BILATERAL SEQUENTIAL COCHLEAR IMPLANT
RAINBOW BABIES AND CHILDREN'S HOSPITAL
UNIVERSITY HOSPITALS CASE MEDICAL CENTER
Cleveland, Ohio
February 24, 2009

ANNOUNCER: Welcome to this OR-Live webcast presentation premiering from University Hospitals Case Medical Center, Rainbow Babies and Children's Hospital in Cleveland, Ohio. During the program it's easy for you to make referrals, make appointments, or request more information. Just click on the buttons on your screen and open the door to informed medical care. OR-Live: the vision of improving health.
00:00:35
GAIL MURRAY, PhD, CCC-A: Hello, and welcome to Rainbow Babies and Children's Hospital in University Hospitals Case Medical Center. We are filming from Cleveland, Ohio. My name is Dr. Gail Murray, and I am the clinical director of the cochlear implant program at UH. Today we're going to show you a bilateral sequential cochlear implant procedure on a 3-year-old boy. This procedure is done on individuals with severe to profound sensorineural hearing loss or deafness and only in those who do not benefit from appropriate or suitable hearing aids. We're going to show you the preparation for the procedure, a mastoidectomy, a cochleotomy, and the insertion of the cochlear implant.
00:01:25
Before we get started, I'd like you to know that this -- you'll have an opportunity to email us your questions and we will email our response back to you while you're watching. Let me give you a little bit of background on our patient as we get started. This case is CR. He failed a universal newborn hearing screening procedure as an infant in the hospital. He went on to demonstrate a profound bilateral sensorineural hearing loss, which was confirmed by auditory brainstem evoked response procedures and ASSR at three months. Following a lengthy hearing aid trial, he presented with very poor speech and language development and he presented for a cochlear implant work-up at 2 years, 9 months of age. He went on to have his first cochlear implant procedure on the right ear at 2 years, 11 months, with then following activation of the right implant at 3 years, 1 month.
00:02:32
Today, CR has profound bilateral sensorineural hearing loss when he is unaided in both ears, with his best threshold of hearing between 90 and 110 decibels for the most important range of frequencies for hearing speech, which is 250 through 4,000 Hz. With his power digital hearing aid at the left ear, he continues to show severe hearing loss levels with responses no better than 60 to 70 decibels for that same speech frequency range. However, with his cochlear implant at the right ear, he's hearing at normal levels between 10 and 25 decibels for the full frequency range that we test, for 250 through 6,000 Hz. He also has very nice emerging speech and language skills, phrasing two and three words together.
00:03:29
If you look at this typical audiogram before and after a cochlear implant, you're going to see that -- excuse me -- the circles represent a sloping severe to profound hearing loss, where actually there's no response for the frequencies above 1,000 Hz where there's still important information for hearing and understanding speech. With a cochlear implant, represented by the CIs in the shaded gray area, you'll see the significant benefit that an

implant provides, particularly for these higher frequencies. So that with an implant, we're able to establish essentially normal hearing. It's also important to note that prior to surgery, one of the candidacy criteria is the speech understanding scores. So prior to a cochlear implant, this patient had very poor speech understanding of no higher than 9%. However, following his cochlear implant procedure, he's scoring on the same measures of 92%. So this is what we anticipate we'll be able to achieve by offering a second implant to our patient today. I'd like to move to Dr. Megerian and introduce him now. Dr. Cliff Megerian is our surgeon. And he can introduce the rest of the OR staff.
00:04:59
CLIFF A. MEGERIAN, MD, FACS: Hello, everybody. Thank you, Dr. Murray. We're very excited to be here today. This is an adorable young man who we're excited to take care of. He, as you know, had an implant done, the right side. And what we're going to be trying to do is really per the family's request go ahead and allow him to hear from both ears. As you know, it's pretty natural to hear from both ears. And as implants have become more and more commonplace and more and more safe and reliable, it's become clear that hearing with an implant is similar to hearing with normal and natural ears. It is -- it's an advantage to hear from both ears. So we're going to take care of him today. And one of the things that we're going to do today is try to concentrate very hard on some unique things we try to do when we're doing an implant surgery when we already have an implant on the other side. So I'll talk through some of the steps that we do.
00:05:47
The first thing we always do is we don't use unipolar cautery, so as not to injure the implant on the other side. For the most part, the surgery will be as if we were doing a single implant. But today, what I'd like to do is talk about some of the things that we do here. I'm not going to say they're unique around the country, but we think they're some of the steps that taken in totality throughout the world have made implant surgery quicker, safer, more reliable. The first thing is the small incision. As you can see, in the old days there was a fairly large incision. We just make an incision in the crease behind the ear. So we're going to go ahead and get started, if it's okay. And we have with us Chris, who's a wonderful nurse I have a lot of experience with; Susan, who's circulating; and Dr. Stork and his team is providing anesthesia.
00:06:33
So we've already injected some 1% lidocaine, 1:1000 epinephrine behind the ear. And as you can see, there is very minimal bleeding. And normally we do these cases with the bipolar when we have a second -- an implant already in the other side. When we don't, we use a unipolar cautery. And what I'm trying to show here is that just with a little injection, sometimes it's possible to get away with using minimal cautery at all. We also have, and you're going to hear some beeps in the background, we already have placed what's called a facial nerve monitor. A facial nerve monitor is designed to monitor the facial nerve. One of the biggest fears that people had early on was that we were going to be injuring the facial nerve. And when I mean early on, I mean early on in the evolution of cochlear implant surgery as a field. Because as you know, for those surgeons out there, the facial nerve -- I'll take a bipolar -- runs through the middle ear. And so we'll talk about some of the things that we do to mitigate that.
00:07:51
So I'm looking for my pedal here. So what I'm trying to achieve right now is I like to call this a superperiosteal flap. In other words, we are making our incision -- I'll take the 15 blade again -- in such a manner as to leave the periosteum down onto the bone. Okay? And I'll take the pickups, please. And we are going to be raising these flaps that will help us at the end close in the most inconspicuous way. Okay. So what we're looking at right now in this field is the periosteum over the mastoid cortex. And we have a little random bleeding here we'll take care of with the bipolar. And we're going to go ahead and put in what we call self-retaining retractors. The next step is to go ahead and take -- again, normally we use a

