



TRANSFORAMINAL LUMBAR INTERBODY FUSION
MEMORIAL HERMANN HOSPITAL, HOUSTON, TX
Broadcast December 13, 2004

NARRATOR

15% of people suffer with chronic back pain. When conservative treatments fail, surgeons must weight the risks and benefits of a variety of complex surgical procedures. During this live webcast from Memorial Hermann Hospital in Houston, TX, surgeons will perform a safer and more effective spinal surgery to treat severe back pain. Surgeons will make an incision in the patient's back, but will approach the spine from the side. Some vertebral bone will be removed, allowing access to the disc and reducing nerve exposure. The disc is then removed and a spacer and bone graft material are inserted. Today's program is part of Memorial Hermann Hospital's ongoing educational efforts to bring the latest information in health care to physicians and patients. During the program, you may send your questions to the OR surgeons at any time. Just click the MDirectAccess button on the screen.

STEVE ALLEN, M.D.

Good afternoon and welcome to this live broadcast. I am Steve Allen, the Chief Medical Officer at Memorial Hermann Hospital and the Texas Medical Center in Houston, TX, and we're delighted you could join us in order to watch a TLIF procedure done on a patient by Dr. Vivek Kushwaha, who is Chief of Spine Surgery here at Memorial Hermann Hospital. I want to remind you that you are watching a live procedure today. During the show, if you have questions, there is a button at the bottom of your screen that you can click on and send us email questions, which we will be happy to answer during the course of this procedure. After the procedure is over with, the show will be archived on the Memorial Hermann website, which is www.memorialhermann.org. I am pleased this afternoon to have as a co-moderator Dr. Rex Marco, who is a surgeon who is skilled and has a lot of experience with this innovative procedure of treating chronic low back pain.

Dr. Marco, what does T lift stand for?

REX MARCO, M.D.

TLIF stands for transforaminal lumbar interbody fusion. I can better show you that on this model here. This is the front of the spine and this is the back of the spine. You can

see this area right here, where the disc usually is. We already have a cage in its place, which is what Dr. Kushwaha is going to put in this patient as well. This is a vertebral body and this is another vertebral body. Transforaminal refers to this area right here. This is the foramen, between this pedicle here and this pedicle here, and we can place a cage now, with newer techniques, from the back into the front, and put an interbody cage between this body and this body, in between the spine, to help it fuse together. In the past and actually in the present, many surgeons still use two procedures, one in the front, through the abdomen, and an incision in the back to fuse the spine, but with this innovative technique, we can all from the back fuse the spine in the front and the back, and we'll show you that a little bit more closely with Dr. Kushwaha's procedure.

STEVE ALLEN, M.D.

What are the indications for performing an operative fusion on patients with chronic low back pain?

REX MARCO, M.D.

We can go over that here. This first slide here shows the MRI and an x-ray of a patient with degenerative arthritis. You can see at the bottom there's a dark disc, where there's that arrow. That is a dark, worn out disc that is arthritic and has lost a lot of water. That's one indication for a spine fusion, especially if this patient has failed all nonoperative treatment courses, including a course of therapy, nonsteroidal medications, an exercise program, and sometimes steroid injections.

This is another indication, spondylolisthesis, with our next slide. You can see on the left is a patient with spondylolisthesis. Spondylolisthesis refers to the slippage of one vertebral body on another vertebral body. Although this isn't exactly the kind of patient, with scoliosis, that we would treat with a TLIF, this is just to help demonstrate what scoliosis is, which is curvature of the spine or an S-shaped spine. This is idiopathic scoliosis, which happens in adolescent patients. The type of patient that we treat with the TLIF procedure would be someone that has degenerative scoliosis and I've got another example of that coming up.

The next example is right here and we'll see this patient here had a previous operation which led to some instability of the spine and some curvature of the spine and this has also caused scoliosis, but this is more related to a degenerative process in the spine, rather than a development that happens as the patient grows older.

STEVE ALLEN, M.D.

Okay. I think we'll now go into the operating room and see how Dr. Kushwaha is coming along with the case.

VIVEK KUSHWAHA, M.D.

Hi. I'm Dr. Kushwaha. I have here, helping me do the surgery, Susanna Knapp, my physician's assistant; Jackie Ferrara, our surgical technician. Jerry Bridges is our circulating nurse. He's helping us get whatever we need during the surgery. Drs. Abraham and Bode are providing the anesthesia.

The gentleman I'm doing surgery on is a 69-year-old male who has actually a previous surgery about six months ago at an outside facility that was designed to relieve pressure on a nerve by doing what's called a laminectomy, where bone is removed to free up a nerve that's pinched. Unfortunately, in his case it didn't work very well and, in fact, his pain has gotten worse, with pain both in the back and going down his right leg. Since that time, the level where he had surgery, at L3-4, has collapsed further and has now become unstable, where the vertebrae are slipping back and forth. In addition, the nerve still is quite compressed and causing him a lot of pain. Intraoperatively, what I have found during the surgery....I have already exposed the spine, as we can see on the camera here. I have already placed some screws that will be used to do the procedure and the fusion. This particular spot right here, where he had the previous surgery, that's actually his joint that is broken and loose and that, I think, is why he became unstable and why his pain is persistent.

STEVE ALLEN, M.D.

The screws that you've placed, Dr. Kushwaha, those are into his pedicle?

VIVEK KUSHWAHA, M.D.

Yes, they're into a part of the bone that's called a pedicle, that connects the front part of the spine to the back, so the screw goes through the pedicle into the body itself.

STEVE ALLEN, M.D.

Just for orientation sake, which is toward the head and which is toward the feet?

VIVEK KUSHWAHA, M.D.

This is toward the head and this is toward the feet.

STEVE ALLEN, M.D.

And what level are you touching right there?

VIVEK KUSHWAHA, M.D.

This is the level that he had previous surgery. This is L3-4. As you can see, it's very loose, this joint. I'm trying to expose that area so I can get to the nerve and free it up and then I can put in screws at the final two spots, here and here, at L4-5, to complete the instrumentation portion of the surgery.

STEVE ALLEN, M.D.

Does this particular finding alter what you are going to try to do to achieve the fusion and stability?

VIVEK KUSHWAHA, M.D.

No, it doesn't change anything I do. It just confirms why it needed to be done. You know, on the x-rays preoperatively, we knew this segment was unstable, but it was difficult, it's not always obvious what is causing that and intraoperatively we see why.

