LESLIE KIM: Good morning. My name is Leslie Kim. And I am an Assistant Professor and Division Director of Facial Plastic and Reconstructive Surgery in the Department of Otolaryngology, Head and Neck Surgery at the Ohio State University Wexner Medical Center. This morning I'll be talking to you about contemporary facial reanimation.

Facial paralysis is a devastating condition with profound functional aesthetic and psychosocial implications. The evaluation and management of facial paralysis is very complex because there are numerous etiologies, wide outcomes after a particular facial nerve insult. Treatment outcomes are equally as diverse.

And what's most complex is that there are something like 40 muscles that are intricately involved in creating facial expression, and recreating some of those expressions are quite difficult to fully restore. So a highly thoughtful and individualized approach is required.

I'll start by first going over five key principles of dynamic facial reanimation. The first principle is that the clock starts ticking for the facial muscles from the day of onset of facial paralysis. So quite simply, the potential for reversing facial paralysis really depends on the status of the facial muscles. After prolonged denervation, facial muscles, like any other muscle in the body, develop atrophy and fibrosis, resulting in irreversible paralysis.

These muscles no longer respond to reinnervation procedures. And the damaged muscles need to actually be completely replaced to restore tone and movement. On the other hand, reversibly paralyzed facial muscles still have viable fibers with intact motor endplates that can respond to ingrowing axons. So for these, you can actually reinnervate these muscles in an attempt to restore tone and movement to the face. However, the response to reinnervation, even after one year of paralysis, diminishes significantly and becomes unpredictable.

The second concept is that the facial nucleus, facial nerve, and muscles provide tone, volitional, and emotional animation that cannot be adequately replaced. So where possible, we want to restore continuity. So as you might know, primary nerve outcome provides the best outcome. So when the primary-- when the nerve has been disrupted due to trauma or surgery, the best options are always to repair the nerve where possible.

But when the one primary nerve repair is not possible, but the proximal facial nerve remains intact, then the next best choice is to do something called a cable graft or an interposition graft, which acts as a conduit for axonal regrowth, shown here. So here is a case example of a patient who underwent penetrating trauma due to a knife attack and presented with facial nerve paralysis secondary to presumed transection.

So he's brought immediately to the operating room. And the facial nerve was found to be severed through the parotid gland and was repaired primarily under an operating microscope, as demonstrated here. And in three months, he was able to regain function, both in eye closure as well as in smile function.

Concept number three is that when the proximal facial nerve is not available, for example, due to intracranial or intratemporal pathology-- such as a vestibular schwannoma or a stroke-- but paralysis is still reversible, we should consider a nerve transfer. The way I explain this to patients, it's like robbing Peter to pay Paul within your own body, where Paul represents the facial muscles, and Peter can be one of a variety of different nerves-- most commonly the masseteric nerve, the hypoglossal nerve, or the contralateral facial nerve.

So what we're trying to do here is repurpose an alternative motor nerve source to reinnervate the existing facial muscles, given that they're still viable. Because methods that reinnervate native facial muscles in a timely fashion are much preferred, because no other skeletal muscle can really adequately simulate the complex morphology of facial mimetic muscles.

The concept number five is that when native mussels are congenitally absent or irreversibly paralyzed due to prolonged denervation, muscle function must be replaced. So most commonly, this is performed by regional muscle transfer, such as temporalis tendon transfer, or free muscle transfer, such as a free gracilis transfer. Static suspension procedures are also used.

So moving on to some of the contemporary strategies for dynamic smile reanimation. The first thing I think about as a facial nerve surgeon is what it takes to recreate a smile. So smiling is complex. On average, it takes about 12 muscles or more for a person to smile, and every person smiles differently. But how do we know when somebody is smiling?

There are three classic features. The first one is eye wrinkling. The second is malar mounding. And the third is oral commissure excursion. So it's really important, as a smile surgeon, to recreate all of these features because, I want my smile back, is universally the most common goal for patients who present with facial paralysis. Dynamic reanimation techniques of the midface are therefore far more preferred over static suspension techniques.

