ANNOUNCER: Welcome to University Hospitals Case Medical Center in Cleveland, Ohio. Over the next hour you'll see a right frontal craniotomy performed with image guidance. Advances in technology have made it possible to identify the precise location of tumors and map various possible trajectories for surgery. Surgeons can remove lesions under a microscope using a delicate tool known as the cavitron. Intraoperative MRIs are done in the operating room to confirm that the goal of complete tumor removal has been achieved. Studies have shown that complete removal can cure seizures and improve quality of life and survival. 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. Now let's join the doctors.

ANDREW SLOAN, MD: Hello, my name is Dr. Andrew Sloan. I'm a neurosurgical oncologist at the University Hospital Case Medical Center. And it's really my pleasure to host today this live webcast on right frontal craniotomy with intraoperative MRI guidance on behalf of the Neurological Institute, Ireland Cancer Center, and the University Hospital Case Medical Center. I'd also like to introduce my colleague, Dr. Stephen Sagar, who's a neurological oncologist and runs the residency program for the department of neurology here at University Hospital Case Medical Center.

STEPHEN SAGAR, MD: Good afternoon, everyone.

ANDREW SLOAN, MD: I'd also like to remind the audience that we are happy to take your questions, and there's a small button at the bottom of your screen that will allow you to email questions to us. Let's begin with the first case.

STEPHEN SAGAR, MD: The patient we're going to see operated on today was a 48-year-old man when he first presented. And he initially developed bad headaches, which led to an MRI scan of his brain. He had no significant other past medical history, was a very healthy firefighter, but his MRI was abnormal, and that led him to be referred for neurosurgical and neurological consultation. So his MRI demonstrated an area of increased T2 and flare signal mainly involving white matter of the right frontal lobe. The differential diagnosis of such a lesion includes a tumor, specifically a glioma; also cortical dysgenesis, areas of cortex that are mispositioned because of developmental abnormalities; or less likely, areas of prior demyelination or inflammation. He was -- this information was discussed with the patient, who was neurologically normal at the time, and the options were presented to him. Those included the conservative option of following him with repeated scans to ensure that this lesion didn't change over time or more aggressive options, including surgical biopsy or surgical resection. Quite understandably, at the time being normal and asymptomatic, he declined the option for neurosurgical intervention and elected for conservative -- for conservative management. This was okay, he did okay, but then in March of the following
year he began having seizures. And this led to an admission at an outside hospital. He was started on an antiepileptic drug, which controlled his seizure, but then he returned for further neurosurgical consultation and was more interested now that he became symptomatic in pursuing the surgical options. And at that point is when the neurosurgeons first met him.

ANDREW SLOAN, MD: That's right. And as you know, Steve, whenever we consider surgery, we really have three goals in this sort of a setting. Number one, we'd really like to remove as much of the tumor as we can without harming the patient or hurting his quality of life. Secondly, we like to perform surgery in such a way as that -- so that we control the seizure focus. And the third thing that we have to do is to make sure that we do not harm anything in the brain that is eloquent. And by that I mean parts of the brain that have functions that are really critical to our day-to-day behavior, such as language -- either understanding language or spoken language such as speech; memory; vision; etc. The reason for that is fairly complicated. And I first would like to just explain why this is so. The brain has more individual variability than any other organ in the body. And in fact, patients with tumors, low-grade tumors in particular, tend to shift these eloquent areas out of the position that they were initially or sometimes actually move them to different areas of the brain entirely. And that is really critically important and something that we don't generally see from our standard imaging techniques. Let's review a little bit about why it's important to get the whole tumor out. This is a topic, Steve, that as you know has been fairly controversial for about 20 years, but in the last 10 years I think the neurosurgical and oncologic community has really come to an agreement that it really does make sense to get the whole tumor out when possible. And I think this slide illustrates why that's so. If you can get 95-- this is a slide from a randomized control study of surgical resection for brain tumors when the surgeon was able to get 95% or more of the tumor out or when he was not. And as you can see, the curve on the right, not only is the median survival, or average survival nearly twice as long, but the number of patients with long-term survival is markedly increased, more than double. Now, this slide actually pertains particularly to higher grade tumors, but there's a lot of evidence to suggest that the same is true for low-grade tumors as well.

STEPHEN SAGAR, MD: I think that's generally widely accepted among both medical and surgical neurooncologists at this -- at this juncture.

