim tube, that is 3mm. You still need at least 5mm diameter of an ear canal. So that means that even with minimum configuration without venting, significant portion of the adult population cannot use completely recessed RIC earmolds. These are somewhat similar to CIC or IIC hearing aids. This is because of size restrictions deeper in the canal and gain requirements. Well, it's not always bad. We usually have room for venting and other components. As you can clearly see in here, you have plenty of room between the outer surface and the sound bore and there's quite generous space between venting and the sound bore itself and then enough room for wall thickness on the other side. But you won't have room for assembling in a pull cord. So the sizes vary between 4 to 14mm typically among adult hearing aid users.

So to give you an example, thanks to Brian, he gave me these graphics, illustrations. So the one on the left belongs to a patient who is a 65 year old female. She has collapsing ear canals. The diameter is only 5.5mm. So this unfortunately doesn't leave us room for venting so we can only place a receiver or a slim tube. On the other hand, while the right we have another patient. He is 52 years old and then he has, it's gonna be hard to pronounce for me, mastoidectomy which results in such large ear canals. So as you see, we have plenty of room for anything you can imagine in the hearing health business. Okay, so let's now talk about extremes. This is a mid-age male, right ear, we chose Oticon 85dB receiver. We were able to apply a large vent, we call this large and I believe most earmold labs call it the same, and a typical diameter would be 2.4mm and the length of this vent is 15.5. We ended up getting 4100 acoustic mass. We had plenty of room and the canal is only close to 8.5mm in diameter so we had room for everything you can imagine. Oh, okay, here's another example for you. So, pretty much the same receiver; Oticon 85dB, only that the nozzle is somewhat different in here but otherwise the body of the receiver is identical to the previous one. Vent? Well, no, we don't have room for it, thankfully the Audiologist did not specify for one. So this belongs to a 13 year old girl with severe to profound loss across the range. The ear canal diameter is 3.3mm so on one side this is barely enough, on your screen, but if you turn this ear canal around you will see that there is simply not enough room to place this receiver in. So, okay, on the audiogram, Oticon 85dB receiver may make sense for this particular patient but that has to stay on paper only because the reality is that we just don't have enough room. So what do we do? It's actually very simple and I don't believe that this is an expensive investment. I would suggest you to invest, spend $20 for a digital caliper, you can get it from any hardware store or Amazon.com or anybody you like, it's not that expensive. It doesn't even have to be fancy or super scientific. All you need to do, just measure the ear canal from different angles to make sure that you have enough room for the components that you plan to insert in. Well, yes. So you have some room for modification for alternative options for between receiver sizes or tubing or some placements. And if we need to, we can reduce overall wall thickness by approximately by another 0.5mm to squeeze tubing or receiver in but please remember that by sacrificing on such critical wall thickness may eventually cause tear or break of earmold material sooner than possibly even the warranty term. So, again, please consider when needing to retube or replace broken receiver. But better yet, I believe it would be safer to keep expectations at a reasonable level. I believe Brian would wanna jump in after this point on to go over the selecting the appropriate receiver sizes in comparison to canal sizes. Brian?

- [Brian] Okay, thanks Ozden and I'll encourage you to jump back in on any of these pieces here because something that I've come to appreciate is just how imperative it is for the Audiologist and the earmold lab, particularly the modelers to have really good interaction with one another because we can solve some what seems like significant problems just with a little bit of communication and I feel like I've been an Audiologist for a good little while, it's been, jeez, I think 18 years that I've been an Audiologist if I include that fourth year, or what we used to call a CFY. So, you know, it's not like I'm new at this game and yet I look at that 13 year old girl with severe to profound hearing loss and you know that for aesthetic reasons she wants to have that receiver in the canal device, she's not going to want that BTE anymore or at least, let's put it this way, it would be very reasonable to assume she's going to want to graduate into a RIC device and yet her ear canal is only 3.3mm in diameter and based on what Ozden just described earlier throughout the talk is that with the smallest, lowest gain receivers, we need a minimum of 3.3mm to fit in the component and now we're going to need an additional 1mm of wall thickness on each side in order to just accommodate that. So the smallest sized ear canal we can get away with putting in a small low gain receiver is abut 5.3mm, or, as Ozden described, that they may be able to get away with a half a millimeter wall thickness on each size, understanding that that may result in the earmold tearing or cracking if it's in acrylic, tearing if it's silicon.