So going back to those key principles, when I determine what procedure to perform, I am really thinking, again, about the reversibility and the duration of denervation. So it all comes back to the facial muscles. So this is a busy slide. But if you look on the left side, it summarizes what we talked about with reversible paralysis. So this is when the facial muscles have been denervated for under a year or two.

And ideally, we want to restore neural input back into the facial muscles because that will result in the most favorable outcomes. So this is performed either through nerve repair, if possible, or nerve transfers. On the right side, irreversible paralysis. So this is when the muscles have been denervated for more than one or two years, or they're congenitally absent. And in these cases, as discussed, we have to replace the muscles in order to restore tone and movement. So the two most common options for this is temporalis tendon transfer and free gracilis muscle transfer.

So focusing a little bit on nerve transfers. Again, we are repurposing an alternative motor nerve source if the proximal facial nerve is not available. So in essence, we're bypassing it. Some common scenarios that we encounter are parotid cancer extirpation with facial nerve sacrifice or intracranial, intratemporal tumor resection, such as vestibular schwannomas.

So when we talk about nerve transfers, there are three main options. The contralateral facial nerve via a cross-facial nerve graft. The masseteric citric nerve, which is a cranial nerve V motor branch. And the hypoglossal nerve, which is cranial nerve XII. And there are other options, such as the spinal accessory nerve, et cetera. But I'll focus on the first three today.

So the contralateral facial nerve is the criterion standard donor nerve for nerve transfer. And this is because, as stated in concept number two, when the ipsilateral facial nucleus and nerve are not available, the contralateral or normal facial nerve and nucleus are the second-best option. And the reason why this is the best choice in terms of a donor nerve is that it utilizes the facial nucleus. And because of that, it's really the only option that is capable of producing a truly spontaneous and emotional smile.

So how this is performed is that I go into the normal side of the face, the non-paralyzed side. And say that we are specifically trying to target smile reinnervation. I stimulate the branches on the normal side of the face to identify one large redundant branch that does smile function on that side.

Then the sural nerve is taken from the leg and connected to that nerve that's identified on the non-paralyzed side. And it is extended across the face, usually under the lip, and plugged into a nerve on the paralyzed side that is also presumed to do smile function. So in this case, the contralateral facial nerve and the ipsilateral facial nerve become synchronously connected so that when the contralateral facial nerve is trying to smile, it basically swoops at the axons across the face.

And the ipsilateral or the paralyzed facial-- the face is allowed to smile. So because it utilizes the facial nucleus, it really is the only option capable of producing a truly spontaneous, emotional smile. However, it's not frequently used solo for nerve transfer, and the reason is this. To use as a stand-alone technique, the denervation time must be under six months because, on average, a cross-facial nerve graft is about 15 to 20 centimeters. Axons regenerate at a speed of about a millimeter per day.

So it typically takes about six to nine months for axons to cross a typical cross-face nerve graft. But as I stated earlier, muscles, when they're denervated for greater than a year to two, undergo irreversible atrophy. So with the additional time after the procedure, there is a risk that it would be taking you beyond that one and a half to two year mark. So it really isn't used very frequently alone.

The other main reason that it's not used often as a nerve transfer technique is because it ends up being a relatively weak donor. The axons must cross two coaptations, one on the non-paralyzed side and a second on the paralyzed side. And research shows that only about 20% to 50% of axons actually make it across. And this is problematic because the more axons there are, the better the functional outcome.

So the hypoglossal nerve was very popular back in the '70s, and still is popular today. But classic hypoglossal nerve transfer, where 100% of the hypoglycemic nerve is taken, is no longer in favor due to significant donor morbidity. So hemiglossal dysfunction resulting in difficulties with speech, swallow, and mastication have really largely put this full transfer out of favor. Also, complete hypoglossal nerve transfer really provides too many axons, resulting in a lot of synkinesis and undesired hypercontracture.