ANDREW SLOAN, MD: The problem becomes once you know where the tumor is, how do you know where these eloquent regions are, particularly as we said, because low-grade tumors are notorious for shifting these eloquent regions out of the way. And so we have to talk about the technology of brain mapping. And there are really three kinds of mapping that we're going to talk about. Number one, mapping anatomy; number two, mapping function; and third, tumor physiology. So when we map anatomy, we're actually talking about a number of different things. We begin by -- the goal, obviously, is to know exactly where the tumor is and other eloquent regions of the brain are in three dimensions. And we start with a very high resolution MRI, which we then make -- use to make a virtual model of the brain in virtual time and space. Then we take the patient to the OR and then under anesthesia we perform what's called a co-registration. And what this allows us to do is use this preoperative MRI and co-register it to the brain in real time and space so that our probe, or the crosshairs on our microscope when we're using the microscope, actually allow us to navigate in the brain very precisely in much the same way as a GPS system would allow you to navigate in your car and tell you exactly where you are in three dimensions. So that tells you where the tumor is. We can also use intraoperative MRI, and that's really a novel technique that really has become a hallmark of our program here in neurosurgical oncology at University Hospital and the Ireland Cancer Center. And that allows us to make sure that we did what we thought we were doing. Intraoperative ultrasound is also somewhat useful,
although we will not be illustrating it today. The fourth anatomical technique that I'm going
to talk about is something called diffusion tensor imaging. And the reason that's important
is that the standard mapping techniques allow you only to map to the cortical surface so
that you know where the cells on the surface of the brain are which subserve these various
functions. The problem is, as you know, Steve, the brain is like a computer. And if you --
even if the parts work, if the wires get disconnected, the system as a whole doesn't function.
And so the brain has various cortical functions on the surface, but if the fiber tracks relaying
the various signals from these surface cells to deeper parts of the brain where they have to
interact with the other cells are broken or crossed, the brain doesn't function properly. So
diffusion tensor imaging allows us to track these fibers so we know not only where the cells
are that control the functions but where the fibers taking this information to deeper
structures in the brain lie. The second type of mapping is functional mapping, and this tells
us, again, what these cells on the surface do. And that can be determined using a variety
of techniques, one of which is a radiological technique known as functional MRI. The second
that we'll be discussing here and illustrating in the surgery is electrocorticography and
stimulation mapping. And when we do that, we are essentially recording electrical impulses
directly from the surface of the brain as well as stimulating the surface of the brain to
induce a very temporary short-circuit, which tells us that if a function stops to -- stops
working, then that function, that location that we stimulate it at controls that function.
Lastly, we're talking about mapping metabolic activity, this allows us to differentiate
recurrent tumor versus scar, and it's really primarily useful in the setting of a recurrent
tumor, and we won't really be talking about it too much today. Well, we talked about a lot
of different techniques. And just to give a brief outline of the various stages of the surgery
and the team members that perform them, I think it's useful to go over a brief outline.
Because while in the old days people used to say that the surgeon was really the captain of
the ship, I think it's clear that increasingly surgery is very much a team effort, particularly
complicated cases like neurosurgical oncology. So the anesthesiologist has a task of -- a
very difficult task of performing anesthesia so that the patient is asleep during the part of
the beginning of the case where we incise the skin, which could be painful, wakes up for the
intraoperative mapping that allows us to figure out exactly where we are, and then goes
back to sleep for the closing. The neurosurgeon is very important for the navigation and for
the microdissection and resection of the tumor when we get to that stage.

STEPHEN SAGAR, MD: Can I just interject? And I can't emphasize the importance of this
image-guided navigation enough. And you'll see later in the webcast as you see the surgery
actually performed that the brain doesn't come with a road map. There aren't marks of
where you are, and the surgeon is operating in a very small exposure of this field. And this
ability to use these image-guided navigation systems to know exactly where you are in the
brain and exactly where the target tumor is has made these neurosurgical procedures in
order of magnitude safer than they were before the invention of this technology. And a lot
of the technology you're going to see today, including image-guided navigation, is really
directed at patient safety. It's directed at making these procedures more safe for the
patients and not doing collateral damage to normal brain.