So there's some real important size limitations here. That said, yes, receiver in the canal hearing aids are increasingly popular because it can give you all the benefits of a behind the ear hearing aid in terms of the performance and the power and the Bluetooth connectivity with the aesthetic benefits of an IIC or a CIC hearing aid. Now that's why, reasonably so, receiver in the canal hearing aids account for about 60% of all hearing aid fittings in the United States. That's a rough number that fluctuates up and down but it's about 60% and in some practices, certainly, it's over 80% of the devices that they fit. So, these are images that are right off of my website where we look at the differences between the behind the ear and the receiver in the canal. There's no question that it's easier to get people to say yes to something like the receiver in the canal than it is to get them to say yes to something like this. Well, what if we were able to give them something that was this aesthetic but in a slim tube product where we only needed 3.3mm and we might get more gain out of that device because the receiver itself is up, outside of the ear and not putting the receiver down in the ear canal itself where we do, in fact, have limited real estate. It's impressive that we're able to accommodate the vast majority of audiograms with receivers. So whether it's a low power through a high power or even an encased mold ultra power receiver, we're able to really fit just about any audiogram. What I, as the Audiologist, had not considered is that the decision making when it comes to the receiver power is not dictated by the audiogram. The audiogram is a component of that, but the ear's physical size is equally important and I think that until I started looking really deeply at ear canals, I didn't appreciate that and in fact prior to me becoming a practice owner where I'm seeing patients all day, every day, I still didn't appreciate that. Well, this individual here, I fitted her with, let's see, what did I have? So these are 85dB Oticon ear receivers and with a custom mold with really large vents, as big as I could get, particularly here for that right ear, we see that we have this shaded region. This is a threshold of maximum stable gain when you do your feedback test. I've got a ton of head room with this. When I fitted her with open domes, her acoustic feedback dropped way down and was actually interfering with giving her adequate gain. In fact she was fit below target because my open dome was causing too much feedback to come through at around 3000, 4000Hz. So in this individual, I'm in really good shape.

You see here on the left side, I can get away with a little bit higher acoustic mass as in a smaller vent and I have even more head room on the left side than I have on my right. So in terms of the selection of the receiver size, and Ozden, let's tag team on this one, but the ear canal itself does not always give you the kind of room that you think you need in order to fit that particular patient. You look at their audiogram and you say well, you know, they actually, they need a high power receiver and we put like a power dome on there and you jam it in that person's ear canal and they complain that their hearing aid is squealing at them on a regular basis because it's migrating out of the canal. Well, to a very large extent, that is because the size of that receiver is too big for the physical space of their ear canal. It may actually fit when their ear is at rest but they don't just sit there still, not moving, not talking, not eating or drinking all day long, that device that you placed down in their ear canal has to have some physical space around it, and even better, needs to have a custom mold to hold it in place. That custom mold requires wall thickness, it may require a vent, it may require a removal string, all these things matter. So not just the actual diameter of it, say in the outer one third to one half of the canal but you also have to think about how narrow does it get down around the second bend because it changes rather dramatically? What's the physical distance between halfway through the first bend to halfway through the second bend? If it's really close together, that matters a lot in terms of whether or not the receiver could even fit. If you have a very sharp first bend and sharp second bend, or just a sharp first bend, that also matters greatly in terms of which receiver to place in the ear. It's not just about the power of the receiver, some receivers are straight, essentially rectangles, and some of them have an angle to their nozzle. So these receivers that have an angled nozzle at the tip, these, so this an Oticon 60dB receiver, so it's the lowest gain receiver, and this is the 85dB receiver, these two provide a little bit more space, a little bit more kinda wriggle room for placing this receiver appropriately deep in the ear canal if a person has sharp first or second bends or has a short distance from first bend to the second bend. The 100dB Oticon receivers are straight and that 100dB receiver requires a really good sized ear canal in order for it to fit. Ozden, were you gonna jump in and chime on that?