cautery, but in this case, since we have an implant on the other side, we're going to use a sharp dissection using this blade to create an incision through the periosteum, up into the temporalis region. And this will allow us to dissect very nicely right down onto the bone and create flaps that we can use at the end. Pickups?
00:10:05
So this is the -- what we call a subperiosteal flap that we're developing. And the landmark that we want to take this flap to anteriorly -- and I'll show it to you here in a second -- is the external auditory canal. And as we put in one of the tines of our retractor, you can see the external auditory canal running away from us right here. Pickups? And now we're going to go ahead and raise flaps going posteriorly, so-called subperiosteal flaps posteriorly.
00:10:53
GAIL MURRAY, PhD, CCC-A: I thought I'd jump in and comment about what makes a good candidate for a cochlear implant.
00:10:58
CLIFF A. MEGERIAN, MD, FACS: That's great.
00:10:59
GAIL MURRAY, PhD, CCC-A: In this case, he obviously has severe to profound sensorineural hearing loss because he has an implant already on the right ear; this is a left ear procedure. The other important thing that I mentioned earlier is that this is a child who was fit initially with hearing aids, and very powerful digital hearing aids that were quite suitable for the hearing loss that he presented with. But he failed to show any progress in speech and language development following at least a four to six-month trial with these suitable hearing aids. So that's the other indication beyond the severity of the hearing loss is failure to make expected developmental progress in communication skills. They obviously have to be a candidate from a medical and surgical standpoint, and that's where a CT scan is used to help the surgeon know that an implant can be safely placed in the cochlea. And it's also --
00:12:05
CLIFF A. MEGERIAN, MD, FACS: Yeah, I think -- I agree with you, Gail. One of the things we always like to do not only is make sure that the implant can be placed within the cochlea but that the cochlea is normally shaped and can accept a normal implant. Because sometimes there's abnormal shapes. I'll take the drill.
00:12:23
GAIL MURRAY, PhD, CCC-A: And prior to finalizing a decision to proceed with the surgery, we also feel it's important with our team that they complete preoperative evaluations beyond seeing just the audiologist and the cochlear implant surgeon. So our patients are also seen by a learning specialist to evaluate their learning style and make sure this is something that they're going to be able to benefit and learn how to use it. They also get some baseline data through a speech and language evaluation. And our team also works with the local school programs to make sure that the people that are educating the child on a day-to-day basis feel that this is a plan that they can support once the implant is in place.
00:13:14
GAIL MURRAY, PhD, CCC-A:. This is basically what we consider the cochlear implant process. It's often the audiologist that first identifies a child as having a hearing loss of sufficient magnitude to qualify for a cochlear implant. And then the child will be seen by an otalaryngologist. And in the case of Dr. Megerian, he's also a neuro-otologist, and these are people that have a special expertise in surgery, the very fine microscopic surgery that's involved in the placement of a cochlear implant. As we already mentioned, it's important that the patient undergo both a medical evaluation and a CAT scan of the cochlear structures to make sure that we have a patent cochlea and that an implant can be safely placed, and that they see the learning and speech and language specialist for those evaluations, which is largely obtaining baseline data against which we'll make comparisons as the child progresses. Then they schedule the surgery date. And typically, the activation of the implant occurs two to four weeks after surgery. And it's important to have this time

frame to give the implant and the incision a chance to heal, because the external processor is something that's going to be placed right over the incision and we want to make sure that that's something that doesn't cause irritation to the patient.
00:14:49
Included some slides on how natural hearing works. And you can see in this example, the sound waves are picked up by the outer ear, or pinna, and they move down through the ear canal and actually strike the eardrum, which is number two on your screen. That sets the eardrum into a vibratory motion, which in turn sends the bones -- or the signal through the bones in the middle ear into motion. These bones are called the ossicular chain and specifically are known as the malleus, the incus, and the stapes. The stapes bone is a very important landmark to us for the ultimate placement of the cochlear implant, because it's -- it marks the landmark of the round window, and the cochleostomy through which the implant will be placed is drilled just beneath the oval window -- the round window, excuse me.
00:15:56
Then number three on the screen is the cochlea. And the vibration of the sound waves ultimately causes fluid inside the cochlea to vibrate and set into motion, which then moves the inner hair cells. The hair cells will then change this movement into electrical impulses, which are sent through the hearing nerve up to the brain and are interpreted as sound.
00:16:28
When a person has a hearing loss, the first step is to fit the patient with appropriate hearing aids. These tend to be digital hearing aids. And when the hearing loss is severe to profound, we ideally like to fit a hearing aid that sits behind the ear, as you can kind of see by the faint shadow that's sitting behind the outer ear of this patient. The microphone of the hearing aid picks up the sound and then sends stronger vibrations through the ear canal, across the ossicular chain, and into the cochlea. So they simply amplify the sound. For a person with a sensorineural hearing aid -- or hearing loss, a hearing aid still may not provide the clarity or understanding that they need for effective communication. And when this word understanding is below 50% accurate, that's when we consider the patient a good candidate for a cochlear implant. In other words, when a hearing aid cannot achieve enough understanding for the patient so that they're hearing more than half of the words in a spoken sentence, then they're considered an appropriate candidate for a cochlear implant. A cochlear implant bypasses the damaged part of the ear that you'll see in the next slide. It does something that the hearing aid obviously can't provide when it sends the sound signal through the entire channel of the ear anatomy.
00:18:08
So this screen depicts how a cochlear implant works. The external sound processor, which again is the shadowed area that sits behind the ear in sort of a gray color, it captures the sound through microphones and converts that sound energy into electrical digital signals. The processor then sends these digital signals to the internal implant that's represented at the number two on your screen. At the third stage, the internal implant, which is now inside the cochlea, converts signals into electrical energy and sending it to an electrode array that actually has, in this example, 20 different channels. These electrodes stimulate the hearing nerve and bypass the damaged hair cells, and the brain will then perceive these signals as sound that it can interpret as words.
00:19:11
CLIFF A. MEGERIAN, MD, FACS: So the first step of a cochlear implant is to go ahead and perform a mastoidectomy. And I'm going to go ahead and get started here. We use a high-speed drill. And in these little kids, the mastoid is fairly small. And as soon as you begin drilling, you will be able to see the air cells of the mastoid. You want to take your time and make sure you have plenty of irrigation. And immediately as you open, you'll be able to fall right into the mastoid cavity. Unlike a standard mastoidectomy that you're performing, you don't have to really remove every hair cell -- every air cell within the mastoid. It's really

