# MED-EL Cochlear Implants and ESRTs: Protocol and Case Studies from Chattering Children

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- [Barbara] Hello and welcome to our webinar. My name is Barbara Foster Clinical Education Manager for MED-EL Corporation. Today, we'll be talking about Electrical stapedial reflex Threshold, ESRTs, a valuable tool to have in your audiology tool box when you're working with cochlear implant recipients. ESRTs are just one of the objective measures available in the MAESTRO System Software from MED-EL. We'll go over an overview of the auditory mechanism along with some data on how these measures relate to cochlear implant mapping. Then audiologists, Julia Reid and Sydney Bednarz from Chattering Children and The River School will discuss their clinical experience measuring ESRTs. But before we get to that let's review some fitting fundamentals with the MED-EL System. After this course, learners will be able to diagram the auditory mechanism that elicits ESRTs measures, be able to list the equipment required to perform ESRTs on the cochlear implant recipient, and describe some clinical tips for working obtaining ESRTs in the pediatric population. The MCL is the most important parameter for fitting MED-EL recipients and should be set at the maximum comfortable loudness level. In other words, the sound should be very loud but not uncomfortable.

Appropriately set MCLs ensure the relative loudness of sounds to each other as they occur in the listeners environment. MAESTRO's default fitting parameters are appropriate for most patients, which is based on years of fitting experience and knowledge of MED-EL cochlear implant technology. There are some cases however where other parameters will need to be adjusted either early on or with continued use of the cochlear implant by the recipient. You might ask that if MCLs are set to maximum, does that mean the patient is hearing at maximum loudness all the time? No, patients here at MCL level only when volume is set at 100% and input level is about 105 dB SPL. At all other times, stimulation occurs below MCL and is based on the sound input. The MED-EL Cochlear Implant System has an instantaneous output range of about 55 dB. by automatically adjusting the gain, the AGC can increase the input dynamic range to about 75 dB SPL or that's our roving window size. This means that the patient will have access to both soft and loud sounds based on the

environment which they're in without having to adjust their volume control. And unlike other cochlear implant manufacturers, our compression ratio is three to one. This is most like hearing AIDS compression, and more importantly, like the compression ratio of the basilar membrane. This means we are processing sounds in a very natural way, like the auditory system is designed to do. One of the settings that may be manipulated within the MAESTRO fitting software is thresholds. It's important to know the parameters of each Cochlear Implant System, since each system operates differently. For a medal recipient thresholds should be inaudible. Most of the time using default parameters of locking the thresholds to eight to 10% of the MCL are completely appropriate.

There are instances however, where you may wish to measure threshold, and if so, be sure they are in audible. When fitting any cochlear implant patient, it's important to know general averages for loudness levels, which vary from manufacturer to manufacturer. MED-EL's maximum comfortable loudness levels typically range between eight and 15 charge units at the initial stimulation, or first fitting. Later when the patient has achieved a more stable map, the MCL levels approximate 15 to 25 charge units on average. Keep an eye out for outliers in the map, especially very high MCL levels. MCL set beyond a patient's maximum loudness comfort could lead to overstimulation, poor performance, or even facial nerve stim. These general parameters are important to keep in mind with all patients, but especially when you have patients with unique loudness requirements or cochlear abnormalities. Here's a summary of some fitting reminders for the MED-EL Cochlear Implant System. The MCL, a pivotal parameter, should we set as accurately as possible for the patient to receive appropriate loudness growth with their map. With MED-EL, MCL indicates the patient's maximum comfortable loudness level. Next, the threshold level should be programmed, so they are inaudible to the patient and the default setting locks the thresholds to eight or 10% of the MCL. This should be an appropriate setting for most routine fittings, but maybe adjusted based on clinical protocol or cause. For safety, the default volume for a map is 75%, and should we change to a 100%, in order for your

patient to receive the maximum benefit when listening to their appropriately-fit map? Remember the patient can always reduce the volume with their fine tuner or fine tuner echo remote control. Be sure to watch for red flags or outliers, which often indicate parameters may need to be adjusted. And finally, it is normal for sound field thresholds to be about 30 dB and better with the MED-EL system. The ultimate fitting goal for any cochlear implant clinician is to achieve the most appropriate map for that individual with a balance of comfort, satisfaction, and performance. This can become a challenge when working with recipients who may be inexperienced, unable to, or unreliable in reporting accurate loudness levels. For those reasons, objective measures are a good way to verify fitting levels for your cochlear implant patient. ESRTs are stimulable for many cochlear implant patients, much like the acoustic reflex of normal hearing patients. They're measured in response to loud sounds using the cochlear implant to stimulate the hearing nerve. The correlation between ESRTs and MCLs, isn't a function of the implant system. Instead, it's a function of how and where loudness is determined along the neural pathway. Here, you can see a simplified diagram of the ESRTs pathway, which should look very familiar to you.