So right now I've got this loose fragment almost freed up. I'm trying to free it up from the underlying scar tissue from the previous surgery. It's pretty adherent, but I think I've got it off now. I just took it off and there you can see the other side of the joint. The cartilage is right there. At this point I think I've got enough exposed that I can go ahead and put in my last two screws before I go on to the TLIF part. I bite off some bone so I can see the landmarks to put in the screws and then I drill a little hole with this drill to make the pilot hole for the screw. Then I use a hand drill to guide where the screw's going to go.

STEVE ALLEN, M.D.

You adjust the depth, how far the screw is going in, by what technique?

VIVEK KUSHWAHA, M.D.

There are depth markings actually on this instrument that tell me how far I've gone in.

STEVE ALLEN, M.D.

How far do you usually choose to go in?

VIVEK KUSHWAHA, M.D.

This is actually a large man. He's 6'4", 6'5", so I want to use one of the larger size screws, so in his case I'm using screws that are about 45 mm long. Right now I'm tapping the bone. For those who are involved with carpentry, frequently you have to tap structures before you put a screw in.

STEVE ALLEN, M.D.

Because he had a previous back operation, sometimes the scarring postoperatively makes those patients' subsequent operation more challenging. Are you finding that to be the case here?

VIVEK KUSHWAHA, M.D.

Not yet, so far. I mean, obviously we saw that scar tissue earlier that I was trying to free that loose bone from, but when I do the TLIF part, I'll have to investigate that in more detail. That may be a problem, but it's not anything we can't surmount.

STEVE ALLEN, M.D.

You've done how many of these, Dr. Kushwaha?

VIVEK KUSHWAHA, M.D.

This particular technique I've done probably well over 200 by now.

STEVE ALLEN, M.D.

What's your general impression of the success of these compared to some of the more traditional approaches, the final stabilization?

VIVEK KUSHWAHA, M.D.

I think it compares very favorably. It results in a high rate of fusion and the complication rate is low. Some of the other types of surgeries, for instance, the 360, where you fuse someone both from the front and the back, has a very high rate of fusion but also has a significant rate of complications and that can be a problem, of course, so I think this surgery is relatively safe compared to that and can provide results similar to that.

STEVE ALLEN, M.D.

Are there patients with lumbar instability who are not a candidate for TLIF?

VIVEK KUSHWAHA, M.D.

Yes. If someone has had really a lot of previous surgery and they're really scarred up, then it may be more difficult. If someone has very unusual anatomy, where some of the landmarks are not as well seen. And then, of course, if someone needs many levels fused. I've done up to three levels for a TLIF. The people who need more levels, perhaps another technique may be a little more appropriate.

REX MARCO, M.D.

Dr. Kushwaha, for some of the surgeons that are watching, can you explain what your landmarks are for putting in the pedicle screws?

VIVEK KUSHWAHA, M.D.

The landmarks are the joint itself, the facet joint; the transverse process, which is a bone that grows off the side of the vertebra; and the pars, which is a bone that connects the front part of the spine to the back, so there's a spot that all three of those structures converge, where is usually the best place to put in the screws, so in his case, I've already exposed that spot right here and I'm going to put in the last screw.

REX MARCO, M.D.

And the last thing you just did was to take off the inferior facet of L4? Is that correct?

VIVEK KUSHWAHA, M.D.

Correct.

REX MARCO, M.D.

You take off the entire inferior facet with the pars when you perform this procedure?

VIVEK KUSHWAHA, M.D.

Yes. On the side that you're doing the TLIF, because that's what you need to do. You need to have the proper exposure into the disc to take it out and put in the spacers.

STEVE ALLEN, M.D.

I want to remind our audience at home that they are watching a live lumbar stabilization procedure called a TLIF, being performed by Dr. Kushwaha, Chief of Spine Surgery at Memorial Hermann Hospital in Houston, TX, and that we are taking your email questions. I want to take a moment to ask a couple of these email questions to Dr. Marco, who is co-moderating with me. How long does it take to heal and what restrictions do you put on patients following this type of procedure?

REX MARCO, M.D.

Most of our patients go home between the third and fifth day. We ask them, while they're home, to start a walking program. Before they come back to our clinic, we want them to walk at least a mile. They come back to our clinic about two weeks after the operation and they should be walking at least a mile by the time they come back. Overall, it takes a while for the bone to fuse. At about three months after the operation, the bone is 90% healed. Six months to a year after the operation, the bone is 97% healed and during the last year of the two-year period that it takes to heal, the last 3% of the bone heals.

STEVE ALLEN, M.D.

What's the percentage of patients who have nonunion with TLIF?

REX MARCO, M.D.

That, I think, varies on the technique and the surgeon, but it's probably around 5%, but it may be less with the newer techniques that we're using, with the special bone-forming proteins. It will probably be less than that.

STEVE ALLEN, M.D.

A patient sends in a question. They've had a previous L5-S1 discectomy followed by a fusion, but still have low back pain. Would a TLIF be indicated for that patient?

REX MARCO, M.D.

A TLIF may be indicated for that patient if the patient has pain that's coming from the disc above that, like the L4-5 disc. If the L5-S1 disc is truly fused, depending on what type of fusion technique was used, you may or may not be a candidate for a TLIF procedure. We would have to look at your x-rays and examine you to make sure that you would be a candidate for a TLIF procedure and get other studies as well.

STEVE ALLEN, M.D.

The patient's child is watching this procedure being done on her dad and asks the question, how long will be in recovery?

VIVEK KUSHWAHA, M.D.

He'll be in the recovery room probably 1-2 hours, depending on how quickly he wakes up from the anesthesia.

STEVE ALLEN, M.D.

Another question we were asked, that I'll give to Dr. Marco. Because you're putting in a new bone within the vertebral space, this observer wants to know, will the surgery make the patient taller when the bone grows?

VIVEK KUSHWAHA, M.D.

That's actually not a bad question. Certainly sometimes when people's disc spaces are collapsing, we put in a spacer to increase that. That does put literally more length to their spine. I don't know if it's enough to make a measurable difference in their height, but I've had patients tell me they feel like they can stand up straighter once they've had their spine fixed so they're not standing on unstable spinal segments.

REX MARCO, M.D.

Some of our patients that have degenerative scoliosis, where they have a curvature of the spine, if we can straighten them out some, they're usually a little bit taller as well.

STEVE ALLEN, M.D.