important to find really one critical structure, which we're starting to see right now and I'm going to point out, which is called the horizontal semicircular canal. Let's roll the patient away from us, please. Let's roll the patient away, please. Good. Keep going. Keep going. Perfect. All righty.
00:20:27
So what we're going to do now is I'm going to point out -- you can see how quickly really in pediatric patients the mastoid opens. And as you see, we're going to be pointing out our horizontal semicircular canal, which is right here. Why don't we take a [Rosen] so I can point that out. That's our first landmark. While we're doing that, why don't we switch to a number 3 drill. And right here you can see the horizontal semicircular canal. People sometimes wonder why you have to open the mastoid to do a cochlear implant if in reality you're really working in the cochlea, which is visualized in the middle ear. Well, the reason is that the mastoid allows us a pathway directly to the middle ear and the cochlea that bypasses and preserves the eardrum. And so when it's all said and done, you'll have a hermetically sealed implant. Now, if we move our microscope back just a little bit, we're going to be able to see another important landmark, which is right here, called the incus. Let's take the Rosen. Once you find this incus bone right here, you can follow the end of it right into the facial recess. Let's take the 3 cutter, please. One of the things that we like to do is we like to really thin out the bony posterior canal, because that's going to allow us to fall right into this facial recess area.
00:22:39
GAIL MURRAY, PhD, CCC-A: Dr. Megerian, one of the patient's concerns are often whether this surgery will interfere at all with the function of the facial nerve. And can you comment on where that is in relation to where you're drilling right now?
00:22:55
CLIFF A. MEGERIAN, MD, FACS: Right. So what we've -- what Dr. Murray's getting at and what I was alluding to earlier is the facial nerve is a very important structure which runs right through the middle ear in the mastoid. And part of the job of the surgeon is to avoid injury to it. One of the best ways is to identify the facial nerve to avoid injuring it. The other way is to open the facial recess directly, and as you're opening the facial recess, know where the nerve is going to be in that relationship. So one of the tricks that we do here is we find the incus, which is right here -- let's turn the water down just for a second. Here's the incus. And then what we're going to do is we're going to follow the end of the incus, which is right here. This is called the short process. And that points directly into the facial recess, which is an area where we have a pathway going directly above -- we'll take a 2 diamond -- directly above the facial nerve and under the eardrum. So as we start drilling, we're going to show you the region of where the nerve is going to be and where we can safely go above it to get into the middle ear.
00:24:06
Okay. So this is the number 2 -- this is a diamond drill. And a diamond drill is unique in that it doesn't have fluted edges, so it is much easier on soft tissue in the event that we get close to the nerve. And what I want to show everybody is...if you can give me a little bit more irrigation, Chris. Our facial nerve is right here, running right into this area right here. You can kind of see through the bone there's a redness. And once we see that, we can come right above it into our facial recess. And this is a very important step, because once we get into this facial recess, we should be able to directly visualize the important structures of the middle ear, and more importantly, the round window, which is really the area that we're trying to target.
00:25:45
Okay, so one of the ways that you know you're going in the right direction is you all see through here -- you see a little what looks like a little tendon. And that's the tendon of the stapes. Okay. Let's take the 5 suction. So you kind of know you're heading in the right direction is when you've gone through the facial recess and you see that really nice-looking

tendon there. And that's the tendon of the stapes, so-called stapedial tendon. And now what we want to do is we want to carefully go above the facial nerve, which I pointed out is right under here, but not hit it, but open this facial recess until we can see what's called the round window. And we're going to see that together here in just a minute. That's the window that opened us into the cochlea. What you have to be very careful about is not putting your burr or your drill on the facial nerve. Because our facial nerve, as I mentioned, right here is protected by bone, but if you didn't really have bone over it, you could injure that nerve with that turning of your burr. And now you can see the round window. If you look very closely -- let's take a 20 suction -- you're actually going to see your round window. So we've done some of the most important part of this operation already, is expose this round window right over here. You can see this window. And there's a little bit of irrigation. If you noticed, we irrigate during the surgery. Irrigation makes sure that we don't burn the bone. It helps the drill move faster. And there's the window right there. You can kind of see a half moon right there. And there's your stapes tendon.
00:27:40
So we have prepared the opening. And in essence, when we open the cochlea we're going to go right through this area to put in our electrode. But we've got a little bit more work to do. What we have to do now is we have to prepare an area to seat the implant device. So as Dr. Murray pointed out, the implant has two parts: one part is the part that we're going to put in today, which is the internal electrode lead and the signal processor; and the external is the microphone and the rest of the external components. What we need to do is put an area in the bone underneath the skin that's inconspicuous as possible where that is going to be housed. So let's go ahead and do that. I'm going to actually not work under the microscope now. I'm going to push this away. We're going to roll the patient toward us. And we're going to come up with Chris to make and hold some rakes here. Thank you. Hold here. And hold here. And we'll take a periosteal elevator. We're going to go ahead -- let's remove this retractor just for a second here. He can come out. And let's turn this around this way. One of the things that we have to do is release the soft tissue. There we go. And we'll take this, put this here. And we'll put this over here.
00:29:39
Okay. Now the fun part is to take this -- this is a dummy implant -- it's really silicone, or silastic -- and we want to fit this -- this is a silastic. This is about the shape and the size of the implant. And we'll show it to you in just one more second. Let's make sure that we have enough room to put this in. And this is -- we call it a dummy because we're really going to be making some measurements and making sure that it's where I want it to be. So we're going to pull back the temporalis muscle and fascia here now. I'm going to pull this back here. And here. It's amazing how much room that you can have through this small incision. And it's really amazing how much progress we've made, I think collectively, as surgeons around the world, really, in making this a small incision compared to before. So I'm going to go ahead and use this marking pen to delineate an area where I want this to sit. And we'll take a sponge. And this is where we bring the microscope back. Are you going to be able to be okay there, Chris?
00:31:22
CHRIS: Yeah, I should be okay.
00:31:37
GAIL MURRAY, PhD, CCC-A: There are about 6,000 of these procedures that take place annually in the United States. And there are actually three manufacturers of cochlear implants. And then just throwing out a statistic, one of the -- as of last year, it's estimated that approximately 120,000 cochlear implants have been performed worldwide. Okay. So it's amazing how this technology has taken off. It's also interesting to note that by the time an adult reaches the age of 75 years of age, about one in three of those individuals will have a hearing loss that -- of sufficient degree that will actually be handicapping when it comes to communicating effectively. So there are many more people that no doubt are