Although ECAT measures like auditory response telemetry occur at the level of the cochlea, loudness doesn't occur there. It is processed higher in the brainstem, the superior olivary complex. Once the stimulation crosses over it then travels down the seventh nerve to the middle ear space where it contracts the stapedial muscle. And in turn stiffens the tympanic membrane and becomes an observable output on meatus bridge. While stimulation is unilateral, the reflex occurs bilaterally and can potentially be recorded in the ipsilateral or contralateral side. Although not present in a 100% of cochlear implant recipients when available these responses correlate very well with behavioral measures for MCLs, which is well documented in many research articles. over the years, we have learned how early identification and early implantation plays such an important part in speech and language development for profoundly hearing impaired children. And according to a recent study by Cassandra et al, researchers measured cortical responses to link sounds with MED-EL cochlear implant patients. If

it was determined to be suboptimal compared to normal hearing peers, their map was reevaluated using ESRTs to ensure accurate mapping levels, which leads to access to speech at normal conversations levels and ultimately auditory cortex maturation. This innovative research demonstrates the value of using objective measures like ESRTs to ensure recipients reach their best benefit as early as possible by having appropriately-fit maps. If you haven't tried ESRTs yet in your clinic, I would encourage you to do so. For reference, MED-EL offers an ESRTs guide with step by step instructions for completing ESRT utilizing the MAESTRO System Software. In addition, you can find a myriad of short modules on fitting cochlear implants, including our most recently launched hardware, software, and accessories in our online learning platform, MED-EL University. Please contact your clinical account manager for further information. I'd like to turn it over now to audiologists from The River School, Julia Reid and Sydney Bednarz who will be sharing their experiences using ESRTs.

- [Reid] Thanks dr. Foster for that great overview of ESRT and MED-ELs Cochlear Implant System. I'm Dr. Reid, one of the audiologist at The River School and Chattering Children, and I'll be joined later by my colleague, Dr. Bednarz. We will be discussing how we use ESRTs in our clinic and give you some practical tips for implementing it in a pediatric setting. We'll talk about our general clinic protocol, a step by step of ESRTs and what that looks like for us, benefits and challenges that we've encountered, some billing considerations, and then go into a few case studies. Let's dive into our clinic protocol and how we incorporate ESRTs into it. First of all, I'd like to provide a quick overview of our center. The River School is an independent school with an inclusion program for children with hearing loss who use listening and spoken language. The kids learn alongside their normal hearing peers in small classroom sizes with a speech pathologist and masters level educator in every classroom, allowing for a truly language-rich environment to build the children's spoken language skills. Chattering Children is the clinical entity of The River School and includes occupational therapy, audiology, speech pathology, auditory verbal therapy, and psychology. In the audiology realm for The River School, we complete hearing evaluations, hearing aid

and Cochlear Implant Programming, troubleshooting services, and aided evaluations for students with hearing loss. Chattering Children also serves an outpatient population of children who do not attend The River School. So The River School refers to the entire school program, regardless of if the child has typical hearing or hearing loss, Chattering Children is the clinical piece. The patients who are seen at Chattering Children have a hearing loss and they do not necessarily attend this school. Because of our background as a school and a clinic, we have a lot of transfer patients that come to us for the school program, and this informs some of our protocols. Well, many of the children come to us with an implant already from a Cochlear Implant Center. We do partner with some centers in the area for the entire mapping process. We see patients frequently during the first year in order to track performance and ensure they have an optimally programmed map as quickly as possible. While our first couple of visits are focused on mapping and counseling, we typically start sound field testing at the four week visit and include booth testing at every visit thereafter. For those who have had a cochlear implant for over a year, we see them less frequently in audiology, but often enough to be tracking speech perception, performance, and ensuring progress. So out of all these visits, when does ESRTs come in?