Another viewer asks, would this procedure be appropriate for a 55-year-old patient suffering from "diffuse lumbar spondylosis," which has been said to be too severe for surgery? That's kind of a hard question to answer without more information, isn't it?

VIVEK KUSHWAHA, M.D.

Yes. Spondylosis is basically a generic term for arthritis, so if she has diffuse arthritis, then that's not really a candidate for any surgery, but sometimes arthritis can cause other problems in the spine that can lead to problems that are surgically practical.

REX MARCO, M.D.

Dr. Kushwaha, you're now removing the ligamentum flavum?

VIVEK KUSHWAHA, M.D.

Yes, I'm now exposing the area for the L4-5 disc and, in fact, I think I have enough exposure that I'm going to start doing the TLIF part of it. I don't know how well this can be seen, but the disk is right there now.

STEVE ALLEN, M.D.

Okay. I think we'll take a break from the OR here, just to show a graphic off of our computer screen, to give the viewers who are watching this on the internet a little bit better idea of what is going on in surgery in a way that you couldn't possibly see in the operating room. Dr. Marco, could you walk us through what's happening now in the procedure?

REX MARCO, M.D.

This illustrates what Dr. Kushwaha is doing. On the far right, you see that the screws and the rod are already in place and the surgeon is placing a piece of graft into the disc space, all from the back, instead of having to go in from the front. The graft can be put in between the two vertebral bodies, all from the back, and this is carefully done by a special retractor holding the nerve sac out of the way so it's not injured during the procedure. You can see that the inferior facet or this part right here, right there, this part right here is completely removed in order to do this procedure. Dr. Kushwaha showed that very nicely and then what we're seeing him start to do is distracting and opening up the space on the screws with a special distractor, so that also helps him take out the disc, which you can see on the slide. Let's go back to the slide again. On the far left, you can see that the surgeon is reaching around and taking out all of the disc, all from the back,

and that's what Dr. Kushwaha is about to do. We can probably go into the operating room again.

VIVEK KUSHWAHA, M.D.

Yes. I have actually exposed the disc. I've gone into the disc and started removing disc material. As is often the case in a disc that is worn out and degenerated, there's not very much disc material in there. It's kind of bone on bone. Before I do that, I'm going to take some bone marrow from the hip itself. Certainly traditionally taking bone from hip has been used as the bone graft for a fusion, but often it is associated with a lot of pain from the area where the bone is literally cut out, so what I do is I take bone marrow, which has all the bone growth properties of bone...you can see there's a syringe of bone marrow and I mix it with some crushed cadaver bone and then I also add a relatively new substance called bone morphogenic protein, which is a substance that is a bone growth hormone. I mix all that together and I use that as my bone graft, rather than taking bone from the hip. That, I've found, has worked very well and avoided the pain that is associated with harvesting bone from a patient's hip. So now that I have that bone ready to go, then I can start cleaning out the disc and start putting bone into the disc space.

The first step is to use this instrument, which is called a curette, into the disc space to scrape out the disc. Unfortunately, there's not really any delicacy to it. It's a procedure that involves cleaning out that space so the bone can grow, so we have to literally scrape out as much disc as we can.

REX MARCO, M.D.

Dr. Kushwaha, we had a question about the learning curve here from one of our surgeons out there. He was asking about the learning curve. I think you do some things very nicely here which, with the use of your curette, instead of pulling up, you use a gentle pushing motion and you're creating, from what I've seen you do, you create a trough for this bone and cage to go into and I think that helps decrease the time that the surgeon will spend doing the discectomy.

VIVEK KUSHWAHA, M.D.

Yes, this is a technique that, like any technique, has a learning curve to it. I think most surgeons who do a lot of spine surgery should have no problem doing it. The major portions of the surgery are parts that most surgeons already do anyway, a laminectomy, discectomy, instrumentation. It's just a manner of putting them together in this particular manner.

STEVE ALLEN, M.D.

Another viewer asked how long did it take you to dissect the muscle away from the spinous processes and the lamina?

VIVEK KUSHWAHA, M.D.

15 minutes.

STEVE ALLEN, M.D.

And how do you get it to reattach?

VIVEK KUSHWAHA, M.D.

I sew it back together at the end.

STEVE ALLEN, M.D.

How is it that you judge how deep to manipulate the curette into the disc space?

VIVEK KUSHWAHA, M.D.

These instruments, again, have markers on them that show you how far they're going in, so that is certainly a measure that you can use. Then of course, early in my learning curve, when I was first doing this surgery, I was doing them under live fluoro; that is, under radiographic vision, which allowed me to see exactly how far I could put them in.

REX MARCO, M.D.

That special pituitary is curved and it has a gold marking on it so you can tell the depth that you're in, right?

VIVEK KUSHWAHA, M.D.

Correct.

REX MARCO, M.D.

And then your other instruments have actual markings to tell you how deep you are as well.

VIVEK KUSHWAHA, M.D.

Right. At this point, what I'm going to do now is, I've cleaned out the disc pretty well. There's not much disc material left. Now I'm going to put in what's called a trial spacer, which is a temporary spacer that allows me to tell how big of a cage I can put in.

REX MARCO, M.D.

Dr. Kushwaha, you just did some other very important maneuvers here. You have your assistant, Susanna, holding the thecal sac and protecting the thecal sac as well as the exiting nerve root.

VIVEK KUSHWAHA, M.D.

Yes. The advantage of the surgery is that the nerves are not really endangered during surgery in terms of being stretched on or pulled on, but in this particularly physical part of the surgery, I do use a couple of retractors to make sure that I don't disturb them when I do this. What I've just done is put a spacer into this disc space and it is a very tight fit, so that means this is the right size that I need to put in and this should be a good fit because it's a little bit hard to take out, but that's good because the better fit you have, the more likely it'll succeed.

STEVE ALLEN, M.D.

I want to remind our viewers that you are watching a live TLIF procedure on a patient at Memorial Hermann hospital, being performed by Dr. Vivek Kushwaha, who is Chief of Orthopedic Spine Surgery here, and that we are taking your email questions and answering them on the air and will continue to do so for a week after the procedure.

REX MARCO, M.D.

One of the other nice things that I've seen you do and the viewers may be able to see this at the next level is that you find the disc in a very bloodless, almost bloodless fashion. Can you explain how you do that?

VIVEK KUSHWAHA, M.D.