- [Ozden] Sure, okay, so spatially speaking of the bends, I call them, this is gonna be quite a faulty term, I call them tricky canals, tricky ears because it is so tricky to place anything in there. I'm gonna jump back to this little girl's.

- [Brian] One more I think.

- [Ozden] Yeah, okay.

- [Brian] That was a good one.

- [Ozden] So, yeah, sometimes, sometimes, again the distance may not be long enough so we may end up pulling the receiver towards out. So, yeah, we can somewhat manage to fit the receiver in but the end result will be the receiver will be sticking out of the canal way too much in a way that that would ruin the cosmetics that this little 13 year old girl was expecting to receive.

- [Brian] Yeah, cosmetically not appealing. Let me go back a couple more. There we go, this particular one, is it this one you were thinking of with this kind of bend here and that insanely skinny region right before the second bend?

- [Ozden] We can possibly fit only the nozzle section of the entire receiver. I can almost guarantee that the whole body of the receiver itself, except the nozzle, will stick out so I think this is gonna look even worse than any other hearing aids and earmold configuration. So if the cosmetics are a concern, again, let's be realistic, let's make sure that we have enough room, let's measure the impression over your skim data to make sure that we have enough room. Well, sometimes we don't have enough room and in that case I think we have a few more slides to go over.

- [Brian] Yeah, yeah.

- [Ozden] Brian, can you help me with, yeah?

- [Brian] Yeah, I'll bring these guys right on back. There we go, I just wanted to get to that really awesome example. Yes, so this actually, this is the other angle of that particular ear where it actually gets fairly large down inside and past the second bend but this region right through here gets awfully skinny. So, in a perfect world, you'd actually like that nozzle to get down into here and pointing toward the ear drum so that you actually have a fairly small acoustic volume upon which to act. You can actually get away with getting a smaller receiver and getting more insertion gain in this kind of ear but that, of course, dictates can I get the sound down in there? And I can tell you, if Microsonic can't, it can't be done. So that's gotta be my call out to the receiver manufacturers to give us more power in a smaller thing, in a smaller package. I know that defies the laws of physics but I'm still gonna ask for it anyway. In some ears, and you know this is really illustrating the whole point of the physical size is one thing but the geometry of it, the angles, the distances between the first and the second bend, those matter as well. Here's a woman who's, boy, she's got a tiny little ear canal, right here, right past that second bend. Her ear drum is just literally right on the other side of this. We were able to fit an Oticon 60dB receiver down in here and, yes, Microsonic did make a very deeply recessed earmold that fit all the way down inside. It actually, it sat right about here and that nozzle was right at the very end here at this piece. I can tell you that in this ear, this person actually has a severe to profound hearing loss, we're going straight BTE with this individual, not even a slim tube for her, which for her needs is absolutely fine but it's the kinda thing where we knew right away, yep, we are not gonna be going with a receiver in the canal device for you, we're going BTE and it was just all about really good expectations so to speak. Anything else on that one, Ozden, that you wanna point out with this anatomy?

- [Ozden] I believe you have covered pretty well. Just one more thing about the slim tube. I think the scenario that the receiver sticking out, I think it would apply to this, to this example on the right. So if you go with a slim tube, thin tube instead of a receiver, it's gonna pretty much be the same. So that little plastic thing will stick out awkwardly from the earmold. That would, again, ruin the cosmetics so why just we don't accept reality and then go with a regular conventional BTE with 13 thick tubing. Unless you expect us surgically. Place the earmold with the receiver beyond second bend, but we can't do that.