candidates for a cochlear implant out there trying to use hearing aids unsuccessfully who would actually qualify for this procedure.
00:32:47
CLIFF A. MEGERIAN, MD, FACS: Okay. And what we're doing right now is we're exposing the area. And what we like to do is we like to work underneath this skin flap so that in the end it's all covered back up again. And we like to expose -- relax a little bit. There we go. Expose this bone. This is kind of thin bone in children. Can you pull back? And we have to make like a little well here. Now, one of the challenges that we have is in children this is very thin. In adults, it's a little thicker. Okay, you really need to let go just for a second. Let go just for a second. And you need to pull, okay? There you go. Pull. Sorry. The challenge that we have in children is sometimes this bone is very thin. And what you don't want to have is, in an implant, is you don't want to see or feel the implant sticking through the skin too much. And so what we try to do is we try to make sure that we have a nice little pocket in the bone for this to sit. And this sometimes can be one of the more challenging parts, because what you're going to see very quickly is the dura.
00:34:38
GAIL MURRAY, PhD, CCC-A: And for the people that don't know what dura is, do you want to ex--
00:34:43
CLIFF A. MEGERIAN, MD, FACS: Yeah, the dura is directly under bone, and it's the covering of the brain. And we don't violate the dura, we don't injure the dura, but what we do is we want to put the cochlear implant so it's as flush as possible in the child. And that means sometimes removing bone right to that dura. This is pretty standard. And it takes just a little bit of extra work just to do it safely. Okay. Let go just for a second. Give me a little irrigation there. You can see here we have quite a bit of room on this lower end as we come up here. We have a little thinning of the dura there.
00:36:32
I think there's about three or four things that a surgeon can do during the surgery to make the implant as trouble-free for the patient postoperatively. One of them is taking this time to create a nice well -- I like to call it a well -- for the device to sit so it's not protruding through the skin. The second thing, I think, is a nice, small incision just in the postauricular area, with minimal extension behind. I think these are some of the steps that have made the implants become much more risk-free. In other words, when implants first became popular, there were more problems with infections that developed in the postoperative period. And a lot of them were due to the flaps in the skin. But now since we make a small incision and we tend to -- as you'll see at the end of the operation -- hide the device very nicely, those complications have really been minimized because the implant is nicely seated and sealed. In this case, we're digging a very beautiful little pocket here.
00:38:10
Now, in this case we have a little challenge right now. We have a little bit of the dura here that is going to be in the way of a perfect seat. So what we may do in this circumstance is take a diamond drill and just expose and kind of relax that dura a little bit. This is kind of a modification of this thing we call a dural island. Let me show you. If I go up in power a little bit, you see one of the challenges of seating this implant in this young man will be the implant will want to be protruding in this one part, because the dura, as you can see, is a little bit lateral. But what we can do is take a diamond burr and just gently…remove the thin bone. Be careful not to injure it. And this dura is just going to sit down nice like that. Do you see that? Pardon? So if you see right over here, that's going to sit nice and flat when the implant goes in.
00:39:56
GAIL MURRAY, PhD, CCC-A: And the dura actually looks like a tough piece of tissue, looks kind of like a rubber band to me. That's how I would describe it. It's not as thin as one would imagine.