Yes. The key is to find the right plane of dissection. You will occasionally find bleeding. Like any type of surgery, the sooner you find it and stop it, the better it is, but the key is to know exactly which parts you need to expose first so you don't get into bleeding that then becomes disruptive and slows down the surgery.

REX MARCO, M.D.

Some of the things that I've seen you do are take away the overhanging bone on the superior articular facet and the you take your Penfield and a paddy and sweep it over the disc and move the nerve root as well as the veins cephalad.

VIVEK KUSHWAHA, M.D.

Yes, there are always veins on top of the disc and by sweeping them out of the way, I don't put them in the path of being cut and then cause some bleeding that can be annoying.

REX MARCO, M.D.

What are you doing now?

VIVEK KUSHWAHA, M.D.

Now I just put some of that bone that I mixed with the bone marrow, I just put that through a funnel into the disc space and that will help that disc space to fuse together, so now I'm ready to put in the cage and into the cage I will also put in some bone growth hormone, which also will help the area to fuse.

STEVE ALLEN, M.D.

People have used a wide variety of material over the years into the disc space. I was wondering if you could comment about some of those that have been used. I know people probably recently saw some information concerning your use of an artificial disc.

VIVEK KUSHWAHA, M.D.

Yes. An artificial disc is a metal and plastic device. It allows you to retain motion and it is useful for certain kinds of disc problems. It would not be appropriate for this patient. He has instability and a situation where his spine has a deformity that a disc replacement would not be enough to correct the problem, but in terms of the different materials that people have used, certainly titanium, carbon fiber, various highly specialized plastics, and of course bony material, machined or milled cadaver bone to place into the disc space is also commonly used.

REX MARCO, M.D.

What is your experience with that bone morphogenetic protein and putting it in the cage like that?

VIVEK KUSHWAHA, M.D.

I think it has worked very well. I think it stimulates the fusion very nicely and I've not had any significant problems with it stimulating too much bone growth. Now I'm putting in the cage. It's going in very nicely. It looks like it will be a good fit.

REX MARCO, M.D.

The purpose of putting in the cage with the BMP and the bone fragments is to restore the intervertebral disc space?

VIVEK KUSHWAHA, M.D.

Correct.

REX MARCO, M.D.

And also what does it contribute to the overall anterior fusion?

VIVEK KUSHWAHA, M.D.

It's the main mechanism by which we get the interbody fusion. Okay, now I've placed the L4-5. Now I'm going to come up to the L3-4 level, which is where he had the previous surgery and that may be a little bit more difficult to expose because that's where he has more significant scar tissue, but I guess we'll find out. Right now it doesn't seem too bad. What had happened with him is that in the area where he had the previous surgery and the section I did, he had developed a little scoliosis where the disc had collapsed. He had developed a little instability where the bones were slipping out of place, which all combined to cause his back pain and the pain going down his leg from his nerve roots being irritated.

REX MARCO, M.D.

So another thing that helps with this procedure is what you just did. You put in the graft or the cage, you put it in straight, and it's shaped like a banana, it's curved, and then you took the other tamp and then used that to push it in further.

VIVEK KUSHWAHA, M.D.

Right. It goes in straight and then it curves into the space of the disc to go into the other side and be in the middle.

REX MARCO, M.D.

What are some of the dangers of using the curettes and spacers, if you went too deep?

VIVEK KUSHWAHA, M.D.

Well, obviously the most significant danger is if you went too deep, you would get into the contents of the abdomen, which would include most significantly the aorta and the vena cava. Of course, that would be a major problem if you injured those structures.

REX MARCO, M.D.

Do you think the risk of injuring those structures is higher with this procedure or with an anterior spinal fusion?

VIVEK KUSHWAHA, M.D.

I think much higher with an anterior spinal fusion. I've done lots of anterior spinal fusions and I can count a number of times where the vena cava or one of the major vessels was injured. The difference is that's recognized at the time of surgery and repaired right away, so it doesn't cause any clinical problem usually. The difference with this is that it may be more difficult to recognize, so it may be a little harder to repair, so it may be more of a clinical problem.

STEVE ALLEN, M.D.

How severe was this patient's pain by the time you saw him?

VIVEK KUSHWAHA, M.D.

He was in a lot of pain. He was taking a fair amount of pain medication. It was hard for him to walk. It was hard for him to sleep. He already had one surgery that didn't really work for him, so for him to consider another, I think he was not willing to live with it. Right now I'm trying to free up his nerves from the scar tissue and you can see that there is a little bit of adherence and it's going to take a little bit of work to free this up.

STEVE ALLEN, M.D.

While you're doing that, I'll ask another question. This is obviously a patient that had a 360 fusion of L4-5 12 years ago. The patient says that they also have been told they have arthritis at L5-S1, as well as narrowing of the disc space. Is the TLIF surgery applicable if the patient needs a fusion at that level? The patient does have severe back pain that radiates down the left leg and is seeing a pain management doctor to decide if something more needs to be done.

VIVEK KUSHWAHA, M.D.

I think that's where a TLIF is most useful. When somebody already has surgery from the front, it's very difficult to go back in from the front and do surgery on another level. The scar tissue from the previous surgery makes the exposure very difficult, so to not have to go in the front at all and do it all from the back is ideal.

STEVE ALLEN, M.D.

Another patient asks, they had a discectomy three years ago and are still in constant pain. The right leg goes numb. They are wondering if this type of procedure might benefit them.

VIVEK KUSHWAHA, M.D.

It certainly could. A lot of times when somebody has a discectomy or some sort of decompressive procedure, even though it may have been done perfectly fine, it may simply not have been enough to solve his problem. The nerves can get irritated in many

ways and just going in and removing part of the disc is sometimes not enough to address the different ways the nerve is being irritated, so a TLIF allows you to decompress the nerves in a much more complete manner and then allows you to do a fusion to stabilize whatever segment that may be unstable.

STEVE ALLEN, M.D.

I know there probably isn't a straightforward answer to this, but a lot of what you and Dr. Marco do is to fuse portions of the lumbar spine, implying that instability is a cause of pain. Does anyone know why instability creates pain? Is it compression of the nerve roots? Is it local muscle spasms? Something else?

VIVEK KUSHWAHA, M.D.

I think it's probably some mechanical irritation of the nerve root from the motion. I've had patients who had spondylolisthesis, where the vertebrae were slipping out of place. By both MRI and myelogram, the nerves seemed to have plenty of room and should not have been bothered, but just the fact that the bone was slipping out of place caused that nerve to get irritated and cause pain.