ANDREW SLOAN, MD: I think that's absolutely right. And the other thing to emphasize is
the very important role our friends the neurologists and electrophysiologists play in the OR.
They're the people who do a lot of the functional mapping to enable us to know not only
that this lesion is in a certain place in time and space but what it's actually doing and what
function it has. So let's begin by showing a little bit of the preoperative planning segment.
And I'm going to illustrate this. As the surgeon here illustrates his planning using something
called diffusion tensor imaging, the image that you see as a PowerPoint illustrates the same
thing in a slightly different way. Basically we're looking at the various fiber tracks, and if
you see on the right of your screen, there's a tiny little dot of enhancement. And that is the
area that's most concerning with respect to the tumor because that could be the area of highest grade. And then you see the blue fibers are the fibers coming from the top and going down, the green fibers are the fibers going from front to back, and the red fibers you see are the fibers going from left to right. And as you -- if you compare the region on the right to the region on the left, you'll see that there's a marked diminution, much fewer fibers on the right than on the left, particularly the red fibers that go from left to right and the blue fibers going top to bottom. So you'll see Dr. Maciunas, the surgeon, screening ahead of time through this lesion, and you'll see that he identifies this lesion on the right region where his cursor is now. And it shows that these fibers seem to be pushed away or essentially eaten or eroded in some way by this tumor. And that's very typical of these low-grade gliomas. And that's why it's really critical to know where these fibers are so that you can take the tumor out while preserving the fibers. Because if you cut the fibers, you're essentially incurring damage that you wouldn't have necessarily been able to anticipate from knowing the anatomy of the cortical surface itself. There's the enhancing lesion there, and you can see in the center the fibers are pushed far away from it. So we've talked a little bit about preoperative planning. The importance of positioning in anesthesia we've already talked about, as well as the pre-op imaging. Next we're going to show an image -- some segments that show a little bit about how we physically do this. We can go for the next segment, please. And I think it's really interesting to many people how we get into the brain because of course the brain is a very soft, delicate structure surrounded by the bone. And so, what we do is we start by drilling burr holes, which you'll see them do here, with a very high-powered pneumatic drill.

STEPHEN SAGAR, MD: And these don't quite go through the skull.

00:16:44

ANDREW SLOAN, MD: No. As we said, the brain is covered by essentially two layers: one is a layer called the dura, and the second is the bone, of course. So these holes go through the bone, but they do not go through the dura. And as you'll see in a few moments, they allow us to put instruments in between the bone and the dura which allow us to separate those two structures. And then you'll see in a few moments we are able to take a very high-powered drill and essentially put the tip of the drill on the dura while using the side of the drill to drill the bone. And that allows us to drill what we call a craniotomy flap.

00:17:29

STEPHEN SAGAR, MD: And what they're doing now is curetting out the last bone from the burr holes, is that right?

00:17:35

ANDREW SLOAN, MD: That's correct. And the idea here is in order to get your instruments in safely without hurting the dura, you need to have a hole of a certain size. So they're just enlarging those holes slightly. So here you've seen - we've skipped ahead a little bit -- and you see there's tracks in the bone. This craniotomy flap has already been drilled, but as you can see it's somewhat stuck to the dura, which is typical. And so now they're trying to elevate -- very gently elevate the flap while scraping the dura from the underlying bone -- from the overlying bone without hurting the dura or the underlying brain. And although this looks fairly simple, you have to be quite careful because you can imagine if one of those instruments penetrates the dura and hits the brain, it could do a significant amount of damage.

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STEPHEN SAGAR, MD: And the bone flap is set aside and then replaced at the end of the procedure. Is that --