We had not always been using ESRT at our center until the past few years. As pediatric audiologist, we often rely on clinical judgment and observation of the child's behavior to help them form mapping. Is the child aware of the sound in general? Are they crying? Do they blink in response to loud clapping or loud sounds? These are important factors to consider, and we need to ensure that the child is comfortable and happy with the sound. But having an objective measure for loudness helps to take away some of the ambiguity of whether a sound is truly too loud. As we've gotten more confident with eliciting the measures and manipulating parameters, we've developed a few guidelines for when we should consider using ESRT. For our initial stimulations, we attempt to measure ESRTs within the first month after the child has had some time listening to the device. We'll try to get as many electrodes as we can in one sitting, but if we're unable to complete the entire array, we'll focus on a low, a high and a mid

frequency electrode and fill in the gaps at future visits. We use ESRTs to verify programming for patients that have never had it completed or for transfer patients in order to get a better understanding of the patient's map. I had a particular three-year-old patient who had a narrow dynamic range and not optimal access to soft sounds in the sound booth. She would blink as we tried to turn up her comfort levels and was particularly headstrong about changes of mapping. Once I was able to measure ESRT I felt confident that I was nowhere near uncomfortably loud for her, despite her blinking, and was able to ease her into progressively louder programs to get her better access. She's since adjusted to the flatter map and is no longer a blinky. Finally, we're continuing to develop our protocol and are in the process of adding an annual measurement of ESRT. Several studies have found that ESRTs increase over the first year. For those patients who we measured early on in their implant use, we want to circle back and see if ESRTs have changed and determine if our mapping levels near that same pattern.

Additionally, the ESRTs has been found to stabilize over time. One study found that although the ESRTs levels increased in early mapping sessions, they stabilized around the nine month mark and were equal to measurements made at the 15 month interval. So this suggests that we can use this ESRTs to check for stability. Well, ESRTs will guide us in mapping for loud sounds. Verification of mapping is essential for understanding a patient's access to soft sounds and their speech perception progress. We're all familiar with the speech banana and which tells us where speech sounds fall within the audiogram. A child's access shouldn't be just within the speech banana, but near the top of it in order to ensure that they can hear all the sounds that are louder than that. If sound booth testing is not completed, there's no way to know what the child has access to. We measure thresholds in the sound booth with warble tones and aim for thresholds between 20 and 30 decibels, depending on the manufacturer and their sound processing. Additionally, because the cochlear implants are designed to process speech information. We will use the calibrated recording of the Ling six sounds to measure the child's thresholds for each of those sounds as a crosscheck to

the warble tones. In addition to measuring thresholds, we evaluate speech perception performance using both words and sentences, we use an adaptation of The Pediatric Minimum Speech Test Battery, or the PMSTB. There's a natural progression in our testing from close-set materials, of picture pointing task, to open-set speech task. We score speech perception, both based on total words correct, as well as the phonemes correct. To see if there's a pattern of specific sounds the child's missing to help inform us for either targeted therapy or for continued mapping. The PMSTB was created by a group of over 50 experienced clinicians and researchers across the United States. In order to create a more uniform test battery for candidacy and follow up. It emphasizes the importance of consistency between test measures with recorded materials, presenting speech at conversational level, and replicating the natural auditory environment by not only measuring in quiet, but also evaluating speech perception in noise. These are the tests included on the PMSTB. At our clinic, we use the majority of these tests, we don't use the tests that are grayed out, but we do also add the NU-CHIPS as another picture pointing task and the PBK as an another open set transition between the MLNT and the CNC.

This diagram illustrates that the child has reached seiling for a test when they're achieving equal to or greater than 80% correct, and that they should progress to a more difficult task. If their speech perception ability is less than 25% then an easier task should be used for performance tracking. The clinician should move up to a more difficult speech task as the child makes speech and language progress. The importance here is that you want to be testing a child at a level where you can track changes over time. If the child is feeling out on an easy task, you may miss important changes in their speech perception that may indicate a deeper issue. I can't emphasize enough the importance of verification and validation of mapping in order to confirm access to soft sounds, track patients over time, identify problems and ensure that the child is achieving the best possible outcomes for their potential. So now that I've given you some insight into where ESRTs fits into our protocol and that optimal mapping and

speech perception, and booth testing go hand in hand, I'll turn it over to my colleague, Dr. Bednarz, for a more practical step by step of our process for eliciting ESRT.