00:40:06
CLIFF A. MEGERIAN, MD, FACS: No, dura is very tough, it's very thick. In fact, *dura mater* means "tough mother." It's the mother of the brain, and the dura means it's tough.
00:40:19
GAIL MURRAY, PhD, CCC-A: So while drilling down the dura, which is the covering over the brain, might be frightening to some parents, it's actually very safe to expose that and to lay the implant right on top, because it is so tough. It's a nice, tough covering to basically protect the brain.
00:40:40
CLIFF A. MEGERIAN, MD, FACS: The younger the child, the more exposure you're going to have, at times, of dura, and that's a standard procedure. In some cases, you have to expose the whole area of the dura. Next step for us is to make a little trough. And we're more than halfway done with this operation. Just kind of the winding down part. We're going to make a little trough between the mastoid cortex here and the implant receiver well here. And we take a little cutting drill. And you can see we have a very nice pathway right here. Sometimes you've got to be careful if the sigmoid sinus is running high, but in this case it's very nice.
00:41:33
The next step for us is we like to -- we kind of like to really secure our implant so it's not going to move. So to do so, I like to put sutures. And what we've kind of decided upon here is putting in sutures through the bone. So I take a number 1 drill and I make a little opening and pop through. Same on the other side. And then we take a suture -- I usually take a 2-0 neurolon suture that's already loaded here by Chris.
00:42:27
GAIL MURRAY, PhD, CCC-A: While we use some sutures that absorb when we do the final closure of the incision, these are nonabsorbable sutures so that they will be there forever, basically, to permanently tie down the receiver packet so that it is stable and doesn't move once it's in place.
00:42:49
CLIFF A. MEGERIAN, MD, FACS: Then I take a bite through the back, through the periosteum. And you're going to see how this is going to nicely hold down the implant when we're done. And we attach these over here to little mosquitoes. And I'll take another stitch, and we'll do the same thing going from the other side. And what I like to do is I like to bite in the back. Let's have you pull up a little bit like this, Chris. Sometimes you have to put your finger here just to feel and make sure you're in the right plane. Okay, I want to get a little bit… There we go.
00:43:31
GAIL MURRAY, PhD, CCC-A: One of the questions patients often ask when they present for a cochlear implant is what the success rate is for this type of surgery. And you can think of success in a number of ways, the first being what the reliability of the implant is in terms of the long-term longevity of the device inside the body continuing to function. And my response to these patients is that the implant's designed to last a lifetime. Once it's in, we do not ever expect to need to remove it and take it out. On the other hand, the device -- or the part of the device that's worn outside of the body is something that we expect to change over time. The external speech processor is something that is replaced as technology advances and improves and -- excuse me -- provides better function and actually better outcome and performance over time. So while we never anticipate that the internal implant will ever need to be replaced, the external equipment will be replaced as advances occur.
00:45:54
CLIFF A. MEGERIAN, MD, FACS: Let's roll the patient away, please.
00:45:57

GAIL MURRAY, PhD, CCC-A: The other thing to think about in terms of success rate is the actual performance of the patient with the implant once it's applied. And it's important for us to set realistic expectations for the patient prior to the surgery based on their individual medical history, because there's a broad range of postoperative outcomes and postoperative performance. This is often associated with the ideology for the hearing loss, the duration of deafness, the amount of language or time -- say, in an adult with an acquired hearing loss, the amount of time they heard prior to losing their hearing. In the case of a child like this, our goal is to implant the child as young as we possibly can so that they have as much exposure to sound during the most important years for speech and language development, which is generally thought to be between birth and the first three -- third or fourth year of life. So --

00:47:07

CLIFF A. MEGERIAN, MD, FACS: The way we're -- I'm sorry to interrupt you, Gail. I just wanted everyone to see as you're talking, now we've gone back to our facial recess. And again, I'm going to point out the structures, because we're getting ready to go ahead and make our opening into the cochlea. And this is really a beautiful anatomical view. You have your facial -- facial recess is right here, this opening. You have your horizontal semicircular canal here. You have your incus right here. Your incus is moving right here and you can see your stapes moving in and out. And as you look downward, you have right here is your round window area, okay? Okay, we'll try it again. Let's take a pick, please. So I just want to show some of this really nice anatomical structures that we have. This is what you want to see as you're getting ready to do your cochleostomy. You want to see a nice trough right here, you want to see your horizontal canal. You can see your facial nerve and its horizontal segment right here. You can see your incus, and you can move your incus. And you can see your stapes moving. And then inside you can see your round window right here. Now, our goal is to go ahead and make what's called a cochleostomy, which is an opening. And I like to make it right over the lip here and make sure I open to the scala tympani. We're going to go ahead and take a 20 suction, which I have in my left hand and a number 1 diamond drill, and we're going to have – Chris will irrigate for me as we're drilling. And we'll move the pedal over a little bit.

00:48:44

One other thing that's very important as you're doing this is to make sure that your shaft of your burr is not on your facial nerve area right here. It's a quick way to injure the nerve, and if you make your opening large enough in your facial recess, you have plenty of room to avoid injury and avoid that happening, okay? Make a little divot there. Make sure we're centered here so everybody can see.

00:49:29

GAIL MURRAY, PhD, CCC-A: Again, what's the size of the drill you're using?

00:49:32

CLIFF A. MEGERIAN, MD, FACS: This is a 1-millimeter diamond drill. And you can now see the endosteum, which is the inner lining of the cochlea. And there we have it. Now, you don't want to suck too hard, but you want to be able to see -- there we go -- that we're in the cochlea. And you can see that very nicely, okay? And we can actually see the basilar membrane so that we're for sure in the scala tympani. And here's the basilar membrane right here. We're going to go up in power a little bit, take a little suction here but not suck too hard. This is a very nice important view. Let's take a pick, please, so we can all see. Let's take a pick, please. You can see right up here is the basilar membrane up top. Here is the round window, and then there you're going to see going away from us, there is perilymphatic fluid...and the first turn of the cochlea, the so-called basilar turn. You go back a little bit, maybe it's a little better view this way. I like to make my cochleostomy between the stapes and the promontory. And I'm always able to preserve that basilar membrane right here. Now, you don't suck too hard, but you know you're within the cochlea, because