STEVE ALLEN, M.D.

We have another email question to ask while you're still doing that dissection. The patient says they've been diagnosed with marked intervertebral disc degeneration with moderate degenerative subluxation at L4-5 and a bulge at L3-4 as well as at T11-12 and minimally at L5-S1. The patient had a laminectomy at L4-5 about 7 years ago. Would they be a candidate for this procedure?

VIVEK KUSHWAHA, M.D.

Probably. That sounds like a guy who definitely could use it.

STEVE ALLEN, M.D.

And then it goes back to a big indicator for this type of procedure, the evidence of degenerative disc disease.

VIVEK KUSHWAHA, M.D.

Yes, and instability, and certainly when people have had previous surgery and have persistent pain after the previous surgery, that often is a sign that there's more going on.

STEVE ALLEN, M.D.

Another question that was sent in is how would you compare the typical postoperative course in the hospital of a patient who undergoes a TLIF versus someone who underwent a 360?

VIVEK KUSHWAHA, M.D.

I think the initial healing time is faster because it's not as invasive a surgery. I think people do go home sooner. They tend to have fewer initial postoperative complications. Probably the first six months of the patient's recovery are probably a little faster with the TLIF, but ultimately, 1-2 years down the road, that initial rate doesn't matter as much because by then they've recovered and the whole issue is whether the fusion helps them or not.

STEVE ALLEN, M.D.

We talked a lot about the problems with the other procedures, anterior and posterior fixations. What is the most common complication or side effect from the TLIF?

VIVEK KUSHWAHA, M.D.

I think there are some complications with the TLIF that are true with any kind of fusion you do. It could be due to the fact that the fusion may not be simply appropriate for the problem that you're trying to fix. You may not be doing the right levels. It may be creating a situation where the spine gets too stiff and creates too much stress on the adjacent segments. That's true of any fusion. Then the problems that are inherent to the TLIF I think are probably the most significant in this particular part I'm doing right now, where I'm trying to free up that space. If you don't do it properly, you certainly could cause a problem with either the nerves or the lining to the nerves and create a dural tear.

It looks like I've been able to expose this disc enough to do the TLIF now, so I'm going to go ahead and make an incision into the disc itself. I'm going to put in instruments to start taking out disc material and start cleaning out the disc.

STEVE ALLEN, M.D.

On the MRI, was this disc pretty degenerated?

VIVEK KUSHWAHA, M.D.

This particular disc was degenerated. In addition, there was instability. There was a spondylolisthesis that moved on x-ray. That is, as he moved, the bone was slipping back and forth.

STEVE ALLEN, M.D.

This has a broken facet as well?

VIVEK KUSHWAHA, M.D.

Yes, this is the one that had that broken joint, which I think is why it was too loose.

REX MARCO, M.D.

So you nicely exposed that disc, even though this patient had a previous operation.

VIVEK KUSHWAHA, M.D.

Yeah. I think the reason why is that when you do a TLIF, you do encounter some scar tissue, but because you're going at it from the side, away from where the previous surgery was, you can get around the scar tissue and then expose the disc, sort of bypassing most of the more adherent scar tissue.

REX MARCO, M.D.

The instrument you put on there is called the distractor. What purpose does that serve?

VIVEK KUSHWAHA, M.D.

That serves to open up the disc so I can get into that space a little bit easier and I can clean it out.

REX MARCO, M.D.

Can you show our viewers how you're protecting the nerve sac so it doesn't get injured?

VIVEK KUSHWAHA, M.D.

Yes. I have my assistant holding this little metal blade that fits between me and the nerve, so I don't get into that space.

REX MARCO, M.D.

And in the past, you used to have to move that nerve sac over almost an inch to get into this space.

VIVEK KUSHWAHA, M.D.

Right. I have this retractor not really retracting, but really serving more as a shield to protect the nerves. The nerves are not being pushed on in any way.

REX MARCO, M.D.

This newer technique allows you to not put so much traction on the nerves within the nerve sac.

VIVEK KUSHWAHA, M.D.

Right. So now I'm going to do exactly what I did on the previous one, where I put in these different scraping devices to clean out that disc. In the next few minutes, I should be able to put the second cage in and start the end of the case.

STEVE ALLEN, M.D.

What type of medications do you typically prescribe these patients in the immediate postoperative period and then on discharge from the hospital?

VIVEK KUSHWAHA, M.D.

Well, I use two different methods of pain relief. In these surgeries, we do have the area of the nerves, the epidural space, readily available, so I'll place an epidural catheter to provide pain relief for the patients postoperatively, just as a woman has during labor, to provide pain relief to the spine itself. Then they also have a more traditional PCA, or self-administered IV pump that you can put morphine or some other medication through.

STEVE ALLEN, M.D.

How long do you leave the epidural in?

VIVEK KUSHWAHA, M.D.

Usually the epidural is in there for two days. That's when the initial pain is most acute. On the second day, we take the epidural out and that makes them a little more mobile. Usually by the third day they go home.

STEVE ALLEN, M.D.

What do you give for antibiotics?

VIVEK KUSHWAHA, M.D.

Preoperatively we give them a very common antibiotic, Ancef, just for preoperative prophylaxis. We continue that for six doses.

REX MARCO, M.D.

We have a question from a premedical student and I think we could probably best answer that question. His question is what are the complications associated with this procedure? I can just tell him that what we tell our patients is that we do everything we can to

minimize complications. The viewer can see most of what we do here is to help prevent those things. First of all, as we just talked about, we wash the skin really well and we give antibiotics before and after the operation. That decreases the likelihood of getting an infection. We protect the nerve roots right there, the nerve sac, and that decreases the likelihood of getting injury to the nerve sac and leakage of the spinal fluid. One of the other more common complications with any spine fusion is that it won't heal. You've done several things here to help this heal. You've taken out the disc and you've put in the cage in place of the disc and that adds stability to the front of the spine. You've put in screws to help hold that cage together closer and provide further stability. You've added some bone marrow aspirate as well as the bone morphogenetic protein, which also decreases the likelihood of nonunion and the patient not healing. You're very careful of the way you put the curettes in there and the other instruments into the disc space so you don't injure any of those structures, like the vena cava or the aorta. You're using a relatively bloodless technique. You haven't lost a lot of blood. That helps decrease the likelihood of getting any transfusion-related problems. You're saving the blood that this patient is losing and any blood that he loses, you're giving it back to him, correct?