- [Sydney] Thank you, Dr. Reid, as Julia mentioned, my name is Sydney Bednarz and I'm the other audiologist at The River School and Chattering Children. And I'm going to talk about and go over what it actually looks like for doing ESRTs in our clinic on our kiddos. So let's start with the rooms set-up, it's a tight squeeze, we only have one booth, but we make it all fit. We use our booth because that's where our Tymppstar Pro was located, so we bring our programming laptop into the booth. We have the child sit in a small child sized chair in front of a low cabinet with a DVD player, so it is set at eye level. The DVD player isn't connected to any speakers, so a movie plays without sound. We have a small selection of Disney movies that we let the child choose from. The temp star pro sits next to the DVD player. And then we use a small child sized table to put the programming laptop on which sits behind the child's chair. As the clinician, we sit either in an adult chair or on the ground in between the small table and the cabinet. That way the table and cabinet are within arms reach. So both can be controlled by the clinician, right hand on the Tympstar, left-hand on the programming computer.

Sometimes there will be a clinician and a graduate intern and the intern can help with pressing the buttons on the Tympstar, However, due to space constraints, it is difficult to have multiple adults in the booth at one time. So how do we set up the parameters before we do any of our testing and our testing? we have changed our default, so that under dynamic stimulation, the MCL burst is set to 300 because we have younger children who cannot always scale their AMS. We leave our default at 300, but if we are scaling, we would change these back to 50. So the burst duration doesn't change the sound perception of the M level. You can also change the burst gap to 1000, if you're having trouble seeing the response, but this is not something we typically change and our default is set to 500. So let's go step by step and try to go over measuring ESRT. How do we start the ESRT? Well, first we start with Otoscopy, of course, just to be

sure that the patient doesn't have a tube or perforation or occluding wax, then you measure Tympanogram in that ear... in the ear that the probe tone will be in. Typically this will be the opposite ear of the cochlear implant that you want to stimulate. So the contralateral ear. After confirming that the patient has a normal tympanogram, you will move into the reflex decay screen to get to the decay screen, press the special button and choose reflex decay, which is the first item listed. Before starting the testing, be sure the time window is set to 15 seconds, so you can see the response. Our Tympstar used to default the time window to 60 seconds, but we were able to change that in the configuration software, so now I default to 15. And then be sure to turn the stimulus down to the lowest level it will go so that it is completely inaudible. One of the trickiest parts of measuring ESRT is keeping the admittance around zero without a lot of movement.

So there are a few things you can try to help keep a steady compliance. The first thing is to manipulate the probe tone. Sometimes you can easily get a response with a 226 Hertz probe tone, and sometimes it can be difficult. Thankfully, research has shown that the probe tone doesn't really make a difference. It actually has found that most responses are better elicited with a 678 or 1000 Hertz probe tone. The next thing you can try would be to adjust the pressure dial. This can sometimes help calm the admittance down, and you can get a smoother response, which will make the ESRTs easier to see. You may also just have to press the auto zero several times. Anecdotally, while the stimulus tone doesn't matter, I've personally found that changing it to 4,000 Hertz has helped. When first starting out, I tried all kinds of combinations of probe and stimulus tones to get the best response and compliance and it just so happens that 4,000 Hertz worked the best for me. When you are ready to start the test, you will first have to press the start to set the pressure and check admins. You should only have to start the pressure once, unless you change the probe tone, or you have to re reposition the probe itself. However, you will have to press the present button multiple times. Present we'll start the tracing, but remember it only lasts 15 seconds. So when you run out of time, you have to press present again. So you have to be sure you're paying

close attention to the Tympstar while measuring. After the time has elapsed, a window will pop up asking if you want to keep the tracing or discard it. You cannot present again until you have chosen to keep that tracing or not. This can be a bit frustrating because then you cannot save multiple tracings for one stimulus. However, you can change the stimulus and then save a new tracing. So now you are ready to measure the ESRTs on the Tympstar. The rest of the setup includes connecting the child's processor to the programming computer using the max interface, removing the child's contralateral device and making sure that he or she is sitting still and quiet. And during all that setup we're allowing the child to watch the video, so usually they're a little bit into that movie already, by the time we're ready to get going. So how do you manage the computer while also managing the Tympstar and monitoring the child? It can feel like you need a third arm sometimes. So it can definitely be helpful to have an assistant, if you can who can manage the Tympstar buttons while you're measuring the electrodes. that also provides an extra set of eyes on the child,