00:18:34

ANDREW SLOAN, MD: That's right. The bone flap -- we put the bone flap back at the end with titanium plates. So the next part you're going to see is they're going to get -- control the bleeding from the bone and from the dura a little bit, and now they're going to put
what's called tack-up holes. And the idea here is we're going to be doing most -- the critical part of the case under the microscope. We're very, very focused, and we don't want any blood to leak out from the bone or from the dura into our field and obstruct what we're doing. So we put these holes along the edge of the bone and then we put a little oxidized cellulose underneath the edges and then we suture the edge of the dura to the bone using those holes. We pass the suture through those holes. And what that does is cinch the dura up against the brain and the oxidized cellulose so that any very slight ooze that might otherwise drip into the field doesn't drip in the field. In addition, it has the additional benefit of preventing any bleeding postoperatively from the head -- from the scalp wound, rather -- pressing on the brain postoperatively and causing what's called an epidural hematoma, because the dura will be tacked very tightly and snugly up against that bone. Which that gives us time to find that problem and correct it before the patient has any damage. And to allow preventing it from occurring in the first place. So now you see we're opening the dura, and you see the brain being exposed. You'll notice they're using a cottonoid to protect the surface of the brain from the scissors as they open. And that, again, is very critical, because the brain obviously is a very soft structure and the scissors obviously are sharp, so we want to open the dura very meticulously and carefully, but at the same time not press on the brain or abrade it in any way.
00:20:42
STEPHEN SAGAR, MD: And you see the glistening membrane over the brain that contains the blood vessels, and that's called the arachnoid, and that's a second but very thin, translucent membrane that covers the brain.
00:20:57
ANDREW SLOAN, MD: That's right. It's not exactly a protective layer like the dura because it, as you pointed out, it carries those blood vessels and really is something that we really need to preserve. So here you'll see they're tacking the dura up out of the way and they're exposing the area of the brain. And you'll notice -- the first thing you notice is that large, dark vessel along it, and that's a vein, and we'll talk more about that vein a little bit later. So here they've set up what's called a Penfield array. And they're now -- that little device that they're placing in right now is basically a grid that we're going to use to check for something called after-discharge potentials. And basically, that'll serve as a ground grid because it'll go a little bit off the field past the area that we're interested in. And now you're going to see in a few moments, using this navigational tool, that green pointer is essentially a wand that now has been coregistered that allows us to track in real-time and space based on the preoperative images. And they can figure out exactly where the tumor is first in the actual plane, and now you'll see in the coronal plane. And now they've attached the Penfield array. What you're looking at here are very small spring-loaded electrodes. And they're spring-loaded because, if you notice, the brain is actually nice and pulsatile. And as the brain sort of pulses up and down, these electrodes have to maintain contact with the surface of the brain to record. And as you can see, that becomes a very critical part of this case.
00:22:50
STEPHEN SAGAR, MD: So the image-guided navigation system also allows the surgeon to correlate the position of the tumor with the external landmarks that he can see on the brain in order to plan his approach as well, is that correct?
00:23:08
ANDREW SLOAN, MD: That's exactly right. So what we're going to see in a moment is a little bit more complicated. We've already found the anatomical imaging. We know exactly where this tumor is and where it is on the surface of the brain, and the surgeon's already planned his idealized approach where he's going to go in. But now we have to figure out where the functional parts of the brain are. So we're going to start by seeing if we can record from that Penfield array where the seizure is coming from. And you'll see some photos of the neurologist and electrophysiologist looking at that part -- the signals from
various parts of the brain to try to determine that. Let's roll that first -- that next segment. So here we have the surgeon and the various members of the electrophysiology team, including our neurologist, Dr. Mary Ann Werz, and various technicians. And could you pause there, please? So what they're doing -- you can see at the top of the screen there are a number of -- there are a number of brain waves that -- I'm sorry -- there are a number of brain waves that seem fairly symmetrical here. And then we come to this one that is very asymmetric -- looks very different from the others, has a different amplitude, different frequency, different wave form -- and that represents somewhat of an abnormality. It's not a bad abnormality, it's not a seizure, but it appears to be consistent with something we call interictal spiking. And that tells us that the area that that's recording from is not normal and may in fact represent the area that gave rise to this patient's preoperative seizure. We can continue that segment. Pause. Now, the next segment is a little bit more complicated. We've now had an idea of where the seizure focus might be coming from. And just to summarize, that is an area right in front of the tumor. So now we have to know where the motor strip is, but how do we figure that out? We figure that out with functional stimulation mapping. But before we can do that, we want to use a current that will be safe and high enough to cause basically a short-circuit in the motor segment of this gentleman's brain but not so high that it will induce a seizure. And so we do that by finding what's called...

STEPHEN SAGAR, MD: Threshold --

ANDREW SLOAN, MD: I'm sorry. Determining what's called the seizure threshold. Or -- and the way that's done is by stimulating at a voltage up until the time where we see something called an after-discharge potential. And that tells us that we haven't induced a seizure, but if we go higher we might. And so we'll see the surgeon -- and for this segment you're going to actually see the sur-- hear the surgeon talk about what he's doing. Go ahead.

ROBERT MACIUNAS, MD: So we're happy. All right. So we're all happy. All right. I'm going to touch now. We're at 4 million amps or 5?

MAN: Five.

ROBERT MACIUNAS, MD: Okay. Ready? On...

WOMAN: Talk to me so we know that you're doing okay, Sean.


WOMAN: We got some.

ROBERT MACIUNAS, MD: After discharge? Irrigate, please. Okay, so we found our setting.

WOMAN: They stopped spontaneous--

ANDREW SLOAN, MD: --is the amplitude required to induce after-discharge potentials, and so that tells us that's the amplitude that we're going to stimulate at to find the motor cortex. So in the next segment where you'll also be able to watch and see what the surgeon's doing and hear as he explains it, we're going to have the patient actually speak, do his ABC's. And at a certain point you'll hear him stop, and the reason he stops is that that bipolar electrode, which we call an Ojemann stimulator, has stimulated a part of the brain that is responsible for facial motor movement and caused a very brief short-circuit. And that tells us that that point is an area that we can't go past because that's the area where the facial motor function is controlled. So let's roll the next segment.
ROBERT MACIUNAS, MD: So I'm going to have you do your alphabet for me out loud, and while I'm doing that you're going to open and close your fingers, tap your thumb to your index finger. All right?

WOMAN: Perfect. With every letter. Go on.

ROBERT MACIUNAS, MD: Okay, A, B, C. Go ahead.

WOMAN: I've got to hear the alphabet, Sean.

SEAN: A, B, C.

ROBERT MACIUNAS, MD: Keep going. A, B, C, all the way to Z.

SEAN: A, B, C, D--

WOMAN: Keep going. Sean? Sean. He stopped talking.

ROBERT MACIUNAS, MD: Yeah, he did. Just where he ought to. Good.