VIVEK KUSHWAHA, M.D.

Yes. I don't think we've even lost enough blood to give back, but potentially if we did, we could do that.

REX MARCO, M.D.

And the blood in Houston is as safe as possible. It's tested for HIV and hepatitis and anybody that donates blood is also extensively screened and tested for these disorders, so in the event that this patient did need blood, which is very unlikely from what I see from the way you're doing this, but in the event that they did need blood, it would be very unlikely that they would have any complications related to a blood transfusion. And then of course we have very good anesthesiologists who watch the fluid levels and the urine output and the oxygen level and the blood level throughout the entire operation and help keep all the organs as safe as possible, like the heart and the brain and the lungs and the kidneys.

STEVE ALLEN, M.D.

Do you have any special anesthetic requirements? Do you drop the blood pressure during these procedures in order to decrease blood loss?

VIVEK KUSHWAHA, M.D.

A little bit. Not too much. Certainly the spine itself requires some amount of blood flow to keep it perfused, so I don't like to get too low when I do spinal surgery.

REX MARCO, M.D.

But you did do a couple of things here which some of the surgeons might want to know. You put him on an Andrews table, which is a special table that takes away some of the pressure from the abdomen and decreases bleeding from the veins around the spinal column.

VIVEK KUSHWAHA, M.D.

Yeah. I think it's important that you have the abdomen free and there are different ways of doing that, but I think with the abdomen free, you can take the pressure off the epidural space and help minimize epidural bleeding.

STEVE ALLEN, M.D.

How does this disc space compare to the previous one?

VIVEK KUSHWAHA, M.D.

This disc space is looser. Because of that instability and that broken joint, it has a lot more give to it, so I'm putting in actually a larger trial than that other one, so I think this one fits well and I think we'll go with this.

STEVE ALLEN, M.D.

How many mm is that trial?

VIVEK KUSHWAHA, M.D.

11. There are different sizes, depending on the size of the disc that you're putting the instruments in, but generally most of the discs that we are operating on are collapsed and degenerated. If they are very thick, they probably don't need to be fused.

STEVE ALLEN, M.D.

I want to remind our viewers that they are watching, live, a TLIF procedure being performed by Dr. Vivek Kushwaha at Memorial Hermann Hospital in Houston, TX, and we are taking your email questions and answering them now and will continue to do so for the next week. If you missed the first part of this fascinating procedure, you can find it on our website at www.memorialhermann.org. Dr. Kushwaha, what are the main advantages to using the metal cages over using bone plugs?

VIVEK KUSHWAHA, M.D.

Well, this particular cage actually is not metal. It's carbon fiber, which is actually better than metal, I think. It's radiolucent; that is, you can't see it on x-ray. There are markers on it to know where it is, but by not being visible on the x-ray, you have a better ability to see the bone growth and make sure that the area is fusing. Then the carbon fiber has a

little better what's called modular elasticity. That is, it's not so stiff that the bone will become reliant on it for support instead of growing itself.

STEVE ALLEN, M.D.

A viewer sends in this thoughtful question. What is the future of this operation? Are there any foreseeable improvements that could be made that just haven't yet made it into conventional clinical practice?

VIVEK KUSHWAHA, M.D.

I think the most significant improvement that could be made would be to have it done minimally invasively. There are already early generations of systems that can do this surgery through a minimally invasive procedure. They are, as technically challenging as this surgery may seem, to do it minimally invasively is even more difficult, so I think the problem with now is those first generation systems are a little too difficult, but I think as technology is improved, we may be able to do this surgery through not only smaller incisions, but less trauma to the local tissues so that people will have a faster recovery and can have less postoperative pain.

STEVE ALLEN, M.D.

Right now, you just took that carbon fiber cage and packed it with some material that's been soaked in bone morphogenic protein?

VIVEK KUSHWAHA, M.D.

Yeah. I've already put in some cadaver bone that I soaked in the patient's bone marrow and now I've put in the cage with the bone growth hormone in it as well. Now I'm going to take an x-ray to make sure that everything I did looks right.

STEVE ALLEN, M.D.

So if the x-ray shows everything is in place, what would be the next step?

VIVEK KUSHWAHA, M.D.

The next step will be to connect the screw to the rod and tighten everything together and close it up. Right here you can see where his previous surgery was. There's a lot of scarred up tissue here, but the nerve itself is now very free. There's no bony material or disc material pushing on it at all. I can pass my probe all the way around it without any sign of compression.

STEVE ALLEN, M.D.

Could you just point out those landmarks again?

VIVEK KUSHWAHA, M.D.

This is where the disc was. I've taken that out, so there's no more disc material left. This is the thecal sac and right here is the nerve root itself, the L4 nerve root, so you can see there's nothing touching it anymore. The disc is gone. There's no overlying bone compressing it. There's just this little bit of scar tissue from his previous surgery, but that is not compressing anything, so I think he should do well. I think he'll have some pain, of course, from the surgery, but I think his preoperative pain, especially the pain that was going down his right leg, should improve.

REX MARCO, M.D.

You were just able to take out the entire disc and fuse the bones together, all from the back.

VIVEK KUSHWAHA, M.D.

Yes. That's the key with this technique, that you can do what is actually a lot of surgery in not that much time, with very significant results.

REX MARCO, M.D.

In the past, you would have to do that from a separate incision, correct?

VIVEK KUSHWAHA, M.D.

Yes. What I'm going to do at this point, now that I've got the cages in and I'm waiting for the x-ray, is I'm going to roughen up the bone that's overlying his spine and I'm going to put additional bone grafts on the side of his spine and do what's called a posterolateral fusion, as well as the interbody fusion I just did. That way I maximize my chances of this surgery working. There are different parts of the spine that are involved with the fusion. In this case I'm now exposing the transverse process, which is the part of the spine that is on the side, that will allow me to place additional bone graft material. I have some leftover bone from the first part of the surgery that I can put in here now.

STEVE ALLEN, M.D.

While you're doing that, another viewer has sent in a question mentioning the fact that you were the first surgeon in the Texas Medical Center to use the artificial discs, which we mentioned earlier. They're asking if they would be suitable for cervical spondylosis.

VIVEK KUSHWAHA, M.D.

Disc replacement?

STEVE ALLEN, M.D.

Yes.