So you can make sure you aren't stimulating too loudly or that the probe tone didn't fall out. So we frequently have graduate students that will help us do this in the booth. However, as I mentioned, it's a small space and they're very close quarters, so we don't always have help. If you don't have anyone else helping you, you'll want to have one hand on the programming computer and the other on the Tympstar at all times. I typically have the volume on the computer turned up so I can hear the presentation of the stimulus through the computer. Remember the child shouldn't hear it because they are connected to the computer, with the programming cable and their opposite ear is plugged by the probe. So this allows me to look over at the computer less so I can watch the response on the Tympstar. So I press the space bar and I listen for the response while looking at the Tympstar. Out of habit of opening the Fitting Tab Software, I have not used the ESRTs tab to measure the response, but remember it is there for you in the MED-EL software, if you would like to use it and feel comfortable with it. I have also not used the ESRTs tab because most of our patients come to us from other centers as Dr. Reid mentioned. So I want to base my measurement on

where the child is currently programmed and where their MCLs are set. So after I opened the Fitting Tab on their current map, I choose an electrode in the middle. I press present on the Tympstar and then manually press the space bar on the computer to present the electrical stimulus. If I don't see your response and then increase stimulation in page ups, which is 15%. Typically, I am trying to elicit a first response of the electrically evoked stapedial reflex. So after I find that initial response, I move on to another channel. This leads to creating a map typically above the actual electrically evoked threshold. I use this knowledge to know that further fine tuning can be made at a later appointment, after I have performed some verification measures. Because I am not initially searching for threshold, I always go live to ensure that I am not overstimulating and that the child is comfortable at the M levels I have set. While this is my typical protocol, both Dr. Reid and I do it just slightly differently while following our clinic's general protocol.

Once I have set my M levels to a clear electrically evoked the stapedial reflex response, I can search for threshold. In doing so you will want to be sure that the response grows and amplitude so that you are truly eliciting the reflex response. Then you will want to decrease stimulation in a page down click until the response disappears and increase using arrow clicks, which is about 3%, and so the response reappears. You can fine tune this even further by increasing by plus or minus clicks, which is 1% changes. If you're thinking, "Wow, that could be time consuming to measure on every channel", you would be correct. Typically I will measure the middle channel one on each end, a high and a low, and then if I can one in between the low and middle and the middle and high. So I will use these five electrodes to interpolate the rest, but if you can only get three, that's great too. If you have the time and the child is still compliant and watching the movie go for broke. Measure as many as you can. I will then label the map that I was working on as what I did. So if I'm reduced M's from ESRTs any degree, or if it is the exact ESRTs map, I will name it. So always go live to check your for loudness. And if your patient can scale, you can do that too. So I've explained how we measure the ESRT, but what does it actually look like? Well, on the screen, you are

looking for a clearly defined change from baseline, either in the positive or negative direction. Sometimes these can look like spikes, sometimes they are nice flat table responses where they increase, flatten, and then decrease, or they decreased, flatten, and then increase. And sometimes they're in between like the picture you see here. The picture here you can clearly see has an increase from baseline right as a stimulus is presented from the computer. It then is repeated two more times to ensure that the response is truly present. Because the response was, can look different, that is why I manually stimulate the electrode, so I can look for the time lag response to my presentation, but you absolutely can use the continuous stimulus option in the MED-EL software if you like. Okay, so now we're going to talk about some benefits and challenges for measuring ESRTs on children. So as we mentioned, it helps set M levels during programming and for children who are too young to scale or behaviorly set their M levels, this can be very helpful.

It also ensures that we're not over under stimulating children who cannot otherwise report loudness and it correlates to target thresholds for link sounds for MED-EL patients and a target threshold for MED-EL is between 25 and 30 decibels. It's also great that you can use it for any manufacturer, MED-EL typically has a one-to-one ratio for where ESRTs and MCL levels are set. And as Dr. Reid mentioned, research has shown they're mostly stable over time, but they can be annually tested to verify the stability and make fine tuning adjustments as needed. So some common challenges. Well, if you've ever worked with a child, you know, that he or she may not like you touching their ears. So working with children is always going to be fun and challenging all at the same time. And so the main difficulty for getting the ESRTs is to keep the child still. And we have found the use TV screen has been a game changer. While the child is watching the screen, they need to be still in quiet, and sometimes they just want to talk to us about the movie. So if the child continuously talks we like to use The River School's catch a bubble strategy where essentially the child pretends to catch a bubble with their mouth and then keep it there by puffing out their cheeks. Some children are just not into the movie and are too wiggly or they just don't like having that