as you get a little bit of fluid, you can see the basilar turn going away from you. That's really a perfect picture, and he's going to have a perfect insertion, I think. We hope. Okay?
00:51:30
So let's go ahead and get our implant on the field.
00:51:35
GAIL MURRAY, PhD, CCC-A: It's actually the basilar membrane that has the spiral ganglion cells that ultimately are stimulated by the implant, that enable a patient whose hair cells are damaged to hear. Why don't we go back to the PowerPoint slide that I have up at the moment. This basically outlines the advantages of having two cochlear implants instead of one. This is something that has only become common practice in the last about three years, but it makes sense. We're born with two ears. When we find that an individual has hearing loss in both ears, we would never consider only fitting one ear with a hearing aid. And so we find that there are some very distinct advantages of having two cochlear implants as well, and they're outlined here on this slide. The first is that a person is going to hear and understand speech better with two than with a single implant, and that's particularly true when there is competing noise in the background. The other thing that's --
00:53:05
CLIFF A. MEGERIAN, MD, FACS: Are you able to see?
00:53:09
GAIL MURRAY, PhD, CCC-A: The other thing that's important is that we can only accurately identify the location of sound in the space around us when there are two similar-hearing ears.
00:53:21
CLIFF A. MEGERIAN, MD, FACS: Can I interrupt you for one second, Gail?
00:53:22
GAIL MURRAY, PhD, CCC-A: You bet.
00:53:23
CLIFF A. MEGERIAN, MD, FACS: So what we're going to do is we're going to place -- here's our implant device, because -- can everyone see that? Okay, the implant device is going to come under my sutures that I've put in, deep underneath the temporalis muscle, slide back into the slot I've created, and it's going to sit right in perfectly like we see it. Now we're going to pull my sutures, and my sutures hold it in just perfectly, okay? Now we're going to tie these down, and that's going to give us a very, very nice seating for this young man, okay? So we'll tie these down, and we're going to have Chris just go ahead and -- perfect.
00:54:43
And we'll take our scissors. And one more tie-down here. Just holding our leads…so they don't move and migrate. You can see that's holding the leads over the trough. Okay, so we're moving right ahead. The next step is we're going to go ahead and put our extratemporal lead, and maybe Dr. Murray can explain this, but there -- the implant actually comes with two different electrode leads, and you can kind of see them here. One lead is designed to be a ground, and we like to place that underneath the temporalis muscle, so I'm going to make a little pocket here for that. We'll take a pickups and a periosteal. Periosteal, please.
00:56:03
GAIL MURRAY, PhD, CCC-A: While he's doing this, maybe we can flip to the bone fluoro animation and actually give the audience a view of what -- give the audience a view of what it's like to see the implant inserted in live action. So you're looking outside the wall of the otic capsule. Dr. Megerian has referred to the basilar membrane, which has the modiolus, houses the modiolus, and you can see as the implant is being inserted, the electrode is actually advanced off of a stylet that remains stationary that initially keeps the implant straight and rigid, but as the implant is moved off the stylet, the electrode smoothly curls through the cochlea and takes the shape that we want it to have.
00:57:07

CLIFF A. MEGERIAN, MD, FACS: Okay, so what we're doing right now is, as you can see, we've put in our extratemporal lead. We've been able to slide it nicely deep to the temporalis muscle, which is here, and we have a very nice view here of our mastoid, but more importantly, we're going to be looking straight in here at our round window and our opening at the round window. There's always a little bit of blood after that you want to get out of the way. But you can see very nicely. And I don't like to suck too hard over the round window opening, or our so-called cochleostomy. But you want to get the blood out of the way. And you can see our opening there, okay? And our job next is to go ahead and fit our implant and kind of guide it through that opening. So what I like about this particular device is that it has a very simple implant system where in essence you grab gently the electrode lead like this, and then you guide it. So let's take a 20 suction, we could use that.
00:58:15
Now, some surgeons like to go ahead and put the implant in first, like I do, in terms of the housing and the receiver, but other surgeons like to go ahead and put the leads in first. I like to do it this way. I think it's fairly straightforward.
00:58:34
GAIL MURRAY, PhD, CCC-A: That side view was perfect. It really showed the stylet well.
00:58:39
CLIFF A. MEGERIAN, MD, FACS: I may have to re-grab this just a little bit.
00:58:44
GAIL MURRAY, PhD, CCC-A: Here we go. You see the little end is the stylet that we were referring to before.
00:58:55
CLIFF A. MEGERIAN, MD, FACS: Now you want to advance -- do you see that white line? There's a white line that it goes right up to the cochleostomy site, that white line right there. And this -- we're going to be doing what's called the off-stylet technique. We're going to go up in power so you can see exactly what we're doing. The nice thing about this off-stylet technique is you can see that there is a stylet right here, this metal stylet. That's keeping it straight and stiff. As I've advanced it into the cochleostomy up to that white line, it is essentially just about to turn at the basilar turn. But if you continue in that direction with that stiff stylet in, you're going to start tearing membranes and tissue in the cochlea. We want to do this as atraumatically as possible. We want to preserve residual tissue. So what we want to do is we want to pull the stylet out as we're advancing in, and the key is to have this white line right at the cochleostomy site. So you grab the stylet and you engage and you push as you're pulling. And I like to get the three ribs in, and there you have it. You have a nice insertion with the off-stylet technique.
01:00:15
And what Dr. Murray's going to be able to show you are some fluoroscopic images of exactly what it's like for that electrode to be traveling within the cochlea. We're going to give you a closer view. Let's take a suction and a pick. The other thing I really like about this particular device and the way that we do the implant surgery here is that as you can see, when you have the outer three ribs at the cochleostomy site, it essentially is self-sealing. Now, we will put a little tissue around that to seal it again, but it is self-sealing. That Silastic comes right to the edges of your cochleostomy. It really is a nice system. Why is that important? It's important because you don't want to have a lot of flow -- take a scissors, please. You don't have a lot of flow of perilymph or fluid in and out of the opening that you create because you could theoretically injure or cause some sort of toxicity to the cochlea. You know, there is these discussions about meningitis and infections. There is some evidence at least that the large cochleostomies can potentially be a problem. So we like to make as small a cochleostomy as possible. It also helps preserve residual cochlear function. I'll take a 20 suction. I've taken a little bit of fat here, and we're going to go ahead and seal around that cochleostomy.
01:01:43