- [Brian] So for those of you who are on the webinar, those of you clinicians out there, something that's really important for us to consider is the fact that this ear, so we think of this as, well, this is gospel truth, the physical size of all of these and the physical distance of them, the same thing here, where the reality is that roughly right about here and lateral to that, it's soft tissue and some of this is actually highly conformable and moveable. Now, it doesn't mean that this ear would tolerate several millimeters of shift, say, this way on a regular basis, so kind of going toward the back of the head, they may not be able to tolerate that for hours at a time, but, this region, there is some give. There's some bend in there and so I know that on some occasions I have said yeah, I know it's really tight specs here, go ahead and do your typical, you know, like a 1mm wall thickness, maybe give me a little bit of space, give me a 0.7mm wall thickness and know that if it bulges out in your modeling outside of what this surface is, I as a clinician know that it will probably be okay and if it's not and it's uncomfortable for the person then I'm gonna own that and say, yeah, that's my fault for the remake. I think I just made Ozden twitch just a little bit on that one, but.

- [Ozden] Yes.

- [Brian] Here you go. Oh, let me. On the next slide there, we're going here. So, this is something that should probably make the clinicians in the audience also twitch. So when we're in school, we are taught that you don't want to select a physical receiver that is just barely on the edge of being powerful enough because, well, if you're driving that receiver to the maximum of it's ability, then you do run the risk of having distortions. If you drive it to it's greatest power you may run the batter down a little bit and if their hearing decreases then you may, then, of course, you don't have enough power and so they have to turn around and you have to swap out the hearing aid for instance, those would all be bad scenarios. Well, this is an individual who has an asymmetric hearing loss, her right ear a little bit better than her left ear, and I had originally thought, you know, I wanna give this person plenty of head room and so I was looking at fitting with a 100dB receiver on the left and an 85 on the right. Turns out that her ear canals really were too small to get away with event the 85dB on either side and so I scratched my head and said she will absolutely reject a BTE, I knew that from the beginning, she would rather be under fitted and not get adequate gain for understanding soft speech sounds et cetera, she would rather give up on hearing that and get some, and have better aesthetics. Well, I did fit her with 60dB receivers on both sides, asked Microsonic to situate the molds as deep as possible. I did real ear measures, and I'm so sorry I don't have the real ear measures on this, she gets almost full audibility across the entire range and she's got at least 5dB of reserve gain on her hearing aid on the left side. So this manufacturer software screen where it says ooh, 60dB, this is the maximum fitting range is down here at abut 60dB loss, take that with a grain of salt. That's an estimate in the average ear canal. This person has a small ear canal. Because the ear canal is so small, a lower power receiver results in more gain. It's kinda like going into an auditorium and shouting and on the other end of it it's not all that loud versus being in a little closet and shouting, well, it's gonna be just as loud over the entire range. So in smaller chambers, as in smaller ear canals, you can get away with a smaller receiver and still achieve adequate gain, especially if you seat that mold as deeply as I have described, okay?

So in this, and Ozden I think it's time for me to pass it over to you anyway, but I would encourage us all that, you know, you've got your BTE with 13 tubing on one hand, you've got your receiver in the canal on the other hand, don't forget about the BTE with slim tubing. You may end up with the best of both worlds on this. In that small ear canal where you need a bit more gain or the person has good hearing sensitivity in the very low frequencies and so you need adequate venting, you need a fairly low acoustic mass where that person's voice can leak out of their ear and not get trapped by an earmold with an undersized vent, or they wanna be able to mix in ambient sounds so that they don't feel cut off, where they feel like they can hear low frequency sounds in their environment, allowing that to come in. Don't downplay the significance of going back to a slim tube BTE. You may end up have a really, really, really happy patient where you're able to use some of your clinical creativity to meet the need. Okay? Oh jeez, I've basically just covered that for this slide. Bearing in mind that particularly for very short ear canals or ear canals that get really skinny down just before that second bend in what's been referred to as an ismith, yeah ismus, in the ear canal where it gets real skinny, you may not even need to insert that receiver or insert that slim tube down the ear canal all the way, you can get away with only three to four millimeters of insertion, which is really skinny. It's very, very short. You can get away with that in some of these ears. If it's adequately fitted to the aperture of the ear canal, you really should be able to get away with good enough acoustic coupling so that you're not having to engage the software's feedback algorithm constantly. One note, I know that we get away with using the hearing aid's signal processing software to overcome problems with acoustic feedback, what you're doing though, when you say ah, who cares about feedback any more? My hearing aid signal processing will just cancel the feedback, you are draining that batter rapidly. You get much more battery life out of a hearing aid that is not constantly in feedback cancellation. The way to get away with the hearing aid not constantly in feedback cancellation is to have an appropriately fitted earmold sitting in that person's ear so that the hearing aid can do the business of helping them to hear better, not constantly fight it's own feedback. So I think on that note, I think that I've exhausted myself and everybody else. Ozden, any other thoughts or points to make on this before we turn it over to the group for questions?