probe tone in their ear. So this means you may not be able to measure the ESRTs across all electrode channels. And that's okay because getting just one response is informative, so you'd definitely take what you can get. And as the typical measurements of acoustic reflexes, you do need normal eardrum movement to elicit the ESRTs response. So ears with PE tubes perforations or flat tympanograms will not able to demonstrate this response since the eardrum will not end up moving when the stupidious muscle contracts. And then maintaining a seal can be very challenging, so finding the correct size probe tip is important. One recommendation to maintain a seal has been to use auto form around the edges of the probe tip, but we have not experimented with that yet in our clinic. Additionally, hyper compliant eardrum may cause issues with maintaining zero pressure for admittance. While we do utilize the auto zero button, we have also found some success in increasing and decreasing that pressure dial, as I mentioned to help stabilize. So while you will be unable to measure ESRTs in some cases, these are a few tricks that have helped us be successful when issues have come up for those who we can't measure it on.

- [Julia] All right, I'm going to chime in and talk for a moment about some billing and coding suggestions for ESRT. Please note that I'm not providing you with any billing advice as I'm not a certified coder, but just some insight into things that have worked for our clinic and various cochlear implant centers. You should talk to your own billing department in order to determine what is appropriate for your clinic and the payers that you work with. There are certain codes that can and cannot be billed on the same day. The centers for Medicare and Medicaid Services developed the national correct coding initiative to promote appropriate coding practices and reduce improper payment as a result of inappropriate coding in the past. To see relevant coding and code for audiology, you can easily find a comprehensive list on the ASHA Code or AAA websites. Let me get the cursor, here we go. So let's walk through this table with the use of the nine, two, six, zero, one code, which is used for initial activations for children under the age of seven. All of the codes that are listed in this row are able to be billed on the same day with the nine, two, six, zero, one code, as long as the five, nine,

modifier is used. The five, nine modifier specifies, but it's a distinct procedure. The third and fourth columns here indicate whether or not they can be performed on the same day with a Y for yes or an N for no. So, as you can see the first column, there's this first row, all of these codes can be built. And then the second row, these cannot be built on the same day. So let's take a deeper look at which codes these include. So this nine, two, five, five, zero code corresponds to tympanometry and reflex threshold, and nine, two, five, six, eight is acoustic reflex testing threshold. These can be build on the same day as the nine, two, six, zero, one code when that modifier is used. Therefore, according to CMS, you can bill for these procedures on the same day. Completing ESRTs requires additional equipment. and we'll add a little time to your programming session, so in my eyes, these are seen as distinct procedures. At our clinic while we do not typically complete ESRT during the initial activation appointment, you'll see a similar pattern for subsequent programming codes of nine, two, six, zero, two and nine, two, six, zero, four. Again, I encourage you to check with your billing department and specific payers to determine what is appropriate for your clinic. So now let's jump into some case studies for ESRT I'll, turn it over to Dr. Bednarz to discuss her first case.

- [Sydney] Okay, so the first case we're gonna go over is a four year, eight month old male. He underwent Cochlear Implant Surgery in the right ear on July 15th, 2016, and received a MED-EL SYNCHRONY cochlear implant. He was activated on September 16th, 2016 with a SONNET BTE processor on December 30th, 2016, he underwent surgery for the left ear. And received a MED-EL SYNCHRONY cochlear implant, and it was activated on February 14th, 2017 with a SONNET processor. However, the left ear had to be revived on August 21st, 2019, and was reactivated at our center on June 9th, 2019. He also uses RONDOs as his backup. So this is his pre-ESRTs map and as you can see, the M levels are set completely flat as per the typical recommendation, but we've measured his T levels. So you can see that the T levels are based on his behavioral responses. So we have a higher stimulation in the higher pitches than we do on those lower electrodes. So that map that you just saw was based on previous