GAIL MURRAY, PhD, CCC-A: So you use the patient's own tissue to seal off the opening of the cochleostomy.
01:02:02
CLIFF A. MEGERIAN, MD, FACS: Actually, I think it would be better to use some -- pick-ups, please.
01:02:05
GAIL MURRAY, PhD, CCC-A: Do you want to go to the Advanced Off Stylet demonstration quickly while… So this is actually in an animated format showing the actual insertion of the implant using the AOS technique where you see the white line halfway down the electrode array. It's being inserted, and then as the white line disappears inside the cochleostomy, you remove the stylet, and that's what allows the electrode array to settle in and actually hug the modiolus. Okay.
01:02:56
CLIFF A. MEGERIAN, MD, FACS: Okay, and what we're doing now is we're curling the electrode leads within the mastoid, and you can see there's a lot of extra room of that lead to, if necessary, expand as there's growth. We're going to go back to high -- I'm sorry, to lower power and we're going to begin closing. We're essentially done with the meat and potatoes part of this cochlear implant. It took us just under an hour. We're going to go ahead and take some gel foam, and this is another thing I like to do. I like to put a little bit of gel foam, which is an absorbable gelatin, and I like to kind of seat it over the mastoid defect just like that. And we will go ahead and start closing, okay? So what I like to do, and this is another important thing I feel is necessary, is to make sure that we have a layer of periosteum that is covering the device so that when we close the skin, it's not such that the device is directly under the skin layer, that there is another layer of periosteum. So we pull this back and we get our edges of our periosteum. This is going to be a very nice closure.
01:04:25
And I like to do this as a running stitch. I'm able to kind of collect all of my tissue within this stitch. This is a 4-0 MAXON. It is absorbable. Okay, and we have some scissors here.
01:04:49
GAIL MURRAY, PhD, CCC-A: While he's closing, maybe we can go ahead and show that last AOS Flythrough animation. So this again is as though you had a camera pretty much sitting on the end of the implant as it goes into the cochleostomy. You get a view of what it looks like inside the scala tympani as the implant is inserted. Going back to some of the advantages of the bilateral cochlear implant on the PowerPoint slide, we covered the first couple, and that being improved understanding of speech and noise and the ability to localize sound in space, which is, again, only possible with two similar-hearing ears. If we can go back to the PowerPoint. There's also a phenomenon known as binaural summation, and that's where information is taken with the two ears and you actually come up with a little more power than you would if one ear was hearing alone. So this allows for a safer stimulation of the implant, because we're able to do so at lower levels of electrical energy and have the patient still experience the same loudness effect with the two implants. It also spares some of the battery life that is required to drive the implant.
01:06:35
The fourth advantage is that having two implants, one on each side of the head, eliminates what we call the "Head Shadow" effect. The head actually serves as a barrier. So in this little guy's case, with having initially only a right-sided implant, if his mother came off from the left side and was calling him, the head would actually reduce the loudness of her voice by about six to ten decibels and he would not be able to hear her as well. So the advantage of having a second implant is that it eliminates that head shadow effect and allows the user to hear with 360 degrees in a third dimension, essentially. The fifth point is that it guarantees that the best ear with the most neural potential is going to be implanted, and this is something that we're not able to predict with 100% accuracy prior to a surgery. We'd like to target the ear with the most neural reserve, with the most spiral ganglion cells, but

we don't actually have guaranteed presurgical test methods that enable us to do that, so by implanting the second ear, we know that we've actually gotten the best ear stimulated.
01:07:58
Then the last point is that a second cochlear implant is going to provide the patient with guarantee of continued access to sound in the event of a device failure. And while we don't expect the internal device to fail, the part that's worn externally may fail. And in the event that that occurs, it's unlikely that both devices will fail simultaneously, so we know that the patient will continue to have access to sound regardless of the device function. So as I said before, we've been advocating for bilateral cochlear implants for about the last three years. Approximately 50% -- approximately 50% of our population elects to pursue a second-side cochlear implant. Oftentimes this is done in a sequential mode, as we're doing in this case today, where we like to implant the first ear, work with it and know that the patient's going to benefit from the first implant before actually proceeding with the second surgery. But we also have cases where, because of the advantage of having a single anesthesia, they elect to have both sides implanted during a single procedure, and that's certainly something that's feasible that we also advocate.
01:09:22
So back to you, Dr. Megerian.
01:09:25
CLIFF A. MEGERIAN, MD, FACS: Yeah, I think that I want to show what we have here. So the implant is in now. And one of the things that I like to see at the end of the case is that when you close the periosteum, you really can't see the implant, you can't see the mastoidectomy, there is a nice layer of periosteum closing. Okay. Okay, so one of the things I like to show is that at the end of the case -- and I'm sure that this is something that many and most surgeons try to do -- is that the periosteum is completely covering, number one, the implant, which is up here. And you can see, the implant is deep to the skin, so we're able to recess our implant and put the device in through this fairly small incision. But number two, we have the periosteum completely closed, so this is an extra layer of protection. And we can go ahead and put in our stitches now in the skin, and we use what's called a running subcutaneous subcuticular stitch. But the other thing that we're able to do now is we try to go ahead during these cases and do intraoperative measurement of the device itself and make sure that the impedances of the electrodes are working well. And in addition, especially in children, it's nice to know at what stimulation level we're going to go ahead and start the stimulation. So we like to do what's called neural response telemetry.
01:11:03
So we go ahead and attach and do a measurement as I'm closing, and it usually doesn't cause us to waste too much time, or take too much time is a better way of saying it. So whenever we're ready, we can go ahead and do that and I can go ahead and get the suture going.
01:11:38
GAIL MURRAY, PhD, CCC-A: Okay, going back to the computer monitor now. So you actually see -- so you're actually seeing the programming software now, and the -- the transmitting antenna is actually sitting over the flap as Dr. Megerian is closing, which actually has a two-way radio frequency communication that allows us first to measure the implant's impedances. So that's what I'm going to do next. And the details are provided here. And what we want to see is exactly what we're seeing now. We're seeing nice, consistent impedances across four different modalities in which the active electrodes are measured and paired with one of two ground electrodes in one of four different modalities, or modes. And it's important that the electrodes fall within a given range, which each of these do, and it enables us to know that we've got a working implant in place.
01:13:00
CLIFF A. MEGERIAN, MD, FACS: Doing a closure that is a subcuticular subcutaneous closure, and I really like this. It's a running stitch. The child or the adult does not have to have the