STEPHEN SAGAR, MD: I think it's worth commenting on what the patient's experiencing during these awake procedures. Many of the patients that I talk to don't remember the actual procedure. But during the procedure if they're experiencing pain, they can be given drugs to alleviate the pain. And they have extensive local anesthesia in the incision site, as I understand it. So although going through this is not generally described as a pleasant experience by patients, they're not in pain and frequently actually don't remember what happened in the operating room.

ANDREW SLOAN, MD: That's exactly right. And I think it's really critical to remember that the brain itself does not have any pain receptors, so even though we're delivering what might be described as a small shock essentially to the brain, it's not experienced by the patient as pain in any way. And you're absolutely right about the preoperative anesthesia. We basically do a block the entire nerve to the entire region of the incision so that even if the patient were wide awake at the opening there should be minimal to no pain, although obviously we sedate them heavily for that part of the case as well as for the closing. And if the patient is in pain, we can very effectively control that pain. And as you point out, this is actually very, very well tolerated, although it does sort of sound when you first hear about it like some sort of barbaric torture. So after we figured out where the functional regions of the brain are, and you'll see in the next segment we found that that motor area that we just saw was actually one gyrus behind the tumor. And what that enables us to do is -- and you can see here that that little "F" on the surface denotes the area where we think the motor fibers are. The green string maps out the area where the tumor actually is based on our anatomical mapping. And you'll notice that that dark vein that we talked about earlier is in between the parts of the tumor. And I should point out that the area where that electrode is coming from in front is sort of anterior, and so we'll just talk about these areas as either below or above that vein. So that the key thing is we have to remove both the tumor area and -- our goal at least is to remove the epileptogenic foci, which is anterior to it. But we have to preserve that vein so as not to disturb the venous anatomy of the brain and the venous circulation. So we have to do basically separate resections, one above the vein and one below the vein. So you'll see the next section you'll see the removal of a lesion using microdissection, which basically means that the surgeon is working under the microscope to remove the tumor. And you'll see the use of something called the CUSA, which stands for
cavitating -- I'm sorry, cavitating ultrasonic aspirator. Finally we're going to see a little bit about what the pathologist does. Roll the next segment, please. So here we are, we're looking through this surgeon's microscope. And I should say that many surgeons prefer to simply take the CUSA from the get-go and basically suck out this tumor. However, when you're not sure what the diagnosis is, and particularly, when part of the tumor looks in one way and part of the tumor looks different, as in this case we have that small nodule of enhancement which really would be critical to making the diagnosis, it's really important to try to preserve the anatomy and the structure of this cortical resection to as great an extent as possible. So you'll see the surgeon here using a blunt instrument to basically peel this abnormal cortex away from the small vessels in the vein lateral to it as well as from that large vein medial to it. And so now he's freeing it from the vein. And the goal is to take that large cortical segment essentially en bloc as one large piece so that we can then look at it -- look at the gross pathology and help the pathologist figure out what to look at, and thereby help make a diagnosis.

STEPHEN SAGAR, MD: But all of this preoperative planning and cortical mapping has now allowed him to very accurately dissect out that tumor. And as you'll see as it comes out, there really -- there's no visual clues as to exactly where the tumor is. It all had to be done on the basis of the preoperative MRI and intraoperative functional mapping.

ANDREW SLOAN, MD: And that's exactly right. And that's why this is so critical. And you'll recall from the preoperative MRI, Steve, that the area of enhancement was very tiny, perhaps 2mm by 2mm. The chance of finding that just by looking at the brain is essentially nil, but now that we can find, number one, where the tumor is with precision, and number two, know that we can come at it from an angle where we will not disturb any normal brain, is really critical. Now you'll see the surgeon putting a little cotton paddies in the resection cavity just to help get hemostasis and dry up, absorb some of that blood that's oozing. And he'll get very precise and meticulous hemostasis, but in order to do that he has to stop bleeding from one area while he works in another area, and that's what he's doing here under the microscope. The blue device that you're seeing on the left is what's called a bipolar coagulator. And now, remember we talked about the importance of getting as much of the tumor out as possible. Now you're seeing the CUSA at work. There's a teen -- we've gotten most of the cortical surface en bloc, but you'll notice the CUSA is eating away the teeny little millimeters of surface left. And you'll see under -- as the CUSA works, you'll see the underlying fiber tracks are white and shiny. So as the CUSA works, you'll see the two -- the resection bed goes from sort of gray or reddish-brown to bright white shiny fiber tracks, and that's how you know you're done with that portion of the resection because there is no more gray matter or cortical surface to go. And so here you see that resection has really been completed above that vein and they've done the en bloc resection below the brain -- that vein already but have some additional resection to go.