However, it is used now much more frequently as a partial transfer, utilizing approximately 30% to 50% of the nerve as a donor nerve for resting tone. So the most common-- one of the more common techniques that are done today is that the facial nerve is actually drilled out of the mastoid and transposed down inferiorly into the neck for a direct coaptation to the hypoglossal nerve, or a closed coaptation with only a short interposition graft.

And this allows a lot of improvement in resting tone because the tongue is tonically contracted at rest. And it can afford a little bit of movement, as well. For example, when patients press their tongue against the roof of their mouth, or the palate, they're able to generate a bit of a smile.

I'll spend a few moments talking about the masseteric nerve because this has really become the workhorse. The masseteric nerve is a cranial nerve V motor branch, so the master of muscle. And clenching or biting down obviously activates the masseteric nerve, which, when rerouted into the facial nerve, can allow for a dynamic smile, as depicted here.

When used, the smile that develops can be effortless and reflexive, but it really is not truly spontaneous or emotional since the facial nucleus is not used. But there are so many advantages to using the masseteric nerve. First of all, it's a rich motor donor source. It really has a lot of axons and can create a strong smile with a lot of oral commissure excursion. And it's depicted here in an intraoperative photo.

It is located deep in the masseteric muscle and in very close proximity to the buccal branches that you're trying to target for smile reinnervation. This allows for a direct anastomosis and rapid recovery. I can see function, after this procedure, as quickly as two to three months. And there's really limited donor morbidity. I rarely have a patient complain of any chewing difficulties after this procedure.

So here is an example of a patient who underwent masseteric nerve transfer. So she is a young female who underwent three craniectomies for a brain stem glioma. And she's actually seen here-- I performed a masseteric nerve transfer approximately eight months after her last surgery due to zero recovery. And she's actually seen here about a year after the procedure. And she still has complete flaccid paralysis of the left side of her face.

So when asked to smile spontaneously, she actually still cannot. She had an eyelid weight placed by an oculoplastic surgeon. But you can see here, when I ask her to smile while clenching down, she develops beautiful excursion of the left oral commissure. So in this case, although she's still flaccid, we were still able to save some of her smile musculature by doing this procedure at an early point in time.

I did offer her a hypoglossal nerve transfer to improve her tone. But she lost some of her hypoglossal function from the surgeries and, therefore, declined as she was PEG tube dependent for quite a bit-- quite a bit of time and did not want to regress in terms of her eating abilities. Here is another case example that really demonstrates the evolution of facial reanimation, particularly in my practice, as well.

So this is a classic case of a patient who underwent facial nerve sacrifice for parotid cancer extirpation. So he was a 74-year-old male who underwent parotid cancer resection with facial nerve sacrifice. And I performed concurrent cable grafting, as well as a masseter nerve transfer. So this is typical of cable grafting outcomes. So he is seen four months. Obviously had some eye surgeries after that to improve the appearance as well as function.

But typical cable grafting outcomes, I find that even at 10 months post-op, they are just slowly starting to regain some tone as well as volitional movement. But if you can see here in the middle photo, he can actually bite down to generate quite a fairly symmetric smile. And he was able to do this as early as three months after surgery.

So seen here in the video, the first couple of smiles, he is just doing spontaneous smiles. And you can see, the left side really doesn't move very well. But then he adds the clench and is able to generate at least a centimeter or a centimeter and a half of oral commissure excursion.

But he still looked pretty poor in terms of resting tone and symmetry. And here, we discussed some options. And we elected to-- he elected to proceed with static suspension. So I took him back to the operating room. And we did a fascia lata suspension of the left nasolabial fold, which allowed for a lot more symmetry at rest. And sort of the evolution that's taking place is, now, I tend to do the fascia lata suspension up front so that the patients have a lot more symmetry from the get-go. There you could see him biting to smile.