- [Ozden] I believe, thank you Brian, I believe we have covered the most important things that I can think of and I believe our audience may have questions. We would be happy to take any questions.

- [Brian] So, Christy, where are people typing their questions in, seeing as how we have it a little bit different from, our view, different from the participants?

- [Christy] Sure thing Dr. Fligor. So at this time if you guys have any comments or questions for Ozden or Dr. Fligor, just feel free to type them in and then it's gonna pop up for ya in that Q and A box there. We'll pull them over for you Dr. Fligor.

- [Brian] Sounds good.

- [Christy] Such a good course. It was extremely helpful and insightful. A lot of this foundational information but it's always good to review and really think about it in depth so I really appreciate the both of you coming on and sharing your knowledge and insight with us.

- [Brian] Well thank you, I appreciate it and I appreciate Ozden asking me to join in on this one. It's just, gosh, they are so fantastic. Ah, so one of our participants had mentioned no mention of the power molds and how this can affect making the molds smaller. So, Ozden, consider that you can custom make you receiver instead of one that's just right off the shelf, that you can do a custom receiver that's encased in acrylic and it's not a retro-fit where you have to have like a gasket or something for the receiver to slide in and out of the mold itself, any thoughts on how some of these power molds can help with the limitations on physical size of the earmold, sorry, the ear canal?

- [Ozden] Well that would, thank you for the question Gregg. That reminds me of my course that I took years ago at Siemens for their click molds. I remember Siemens used to give away a small reference plastic cards so you can measure the impression, the canal size against the select receiver. So costing that power mold doesn't have anything but the receiver itself. So if you are, you still have to check against the canal size. If it fits, that's fine. And power molds, typically, I would say because they are acrylic type, the wall thickness can go lower than, significantly, can go lower than 1mm but we will still need significant wall thickness.

- [Brian] Yeah, so Ozden, about that. So with an acrylic shell, how thin can you do? At some point the shell is too brittle and it's not gonna hold up.

- [Ozden] Well conventional earmold acrylics, I believe we can go around, safely, 0.70mm.

- [Brian] Okay.

- [Ozden] Maybe I shouldn't hint this way to our manufacturing partners, manufacturers, well there are now acrylic materials available for such thin walls that they can, I believe we can go as low as 0.5, 0.6mm for wall thickness.