STEPHEN SAGAR, MD: And the vein has, as planned, been preserved throughout this procedure.

ANDREW SLOAN, MD: Absolutely, and that's really critical. And also, you know, here the surgeon has made it look easy, but it's not really that easy. Now here is another critical portion of the case. I -- as I said earlier, this is really a team effort. So the surgeon has taken out what we called an en bloc resection, and now he is able to sort of look at it slightly differently. It's removed from the patient's brain. He can feel it, he can see whether it's coarse. This tumor, in fact, had a somewhat of a rubbery feel. And sometimes, although not in this case, you can feel sort of a gritty -- appreciate a gritty quality that clues you in to the fact that there might be some calcification, for example. And that can help us in figuring out what kind of tumor that might be. Lastly, we're taking a little piece off to send as sort of
the surrounding tumor -- aspect of the tumor for the pathologist, and then the surgeon is going to take a marker and indicate where he thinks that critical portion of the tumor is that was enhancing. And he's marking this with a marker so that when he sends it to the pathologist, the pathologist can look a little bit to one side of that at that lesion itself and a little bit to the other side, and that's really critical in helping us figure out exactly -- we've found the part that we think we found. Because as we discussed, the histology of the worst part of the tumor is really going to determine not only the behavior of the tumor, but the way we treat it postoperatively with chemotherapy or radiation.

STEPHEN SAGAR, MD: This is a very important point from the point of view of the neuropathologist, this ability to get the entire tumor en bloc, as the surgeons say, so that the anatomy of the tumor and its relationship to the surrounding brain can be defined by the pathologist under the microscope. And that's very helpful in estimating what the pathology and appropriate treatment of these tumors are.

ANDREW SLOAN, MD: You know, it's also critical to understand that while most tumors should be resected, there are a small number of tumors where if the biopsy indicates the tumor of -- is of a certain type, radiation and/or chemo may actually be as good as surgery, so you might actually stop the surgical procedure based on what the pathologist tells you. So that's really critical. Finally, given the fact that we suspect and later found out from the pathologist that his frozen section diagnosis was that this was a low-grade tumor and we really wanted to take the whole tumor out, it was really critical to see if we had actually accomplished what we had set out to do. And so the next phase of the surgery is the intraoperative MRI. You can roll that segment now.

STEPHEN SAGAR, MD: How long have we had intraoperative MRIs?

ANDREW SLOAN, MD: Intraoperative MRI has really been a recent addition, but we were one of the first places in the United States to get that. What you just saw was the anesthesiologist moving the patient just slightly so that the head was in the magnet. And here you can see the actual MRI of the patient's head. As you can see, it's a very high-quality MRI, almost as good as the pre-op MRI, but the skin is open, so you can see this -- the dura's gone, and this is the resection cavity. This white area tells us that where there used to be this tumor is primarily just this area of empty space filled with fluid. And now we're scrolling through the rest of the brain to see, you know, is there any bleeding that we've caused, have we caused a stroke, have we damaged the venous circulation in any way that would show up on these images? And as we continue to scroll through these images, it becomes clear -- here we are back at the resection cavity -- it becomes clear that we've accomplished what we want to do, and yet other than this resection cavity, the side -- the right side where we did our resection and the left side looked very similar in terms of the surface. There's a little bit of swelling here, which is to be expected, but there's no area that looks like gross swelling or that we've caused any sort of an infarct, which is really critical.

STEPHEN SAGAR, MD: And there are cases where after the MRI you would then go back and do additional surgery because you would see on the intraoperative MRI that you had not achieved a gross total resection. Is that correct?

ANDREW SLOAN, MD: That's absolutely correct, and that's really why we started this program in the first place. As I said, University Hospital was probably -- was one of the first to have intraoperative MRI in the United States -- the first in Ohio. And to the best of my knowledge we have the only full-strength permanent intraoperative MRI in the OR in the state of Ohio, and that's really critical. When we find a tumor after our intraoperative MRI,
we can then go back. Again, here the surgeon is looking to make sure that he hasn't left any tumor behind, but once he's satisfied that he hasn't, we can close. But if we find tumor, we can only go back knowing where it is we need to focus our concentration, but we can adjust for the intraoperative shift that we get based on the preoperative navigational tools and recalibrate our intraoperative navigation based on this intraoperative MRI. So we're actually navigating based on this updated MRI, which compensates for all the changes that have been induced by the surgery. And that's really a revolutionary technique.

STEPHEN SAGAR, MD: It's surprising how much things can move around during surgery. With CSF being removed and anesthesia, using diuretics and reducing blood pressure and blood volume, the brain can actually shift quite a bit during surgery.