sutures removed postoperatively. This is an absorbable MAXON suture. And you can see, it will bring the edges together very nicely. And we're able to do this as Dr. Murray is doing her neural response telemetry.
01:13:45
GAIL MURRAY, PhD, CCC-A: Okay. Whoops, excuse me. Moving back to the laptop. So now we're actually stimulating the innermost electrode, number 22, which corresponds with the apical end of the implant array. And we've lost our visual, but it's recording pretty much automatically through the software where the first neural response is occurring on this channel. I'm not able to see it. And in this -- in the event of the first one, it's taking a threshold measure of around 155 clinical units, which is actually quite good. I'm going to stop this for just a second, see if I can get my screen back. If you want to move back to Dr. Megerian?
01:14:53
CLIFF A. MEGERIAN, MD, FACS: You can see the incision closes to a nice, fairly aesthetically pleasing path along the postauricular crease, which, after a short period of time, you won't be able to see it. Can you see that? Great.
01:15:29
MAN: Try again?
GAIL MURRAY, PHD, CCC-A: Yeah, go ahead.
01:15:33
CLIFF A. MEGERIAN, MD, FACS: Then we kind of tie this off here.
01:15:38
GAIL MURRAY, PhD, CCC-A: Good. Okay. If we can go back to the computer monitor again. And this is an example where we see a very classic, beautiful auditory nerve response on -- electrode 1 just finished, so now we're measuring electrode 11, but what you'd seen was the auditory nerve response, the neural response, to stimulation on the electrode that's actually closest to the cochleostomy, the point of insertion, so we are very happy to see that. It tells us that this patient's going to hear. You'll see that again collected on electrode 11 as the stimulation levels increase.
01:16:22
CLIFF A. MEGERIAN, MD, FACS: Okay, we'll go ahead and take the sticky stuff.
01:16:28
GAIL MURRAY, PhD, CCC-A: And the red line with the two markers is the actual nerve response. This is collected through computer averaging techniques that actually re-samples the response off the nerve multiple times in order to elicit that visual response. And again, now we're sampling on electrode 16, and this response came out actually very early. A very nice response. Okay. We tend to measure responses on the average of between five and nine electrodes. I like to go for a few extra electrodes in the case of a young child who's not always able to volunteer what he's hearing when we do the initial activation, so having a little more data is often helpful for the youngest patients. This data is going to be used to help us establish the very first program or map that will be stored in the external speech processor and used to stimulate the auditory nerve and provide sound.
01:17:42
Usually these NRT markers that you're seeing on your screen in purple correspond to the upper limits of comfortable stimulation that a patient will hear then as a louder sound. And using this data, then we are able to set the lower margin or the low end of threshold, first experience with hearing, or soft sound, about 30 or 40 units below where these purple markers occur. So this is a very effective means of establishing a first program even without the patient giving us the most reliable information at the initial activation.
01:18:27
CLIFF A. MEGERIAN, MD, FACS: Okay. So what I wanted to show you is we finish up with a little Steri-Strips behind the ear, and these come off usually at seven to ten days. We put a mastoid dressing on and the patient goes home this morning. Are you done with --

01:18:43
GAIL MURRAY, PhD, CCC-A: Not quite. We have one, two…a couple more to go.
01:18:46
CLIFF A. MEGERIAN, MD, FACS: Okay.
01:18:47
GAIL MURRAY, PhD, CCC-A: We're almost done.
01:18:48
CLIFF A. MEGERIAN, MD, FACS: If we can start taking this down a little bit.
01:18:59
GAIL MURRAY, PhD, CCC-A: So we've actually sampled on about eight electrodes at this point. You're not able to appreciate the entire screen from your view, but we're stimulating channel 8, which is a mid-pitch electrode channel, and this is increasing the level of stimulation, and we're just beginning to see the response come out, again, in the red line where we now have the two markers. Okay, and we're done.
01:19:57
CLIFF A. MEGERIAN, MD, FACS: Yeah, so it is a really good feeling right now to be finished with your surgery and to have stimulated the cochlea and know that the device that you put in not only is in the right position but also that actually the child or the adult is going to hear because we've been able to actually directly measure the cochlear nerve potentials, which I think is really important. The other thing that I wanted to just show you is it's really -- I think this is something that a lot of the families will appreciate a lot, is that the -- the incision is fairly small, it's fairly inconspicuous. All that they're left with really is a Steri-Strip behind the ear, and when it's healed, you're really not going to be able to see the incision. And you can see the implant is up in this area, and there's really not much for one to see in terms of a protrusion. So all in all, today -- you're hearing me take out the facial nerve monitor. All in all, today's surgery went, I think, very well, exceedingly well, and I want to welcome everybody to our operating room here at Rainbow Babies and Children's Hospital at Case Medical Center. And we'll be available for any questions online. Thank you.
01:21:16
GAIL MURRAY, PhD, CCC-A: This about brings us to the end of our case today. On behalf of myself, Dr. Megerian, and everyone else here in the O.R. at Rainbow Babies and Children's Hospital in University Hospital's Case Medical Center, we want to say thank you for watching. If you'd like to make an appointment, make a referral, or get more information about the procedure you just saw, you can click on any of the buttons on your webcast screen and obtain that information. If you missed any portion of this program or would like to see it again, you can do so by visiting the University Hospital web site at www.uhhospitals.org or at www.orlive.com. Thank you again for watching. Have a great day.
01:22:03
ANNOUNCER: Thank you for watching this OR-Live webcast presentation from University Hospitals Case Medical Center, Rainbow Babies and Children's Hospital. OR-Live makes it easy for you to learn more. Just click on the "Request Information" button on your webcast screen and open the door to informed medical care. OR-Live: the vision of improving health.
01:22:16
[end of webcast]