Another common scenario that we run into is facial paralysis following vestibular schwannoma resection. So this is a case example of a 36-year-old male who just recently had surgery. He had a very large vestibular schwannoma, which was taken out in two surgeries. And he came to see me thereafter with complete flaccid facial paralysis of the right side.

So in this case scenario, there is actually clinical dilemma. So there's complete facial paralysis, but the facial nerve is thought to be anatomically intact. So the dilemma is, do we wait for spontaneous recovery-- which classically is a year-- but risk continue degeneration and decreased success of later surgery? Or do we proceed with early reanimation, but potentially risk harming a recovering nerve and performing unnecessary surgery?

So this is the classic dilemma that we encounter. There's some research that shows that if there's no recovery by six months post-op and the patient remains a House-Brackmann 5 or 6, that their prognosis for a full recovery or even good recovery is low and, therefore, early nerve transfers are recommended. So in this case, the decision-making was a lot easier because the neurosurgeon and the neurologist let me know that the prognosis for spontaneous recovery was thought to be low based on the size of the tumor and the degree of dissection that was involved.

So in this case, we elected to proceed with a hypoglossal nerve transfer to the main trunk of the facial nerve to establish tone and a masseteric nerve transfer to a buccal branch for smile reinnervation. That's depicted in this diagram here. So the mastoid segment of the facial nerve was drilled out and transposed down inferiorly into the neck to connect to a cut hypoglossal nerve that was only cut about 40%. And then the masseteric nerve was specifically targeted to a buccal branch for smile reinnervation.

This is an intraoperative photo that demonstrates the same, as you can see here. This is the proximal segment of the facial nerve, or the mastoid segment, that is in close proximity to the hypoglossal nerve with a vessel loop here. And then the masseteric nerve has a blue vessel loop here. And it was connected to a zygomaticobuccal branch of the facial nerve that was located right here.

So the tricky thing with these cases is that, because these patients don't have facial nerve stimulation intraoperatively, the decision-making for the masseteric nerve transfer is based on anatomic location. And just a second photo that demonstrates the view under an operating microscope. So the proximal facial nerve was put into position with the 40% cut hypoglossal nerve. It couldn't reach all the way without tension, so I placed a small 1 and 1/2 centimeter great auricular nerve interposition graft.

And then this right here demonstrates the masseteric nerve transfer directly co-opted to the zygomaticofacial branch that we had picked out. So moving on to when the scenario is that the muscle paralysis is irreversible. So when patients have been denervated for more than one to two years or their muscles are congenitally absent, such as in Moebius syndrome, free muscle transfer is really the criterion standard for dynamic smile reanimation.

The gracilis muscle is the most commonly used. The advantages are that the gracilis muscle is easy to harvest. There's really minimal donor morbidity. It is located in the adductor or medial component of the thigh. And it is easy to access. You can thin it out adequately to have enough length. And it really has excellent contractility. So as depicted here, the gracilis muscle is taken out of the thigh with its blood vessels, the adductor artery and vein, as well as the nerve that moves the muscle in the leg or the obturator nerve.

Here is an intraoperative video that demonstrates the gracilis muscle. It's already been thinned out. And it's now being-- the obturator nerve is now being stimulated to demonstrate the contractility within the body. And then just to the left right here are the pedicle, the adductor artery and vein.

And you'll notice that there are black stitches along the length of the muscle. And I put these in at 2 centimeter increments because, once the muscle is cut on its two ends, the muscle will shrink and contract. And every muscle has an optimal length at which it contracts with the best force. And the idea is that I want to restore this length in the face. So the markings are made so that when I move the muscle into the face, I know what the length should be.

And as discussed earlier, the same three nerve options are available to power the gracilis muscle in the face. So when I explain this to patients, I have two goals when I do a gracilis transfer. The first one is, I need the muscle to survive. So as shown here, the adductor artery and vein is connected into, usually, the facial artery and vein in the face. And the patient is typically admitted for three days to assess the vasculature through Doppler checks to make sure that the nerve, the muscle is viable.