ANDREW SLOAN, MD: That's absolutely correct, and that's why having an intraoperative MRI not only helps you assess whether you've gotten that 95 to 99% resection, but also, if you haven't, part of the problem is typically that that shift has made your preoperative navigation, the navigation you've been using for the whole case, much less useful because you don't know where it is you're navigating. But once you have the intraoperative navigation, you can basically recalibrate your navigational tools so you're navigating based on that intraoperative navigational device, and you can be very, very accurate and very precise. And also it tells you if there's a problem that you might need to go back and look at, such as swelling or maybe a small blood clot. Do you have any other comments?

STEPHEN SAGAR, MD: No, we do have a question, however. Are we ready for questions?

ANDREW SLOAN, MD: Very well.

STEPHEN SAGAR, MD: Okay. "Is this procedure typically performed for adults only or is it available for children?" I would assume that pretty much the same methodology can be applied to childhood tumors as well, is that right?

ANDREW SLOAN, MD: That's correct, with the exception of the intraoperative awake mapping. Obviously, some children are not really ready to be -- to do that and to cooperate with that sort of an experience. And rather than give an exact age, I think most of my pediatric colleagues would say it depends more on the patient's maturity. But you can also use the intraoperative MRI and pediatric cases, no matter what the age, if they're asleep. So if they're, you know, 14, 15, 16 and reasonably mature, and perhaps even younger if they're mature, you can probably do an awake craniotomy. But even for infants and children, if it was a very complicated tumor, you could use the intraoperative MRI, you would just probably not wake an infant up or a young toddler up to do any awake mapping because it probably wouldn't be fruitful.

STEPHEN SAGAR, MD: But the EEG mapping, the electrocorticography, is still widely used in planning for pediatric --

ANDREW SLOAN, MD: Absolutely.

STEPHEN SAGAR, MD: epilepsy cases.

ANDREW SLOAN, MD: And our colleagues at Rainbow Children's Hospital use this as well.

STEPHEN SAGAR, MD: So this patient did very well postoperatively. I saw him a couple weeks after surgery and he was neurologically intact and doing quite well. What limitations would he have postoperatively?
ANDREW SLOAN, MD: I would expect that he might have a little bit of weakness postoperatively in the face and perhaps the arm and hand on the left because we're on the right side of the brain and the right side of the brain controls the left side of the body. But this would be transient, and he should make a complete neurological recovery probably within three or four days, and perhaps even sooner.

STEPHEN SAGAR, MD: Would you impose any other limitations on him, such as, can he fly postoperatively, can he jog and go back to work?

ANDREW SLOAN, MD: He can do all those things, and in fact all those things are desirable with a caveat that we like to keep the wound -- in the immediate postoperative period, we like to keep the wound clean and dry for about a week. And we typically would prefer that the patient stay in town. Being on an airplane is fine, but we prefer that a patient stay in town for the first week postoperatively just in case there are any problems.

STEPHEN SAGAR, MD: And he would -- he had been on steroids, which are typically administered in order to reduce swelling, and there typically is a fair amount of swelling postoperatively from a procedure like this. But the goal would be to get his steroid dose down and to get him off steroids as rapidly as possible.

ANDREW SLOAN, MD: That's right, and typically we can do that in the first week postoperatively. We can wean the steroids to off. And then, depending on the epileptologist and the neurologist managing his seizures, over time we can typically wean the anticonvulsants as well.

STEPHEN SAGAR, MD: And the part of the reason for doing this procedure was his seizures. And he -- even though he's had the epileptic focus presumably removed, he has had a neurosurgical procedure and in that sense has had trauma to his brain. And our policy usually is to continue the antiepileptic drugs for at least two years postoperatively, and then depending on the patient's preference may try to wean them off at that point.

ANDREW SLOAN, MD: I think that's typically the way we manage these patients. And I think this patient should do very well. Do you have any thoughts on adjuvant therapy, radiation or chemotherapy for this patient?

STEPHEN SAGAR, MD: Well, the pathology of this tumor was a low-grade astrocytoma. It was a grade 2 astrocytoma, which has a relatively good prognosis. And the data we have is that he would not at this point benefit from any adjuvant treatment, meaning additional either radiation therapy or chemotherapy. He has excellent neurologic function and has had a gross total resection of this tumor. We know there are tumor cells left behind, but as I say, the evidence we have indicates that he would not benefit from additional treatment at this time. Unfortunately, sometime in the future, we hope many years from now, this tumor may recur and it may behave more aggressively. And at that point, he may need additional treatment, and the treatment could include at that time additional surgery, radiation therapy, or chemotherapy, depending on what the histologic rate of the tumor is at that time and what his individual anatomy is at that time.

ANDREW SLOAN, MD: Do you think that there's any reason -- do you think there might be another indication for reoperation on this patient if that were to happen?