VIVEK KUSHWAHA, M.D.

Yes, that is an indication that is being explored. It's currently not FDA-approved and it's not generally available, but I think as time and research progresses, disc replacement will also be an option in the neck.

STEVE ALLEN, M.D.

Another viewer sends in a comment and a question. 200 surgeries is not very many. When is it not a new procedure and are other surgeons around the country doing this too?

VIVEK KUSHWAHA, M.D.

Actually, I would say that most people consider 200 surgeries in two years quite a bit and, yes, there are other surgeons using this technique. I certainly didn't make it up. It's been described for a number of years, but in the manner that we do and some other surgeons around the country do, I think it's a little bit different.

STEVE ALLEN, M.D.

This is a question from another viewer that I think addresses some of the points you made earlier. They say, I have degenerative arthritis and spondylosis, but my doctor says it doesn't appear on the MRI that a nerve is pinched enough for surgery. However, they have severe back pain radiating down the right leg for the last three years.

VIVEK KUSHWAHA, M.D.

I think that's a common misconception, that if an MRI or some other test does not show compression of a nerve, there's no basis for pain or something that is not fixable. There are other tests that can show problems with nerves in more detail or problems with the disc, such as a myelogram or discogram, so sometimes it does require additional tests to see exactly what's going on and to diagnose the problem.

Now I'm going to connect the screws to the rod and that will be the final stage of the surgery, where we connect all the screws to the rod and tighten everything up.

STEVE ALLEN, M.D.

What material do you use for the rods?

VIVEK KUSHWAHA, M.D.

This is all titanium. The advantage of titanium is that it is strong and flexible and also MRI-compatible, so if these patients ever need to have additional MRIs done, it is still possible to do so, whereas problems are more difficult to assess with other types of metal.

STEVE ALLEN, M.D.

Another question that comes up is that by having all this hardware in someone's back, does it make it a problem for them to go through metal detectors?

VIVEK KUSHWAHA, M.D.

In the past that wasn't the case, but now, with metal detectors being more sensitive, it is common for people who have had metal placed in their lower back or mid back, that it does set off metal detectors, in which case they have to have one of those portable things placed on their incision to confirm that it is coming from their surgery.

STEVE ALLEN, M.D.

Is there ever a reason to go in and take out the hardware?

VIVEK KUSHWAHA, M.D.

A small percentage of patients do have their hardware removed, for a number of reasons. Most commonly, it is a piece of metal that's in the body and frequently when metal is placed, whether it's a plate for a broken leg or an arm, sometimes people feel it bothers them, so I do remove it once the fusion is complete and healed. It's not the same as putting it in, so it's not the same scope of surgery. It's much smaller surgery to take it out. Then a small percentage of patients have other problems from the hardware. For example, people who have osteoporosis or osteoporotic bone, that can cause the hardware not to hold as well and it can loosen, in which case it needs to be removed to prevent pain.

STEVE ALLEN, M.D.

Are you adjusting these to achieve a certain amount of distraction?

VIVEK KUSHWAHA, M.D.

Now I'm actually going to compress these screws together to lock in the cages I put in. I'm going to use the screws to sort of close down the disc space so the disc is not...before, I was distracting the disc space open to dilate it to put in the cages, but now I want to narrow down that space. I don't want what I just put in to come back out. The tighter the fit, the more likely a good fusion. Okay, I think we're at the point where we can go ahead and get an x-ray.

STEVE ALLEN, M.D.

I think, as Dr. Marco pointed out, the viewers should note what a relatively bloodless field you have here at the end of the case and that, more than aesthetics, it's important to have a dry field, not only for surgical exposure, but also in the postoperative course of the patient.

VIVEK KUSHWAHA, M.D.

Yes, blood loss is directly related to multiple complications, infection most prominently, so if you can minimize blood loss, it makes the surgery easy to do, makes it faster to do, and minimizes the risk of infection.

STEVE ALLEN, M.D.

Alright. I think what we might do is go to our computer screen to look at some...while he's getting his x-ray to check the position of the hardware, we want to go to our computer screen and have Dr. Marco talk to you a little bit about what you've seen and show it in a little different fashion, using x-rays.

REX MARCO, M.D.

This is a patient who had degenerative disc disease and painful discs at two levels. What I really wanted to point out here is that the spine is relatively flat. You can see, looking from the side view, which is the x-ray on the far right, that the spine was sort of flat and the patient has lost the sway in their back. After this procedure, you can see on the next slide, on the far right, in the lateral x-ray, again, looking at the side view. The patient has a much more normal sway to their back and there's been restoration of their normal alignment.

STEVE ALLEN, M.D.

Can you see the cages on the lateral x-ray?

REX MARCO, M.D.

These cages are transparent, but they have little dots that are seen as white dots. There are four of them that you can see in the disc space and they're best seen at the top level. They're here, here, here, and here.

STEVE ALLEN, M.D.

You can see that the screws go $\frac{1}{2}$ to $\frac{2}{3}$ of the way into the vertebral body. That's where optimal positioning needs to be?

REX MARCO, M.D.

Yes. They should be at least halfway into the vertebral body to maintain optimal strength.

STEVE ALLEN, M.D.

How often do those screws loosen within the vertebral body?

REX MARCO, M.D.

If a spine fusion occurs, it's very unlikely that they'll loosen. If there's no spine fusion that occurs, then they frequently loosen and can sometimes break.

STEVE ALLEN, M.D.

Okay, we'll go back to Dr. Kushwaha in the operating room and see how he is doing.

VIVEK KUSHWAHA, M.D.

I'm tightening the screws now so they will lock in the cages I put in. We just took the x-ray and we actually tighten the screws to a certain torque so that they don't loosen. Usually 100 pounds per square inch.

STEVE ALLEN, M.D.

Do you have a torque wrench?

VIVEK KUSHWAHA, M.D.

It is a torque wrench. Now I'm compressing the screws together again to lock in.

STEVE ALLEN, M.D.

We have a couple of questions here, while you're finishing up there, for Dr. Marco, an observer asks, is the hardware porous? I guess by that, does bone grow into the hardware itself? What would be true for the cage, but would that be true for the rest of the hardware?

REX MARCO, M.D.

No, the hardware's not porous but there's a tendency for the titanium to have more ingrowth and compatibility with the normal tissue than stainless steel.

STEVE ALLEN, M.D.