- [Brian] Mm hmm, mm hmm. So Benjamin chimed in on this one. My practice tends to fit universal domes primarily. The benefits of domes are availability, cost and comfort, yep, agree with all of those. The benefits of acoustic performance in earmolds are indisputable, okay, sure the acoustic performance of it, how do you guide a patient into an earmold when a dome is mostly adequate? That is a fabulous question, I'm really glad it was asked and it was actually, so Ozden I'm gonna take this one and say, yeah, it kind of was one of my core questions that I posed to myself around this. Like, you know what? Why do I think that a person, my patients, should be put into custom by default? Why not domes by default and go custom when needed? Well the answer of it is, and this would take a whole Audiology online course to do, but I did a monetary analysis of how much does it cost me to see the patient back multiple times to try to get the fit, the comfort, the stability in the ear canal correct when really only about 20% of people really desperately need custom mold? Probably 10% of them shouldn't have a custom mold for whatever reasons and the rest of them could have a dome, could have a custom mold and it probably won't matter all that much one direction or another. So it was a combination of things. One was we don't know which 20% of our patient caseload needs the mold. Some of them we can probably predict, but a lot of them we won't know until we try it one way or another. If roughly 90% of my people, of my patients, will do as well or better with a custom, and that custom, frankly, doesn't cost me all that much money, it costs barely anything more that then actual hearing aid itself from the manufacturer, it's just a tiny little upcharge on my cost of goods, then I just decided, you know what, let me make 90% of them happy and have them feel as though I've provided customized care for them and not something that I just pulled off the shelf that, frankly, they could've gotten either at a Costco or at a Best Buy for that matter. And so it's a little bit of marketing on my side I will admit, but it's also understanding and saying you know what? 90% of people are gonna do as well or better with a custom mold, let me just stack the deck in my favor and maybe I'll have fewer appointments with them and in fact that is the case. When I went through my analysis to see those who had custom molds versus those who had domes, I saw the ones with domes more often in follow up and it cost me more to see then and take care of them, than the ones that I did the custom molds on. Faiton asked how can the precise acoustic mass be achieved? Ah, Ozden, can you explain in the Cyfex modeling software from the CAD modeling over to the production of the earpiece, what happens in terms of, how predictable is that CAD software and what does the CAD software tell us?

- [Ozden] Okay, thank you Brian and thank you Faiton, and then I would like to tie my answer to Daryl's question as well because Daryl asks do you need to scan the ear to take the full advantage of acoustic mass? So there is an answer for both questions. First, as just Brian explained. The acoustic mass information appears on our screen when we design our earmolds in the 3D design software. So to do that, whether you submit your orders with a physical impression or electronically with an in ear scan. So for a physical impression, we 3D scan everything regardless of the process type, or if we receive the order electronically, an in ear scan, regardless. The 3D information appears on our screen, as soon as we place a sound bore or a vent, the acoustic mass for that given shape appears on our screen. So that being said, by playing with the overall diameter of the vent itself, or it's length, we can achieve precise acoustic mass. If you believe that you can specify the acoustic mass, we can definitely match that and I'm not talking about on behalf of Microsonic, this applies to all earmold labs that benefit from 3D printing process.

- [Brian] What I'll say in chime to that is that the longer the representation of the ear canal, whether it's from an earmold impression or from the ear scan, the more data that you provide to the earmold lab, the better they're able to meet your requests. So I'm completely conflicted, Daryl, and I'll tell you. Of course I'm gonna tell you you need to scan the ear, I'm the Chief Audiology Officer of Lantos. But that said, that's such early commercial stuff and the vast majority of you who are doing custom are of course using earmold impressions and I would just advise that the deeper the earmold impression is, the better the earmold lab is able to take full advantage of that acoustic mass. I would argue that my patients thoroughly appreciate being scanned rather than a really deep earmold impression because it can be quite uncomfortable to go down within a few millimeters of the ear drum with an impression, whereas with an ear scan, frankly, it feels good. So waving my hand with the caveats aside that I'm biased in that but we'll say that Ozden and his team have been the benefactors of direct ear scanning and I'm not gonna put words in his mouth but I know that we've had some really wonderful outcomes. Okay. I think so we're a couple of minutes over.

- [Christy] Thank you so much

- [Brian] Thanks Christy.

- [Christy] We're gonna go ahead and wrap up today's course. We hope that you thoroughly enjoyed today's presentation. If you wanted to do the introductory version of this course, it was available to you on demand in our course library and thank you again Dr. Fligor and to Ozden and also thank you to Microsonic and to Dr. Fligor for allowing us to use all the wonderful graphics and pictures throughout this presentation. Have a great day everyone.

- [Ozden] Thank you Christy.

- [Brian] Thank you Ozden, thank you Christy. Bye now.