STEPHEN SAGAR, MD: Yes, absolutely. Many of these patients undergo reoperation when the tumor recurs. The large majority of the time when the tumor recurs, it recurs within
basically an inch of where the tumor -- original tumor was resected so that it's likely that if he will need additional surgery it will be in the same region. Are there particular surgical issues involved in going back and reoperating on a patient who's already had brain tumor surgery?

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ANDREW SLOAN, MD: Well, that's a very good question. Obviously we like to use the same types of anatomical and functional mapping. But this is where the metabolic activity mapping becomes really critical, because as you know, Steve, we can see radiation damage and scarring often look a lot like enhancing tumor. So many times, especially now that we're using Temodar at the same time as radiation for some of the higher grade tumors, oftentimes we see enhancement and we wonder, is this tumor, is this not tumor, and what do we do about it? And that's a really critical issue when you're talking about possible tumor recurrence. So we tend to use the metabolic imaging techniques that we talked about a little earlier, such as FTG patch, various types of blood flow, mapping proliferative activity, using FLT pats, and MRI spectroscopy when we're trying to assess in a patient who's had previous treatment, is this a new lesion that we see on MRI, is it tumor recurrence or does it represent simply scarring from his previous chemotherapy radiation or surgical procedure, or is this just radiation damage that we've done.

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STEPHEN SAGAR, MD: That can often be a very difficult issue. And even with modern imaging availability, we frequently can't make the distinction between treatment effect and recurrent tumor without having a biopsy or resecting the new lesion, and that's a very important issue in managing these patients in the future.

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ANDREW SLOAN, MD: That's absolutely right. And this is exactly where these types of metabolic mapping come in. We can actually determine in a large area that looks fairly homogeneous on MRI what area is most likely to represent tumor or the most malignant part of a tumor so that instead of biopsying randomly in an entire lesion which may be several centimeters in size, we can do several very small, focused biopsies. And we can usually do this stereotactically so that we can determine whether the patient needs additional treatment without first doing a big operation that ends up being, you know, for nought.

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STEPHEN SAGAR, MD: We have another question from the audience: "Is this kind of brain tumor very common?" It's not. This is an uncommon disease. Probably a low-grade glioma would occur in something like one or two per hundred thousand people per year. So this is fortunately not a common disease. And the other question is what the patient's long-term prognosis is. So as I say, it's unfortunately likely that this tumor will recur. There's a very wide range of time over which low-grade gliomas recur when that happens. We would hope that this man, he has a number of good prognostic factors. We would hope that he would go more than a decade before the tumor recurs, but at his age the overall average is probably something on the order of six to eight years before the tumor will recur again.

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ANDREW SLOAN, MD: One of the reasons that I always tell patients when they ask, "You know, Dr. Sloan, this tumor is probably going to recur. Why should I bother with this whole thing if it's just going to come back?" I think as we've seen, Steve, in the last few years, our treatments have really changed radically and are much better than they were even five years ago. So if you can buy someone six or eight years, their prognosis for a higher grade tumor today may be very different five, six, seven, eight years down the road. And we -- I certainly anticipate and I certainly hope that we'll have much better treatments available. And there's so many new agents, both drugs and vaccines and types of radiation on the market that I really think that if we can give someone five, six, seven years with high
quality of life, that's really an important consideration. And I think it really makes sense, and that's why we treat these so aggressively.

STEPHEN SAGAR, MD: Yeah, I agree. And I also, coming back to the point about patient safety that the technology that was illustrated today really makes it possible to do these aggressive tumor resections much more safely than they could be done even a decade ago because of the availability of this very sophisticated imaging and mapping technology. That can be relatively confident -- that I can be confident that I can send a patient to surgery and that eloquent areas of brain are not going to be damaged, and the patient will come out neurologically intact as this man did.

ANDREW SLOAN, MD: I think you're absolutely right. And really emblematically -- emblematic of that approach, I hate to be cliché, but you have to recognize that Lance Armstrong won seven Tour de France victories a year after having brain surgery for a brain metastasis. And not that having surgery will make you a great biker, but that would have been unheard of only a decade or two earlier. And so that's a testament not only to the man, and chiefly to the man, but also to the surgical techniques that made it possible to do that without really impairing the capability of this world-class athlete.

STEPHEN SAGAR, MD: All right. Remarkable.

ANDREW SLOAN, MD: Do I have any other questions? Thank you very much.

STEPHEN SAGAR, MD: Pleasure.

ANDREW SLOAN, MD: Thank you to our audience.

STEPHEN SAGAR, MD: Have a good afternoon.

ANNOUNCER: This has been the removal of a brain tumor and epileptic focus using intraoperative MRI and brain mapping from University Hospitals Case Medical Center in Cleveland, Ohio. OR-Live makes it easy for you to learn more. Just click on the "request information" button your webcast screen and open the door to informed medical care.