behavioral thresholds. The audiogram that you see now is using the map 71 to measure behavioral thresholds in the sound booth. So as you can see, the right ear is in that target range that we're looking for between 20 and 30 decibels while the left ear is considerably outside of that range. We did a new chips at this appointment, and he got 80% bilaterally, but we did not test individual ears. We also typically measure Ling six sounds, as Dr. Reid mentioned, we used the recorded a Ling six sounds and at mm, he got 35 decibels. And for, oo, he got a threshold at 65 decibels. So in that range, on the audiogram where you see that dip, you can definitely tell that he needs some programming adjustments. He's wearing his processor seven hours a day, and this was prior to his reimplantation for that left ear. So after we got those behavioral responses, we knew he needed some programming changes, so this is when we measured ESRT. what we did was measured ESRTs on the different electrodes and set his T's to be locked at 10%.

So previously he had measured his Ts, but because we were making adjustments to his M levels, which were no longer flat, as you can see, we decided to lock those teas at 10%. As I mentioned, when I initially measure ESRT I don't always find threshold. So these may be slightly super threshold measurements, but that allows me to do further fine tuning once I've done behavioral testing. So all of these are set at a very clear electrically evoked stapedial reflex response. So this next map that you're seeing is what I call a ESR based map, because when I went live, as I mentioned, it's really important to do, to check for loudness he was blinky. So I reduced the M levels by 3% and left the Ts again, still locked. So while the previous map you saw was where those electrically evoked to stapedial reflex responses were nice and clear responses, this one is slightly below that. We then had to make a second ESRTs based map because when we put on his right processor and turned it on he was still blinky and quite a bit. So we decided to reduce his M levels even further by a page down, which is 15% and again, left, his Ts locked at 10%. So our, we are manipulating those M levels, and now you can see that his behavioral responses are into that target range that we're looking for. So this was four months post reactivation, this is using that ESRTs based map,

number 81, and his right ear and left ear are almost identical. And his Ling six sounds are slightly better responses than his frequency thresholds, which is what we would expect cause Lings are easier and more interesting to listen for while his new chips is only 20% for that left ear. He's only four months post activation, so he's able to do the close-set task, which is great, just not where we want him to be speech perception wise, but that's what we're working on now. We've got his detection in a good spot, so we're hoping to build his listening skills and get him back to hearing really well with that left one by itself, as well as with the right one together. All right, so for case number two, I'd like to talk about an adult patient of mine. She was born before newborn hearing screenings, and she was not diagnosed until later. She received bilateral hearing aids at the age of three years, and eventually discontinued use of her right hearing aid when she was seven due to a lack of benefit. At that time, cochlear implants, weren't part of the standard of care. And they were just coming onto the scene. This was in the early to mid '90s. This patient had a progressive hearing loss over time in the left ear. And when she was in graduate school, she received a left cochlear implant.

Prior to measuring ESRT, she had been using her cochlear implant for over five years. She was doing fine, and with a consistent user. She had good access on the audiogram and got about 74% on monosyllabic words. On the BKB-SIN, she needed the signal to be nine decibels louder than the surrounding background noise in order to get 50% correct. So now let's take a look at her mapping. This is her map prior to measuring ESRT. These levels are considered higher than the typical range for MED-EL patients, but she was not complaining of anything being too loud, and she often wanted things to be louder . So we go to measure her ESRT and these are where her thresholds came in. I measured the ESRTs on every channel. And as you can see there was a substantial decrease in her MTL levels for the majority of the array except for channel 11. On channel 11, although this is where her ERT was measured. Facial stimulation was noted when presenting on that channel alone. Based on the differences between these two maps, we determined that she was a loudness junkie. I

wouldn't expect her to like this map given how different it is but my curiosity got the best of me, in live mode, she was not a fan of it at all. Therefore, I created a combination map with loudness balancing and was able to bring her M levels down substantially. She initially reported it sounded quiet, and we actually measured her T levels, which helped to give a little bit of a boost to the soft sounds. Please note that with MED-ELs processing strategies, it's essential that the patient does not hear their T levels. So they recommend working T levels to a percentage of M's. If the teeth are audible, the patient can be hearing a buzzing or humming found. When we measure for Ts at our clinic, we find where the patient can first detect the sound and then bring it down by several arrow clicks or a page down and sweep through the channels to ensure an audibility. I'm really pleased that I was able to decrease her M levels so much at this visit, but they were still a little higher than her ESRTs levels. Therefore, I did discuss a sound diet where the patient would go several days or a week without the processor, if possible, to help recalibrate her to lower stimulation levels. She still felt like things were soft in the clinic, but was able to adjust after some time in life mode.