The second goal, though, is not only to move the muscle into the face, but we need the muscle to move. So the same options are used to power the muscle. So in this diagram here, the cross-face nerve graft is used. But my most common, preferred technique is actually to use two nerves-- most commonly, the masseteric of nerve as well as the contralateral facial nerve through the cross-face nerve graft.

This allows capitalization of both aspects of each of-- both of those nerves. So for instance, the spontaneity of a cross-face nerve graft as well as the power of a masseteric nerve. So here is a patient who is a 35-year-old male who underwent a superficial parotidectomy about 10 years ago at an outside hospital. And he is seen here just six months after the gracilis transfer with dual innervation, so using the cross-face nerve graft and masseteric nerve.

And he gets wonderful excursion on that right side from it. So he is-- bites down there to generate excursion. And then if he bites very forcefully, he gets a little too much excursion. So he's actually had to learn, over the years, to temper how much he bites. And actually, over the years, he now will smile without clenching.

And part of that might be due to that cross-face nerve graft finally coming through. And part of it may be that there's some good research that shows that when the masseter nerve is used, because of the cortical relationships in the brain and the proximity to the facial nucleus, that, oftentimes, the great majority of patients are able to learn how to smile without clenching over time, with a lot of practice.

And here's another example of a young female who has neurofibromatosis 2 who underwent a gracilis transfer for left flaccid facial paralysis following vestibular schwannoma resection. And she also underwent the transfer with dual innervation. So she's seen here at six months post-op.

And lastly, the temporalis is tendon transfer is another option that can be used for dynamic smile reinnervation-- reanimation. The temporalis tendon is attached to the coronoid process of the mandible. And it can actually be released from its attachment to the coronoid and attached to the modiolus. And this allows for a dynamic smile reanimation because the temporalis tendon, again, can also be activated with clenching, which can move the corner of the mouth.

When placed head-to-head with the gracilis muscle transfer, it doesn't afford as much excursion. So in general, with the gracilis muscle, I expect about a centimeter or a centimeter and half of excursion. Whereas with the temporalis tendon transfer, the excursion tends to be on the order of millimeters. However, it's an excellent option for patients, particularly who are older, with a lot of comorbidities who might not be able to handle a free gracilis muscle transfer.

And this is an example of an 81-year-old female who developed complete flaccid facial paralysis on the right side following resection of glomus jugulare. And she was able to look relatively symmetric at rest right away and is able to develop-- or able to generate a few millimeters of excursion with clenching.

So in summary, facial paralysis is devastating. Management is challenging, requires a critical and highly individualized approach. Establishing the cause of facial paralysis really gives essential information about prognosis and the expected course of paralysis. And it's really important to remember and to tell patients and other referring doctors that Bell's palsy is really a diagnosis of exclusion. Eye protection is the number one priority, but smile restoration is the most challenging.

So going back to the principles, if the facial nerve is ever transected, every effort should be made to restore continuity where possible. Timing is everything. After prolonged denervation, facial muscles become irreversibly atrophied. So dynamic smile reanimation is really best achieved when we can reinnervate the native facial muscles while they remain viable. So that's done through facial nerve grafting or repair if possible. And if not, nerve transfer-- so using an alternative motor nerve to bypass the proximal facial nerve when it's no longer available.

And as we discussed, the masseteric nerve is excellent for smile excursion. The hypoglossal nerve is wonderful for resting tone. And the cross-face nerve graft, or the contralateral facial nerve, is really the only option that produces spontaneity. Smaller restoration is even more challenging and never perfect when the native facial muscles are no longer viable-- so when they've been denervated for greater than two years.

So options for muscle replacement include free gracilis muscle transfer, temporalis tendon transfer, and static suspension. And then for those that recover with post-paralysis synkinesis, a non-flaccid facial paralysis, dynamic results can still be achieved through facial neuromuscular retraining therapy and selective chemodenervation with Botox.