Another viewer asks, you answered my questions about replacement discs for cervical disease. They comment, I don't understand if the FDA has approved artificial discs for

lumbar disc replacement, then why not cervical disc replacement? Why is it different for the cervical area?

VIVEK KUSHWAHA, M.D.

Well, it is a different area. There are different biomechanics. There are different materials. It's a whole different product. They all have to go through the same process to get approved and the cervical disc replacement process is not quite as far along as the lumbar discs.

STEVE ALLEN, M.D.

Some of you may be experiencing a little difficulty seeing some of the video images. We expect that to be corrected momentarily. We'll continue to answer these email questions as they come in. Another one asks a very common question also. Would increased calcium intake be necessary after surgery to help with the bone graft fusion?

VIVEK KUSHWAHA, M.D.

I think having healthy nutrition is important. I don't think taking extra calcium will make any difference, but certainly if you're malnourished, that will reduce your ability to heal and fuse.

STEVE ALLEN, M.D.

Someone I think was...yes, well, we won't identify this observer. They sent an email comment saying that their dad is very much of a do-it-himselfer...

VIVEK KUSHWAHA, M.D.

Don't do this at home.

STEVE ALLEN, M.D.

Don't do this at home, right. They want to know how long after undergoing this procedure would they be able to lift and how much weight they could lift.

VIVEK KUSHWAHA, M.D.

Well, when I judge the fusion to be healed and the patients to have rehabilitated their spinal musculature from the surgery and the healing process, then I do release them to do whatever they can handle and I've had patients go back to playing golf and skiing and doing physical things. Of course, not everyone can do that. Some patients have residual dysfunction, so from the standpoint that once the fusion is healed, certainly you can do whatever you can handle, although some people, especially if they have degenerative

discs, should still be careful so they don't hurt other parts of their spine, resulting in those places needing surgery.

REX MARCO, M.D.

I think the person that asked the question was concerned that her dad might do too much. Is it possible for a patient to be too active after this operation and not heal as well?

VIVEK KUSHWAHA, M.D.

Oh yes. I had a patient who I did a similar surgery on a couple of years ago and he did so well, he literally drove himself to his first postoperative appointment 10 days after the surgery and then, on his drive home, got in a car accident and disrupted everything I did, so I generally tell people not to drive for four weeks, not just to keep themselves from hurting themselves while driving, but to stay out of harm's way, especially on Houston's roads.

STEVE ALLEN, M.D.

What is the physical activity you allow them to engage in for the first three months?

VIVEK KUSHWAHA, M.D.

Well, of course we get them walking right away, so the next day after surgery, they're walking. In terms of lifting, I don't generally want them to lift anything more than 10-15 pounds for several months.

STEVE ALLEN, M.D.

We have the video back now and it appears that you're putting on the other rod.

VIVEK KUSHWAHA, M.D.

I've already placed my epidural catheter, which will be used to help reduce his pain. Let's see if I can show it. This is it right here. This is the catheter. I've placed it through the skin so when we need to take it out, we just pull it out. We don't have to go through the incision or anything. This is really the final stage, as I tighten the nuts for this rod, then we'll start closing.

STEVE ALLEN, M.D.

They usually run what through the epidural? A little bit of narcotic and local anesthetic?

VIVEK KUSHWAHA, M.D.

Yes. We have an excellent acute pain service here at the Hermann and they manage the epidural for me. They usually have some sort of drip that has both an anesthetic and a narcotic.

STEVE ALLEN, M.D.

A question that came in that I think would be interesting for both you and Dr. Marco to answer. We'll ask you first. What made you decide to specialize in spine surgery?

VIVEK KUSHWAHA, M.D.

Well, that's a complicated question, but I think the main thing is that it is very challenging surgery and where I thought there was a significant need for people who could do it well. Of course, where I trained, my most significant role models were spine surgeons, so I think that probably summarizes why I went into it.

STEVE ALLEN, M.D.

How about you, Dr. Marco?

REX MARCO, M.D.

I actually initially started doing two years of general surgery and then I wanted to become an orthopedic surgeon, but as I trained in orthopedic surgery, I quickly found out that I really wanted to help save lives, so I then trained in orthopedic oncology or musculoskeletal oncology, where you take care of patients that have bone tumors. In that field, there really wasn't anyone that was trained in both bone tumors and spine surgery and there is a definite need for somebody to be trained in both. I always liked spine surgery and because there is a void to fill for the two specialties together and I liked spine surgery, I decided to train in spine surgery as well.

STEVE ALLEN, M.D.

I want to remind our viewers that, although we are close to the end, they are watching, live, a TLIF procedure being done by Dr. Vivek Kushwaha, Chief of Orthopedic Spine Surgery at Memorial Hermann Hospital in the TMC. We are still taking email questions. If you want to send them in, we'll try to get as many in with the time remaining that we have, but we will continue to answer them for the next week offline. If you wish to see this procedure in its entirety, you can go to our website, www.memorialhermann.org, and you'll be able to watch this show in its entirety.

REX MARCO, M.D.

We have another question about the screws and the bolts. The bolts are the screws and they are considered the same. A pedicle screw really does look like a bolt. I think that's very observant of the questioner.

VIVEK KUSHWAHA, M.D.

I am done.

REX MARCO, M.D.

Dr. Kushwaha, how long ago did you start?

VIVEK KUSHWAHA, M.D.

The incision was about 4:55.

REX MARCO, M.D.

And what time is it now?

VIVEK KUSHWAHA, M.D.

6:45. Two hours. I just got the x-ray back and from 20 feet away, everything looks fine. I need it closer to me. It looks good. Everything looks the way it should. I think we can go ahead and finish the surgery.

STEVE ALLEN, M.D.

Okay, Dr. Kushwaha, thanks very much. I want to remind our viewers, they have been watching a TLIF procedure live, being conducted by Dr. Vivek Kushwaha, Memorial Hermann Hospital at the Texas Medical Center in Houston, TX. This program will be archived and available on our website, www.memorialhermann.org. We're delighted that you were able to join us for our second live webcast and hope that you will join us for subsequent ones coming up in the new year. On behalf of myself, Dr. Steve Allen, Dr. Rex Marco, and Dr. Kushwaha in the operating room, we wish you a good evening. Thanks.

NARRATOR

Thank you for watching the live TLIF procedure from Memorial Hermann Hospital at the gateway to the Texas Medical Center in Houston, TX. For more information, to make an appointment, or make a referral, please click the buttons below.