After the appointment, she admitted that she previously took her CI off when washing dishes, because running water was too loud and uncomfortable. But she was now able to keep her processor on. So this had not been previously reported to me, even when asking about discomfort and different environments it confirmed my theory that she was a loudness junkie, and even with plenty of counseling and questions, sometimes our patient don't always tell us what's going on. This is a followup audiogram, her detection is now within 20 to 35 decibels so it's slightly different, but not by much. Her speech perception is stable, but she received the subjective improvement of more comfort with her MCL levels decreased closer to her ESRTs levels. And she was wearing her processor more often. I still have recommended a sound diet as an option for the future. Case number three is a little girl who currently is four years old, but began at The River School when she was 22 months. She was born with a right unilateral moderately severe to severe sensory neural hearing loss, and was fit a

hearing aid. She experienced a decline in hearing for her left ear between her first and second birthday, and was fit with a left hearing aid after she started at The River School. At that time, the hearing loss in the right ear at also progressed and she had a significant speech and language delay. So she proceeded with a right cochlear implant. This was her audiogram before measuring ESRTs levels. She did not have good access to soft sounds on the audiogram as the majority of our thresholds are falling at 40 decibels or poor. As for her map, her MCL levels are set higher than typical for MED-EL patients with the poor detection and higher MTL levels, I knew ESRTs was needed. She was about two and a half years old at the time, and she watched "Moana", sat comfortably, and let me measure ESR on the entire electrode array. This is what I found. You may notice that the highs are much higher than typical while the lows actually came down compared to where her map was at.

This gave me confidence that I was not shooting in the dark with her MCL levels especially for a child who is unable to scale yet. Given the large difference and mapping levels. I created a mixed map that set her lows and mids at her ESRT and then gradually increased her high-frequency channels to be in line with the ESRTs through progressive maps. After moving through the progressive programs and having some experience with the ESRTs based map, her Ling six thresholds indicated detection between 20 and 35 decibels and her performance on the MLNT and LNT list improved significantly. However, her detection for warble tones did not change much on the audiogram between these two maps. This allowed me to explore a T levels and determine if they should be lacked at 10, 15 or 20%, or if they should be measured differently. After some initial trial with locking at different percentages I went ahead and measured her T levels and set them just below where she measured to ensure inaudibility and her detection improved. This patient's links were brought up and her FM detection was mostly between 20 and 30 decibels while ESRTs levels and measured Ts is what this patient needed to get good detection, I want to emphasize that you should start with the manufacturer's recommended method for programming prior to trying something else. This was her most recent complete evaluation, she's got

pretty good detection of tones and Ling sounds. Every time I see this little one, she's able to perform a more difficult listening task. She quickly feeling doubt on the chips and the MLNT and LNT, for PBK words, she gets about 76% with her cochlear implant. She does really well on sentences in quiet, but does experience some difficulty in noise. Finally, I wanted to touch on her CAPs score from her most recent speech and language evaluation. This was from the fall of this past year, and she was three-and-a-half years old at the time of the evaluation. She is in the high average for the majority of her scores. And she's approaching that above average mark in her receptive language on the sentence, comprehension subtest, her score was equivalent to someone two and a half years older than she is. This little one is doing really well. Her speech pathologists, and they created that pragmatic language, taking risks and expanding ideas can be challenging for her.

So they're supporting her in the classroom to develop these skills. Having that strong basis of receptive communication allows them to focus on some of these higher level skills. In conclusion, either T is an excellent objective measure because of its ability to measure a response that is generated by the lower brainstem, where a loudness is perceived. It's a tool that can be used for all patients, particularly those who don't understand the concept of loudness scaling. It is feasible to measure ESRTs on children, especially when you have the right amount of distraction and something to tune them into by using ESRTs to inform your programming. You can get patients into a good map more quickly, which we know is critical for language learning, brain development, and ultimately better outcomes altogether. And finally, programming could not be completed in a vacuum verification of the programming, ensuring access to soft speech sounds, and tracking patient outcomes are critical components of the cochlear implant audiologist in order to provide the best possible outcomes for your patients. These are our references, and thank you. Thank you for your time and attention. We hope you enjoyed the presentation and gleaned some new information about using ESRTs with pediatric population.