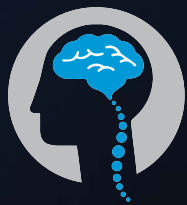


ACDF vs. Cervical Disc Arthroplasty

A guide for patients suffering from a herniated disc, slipped disc, ruptured disc, and/or a pinched nerve in the neck



Neurosurgery One

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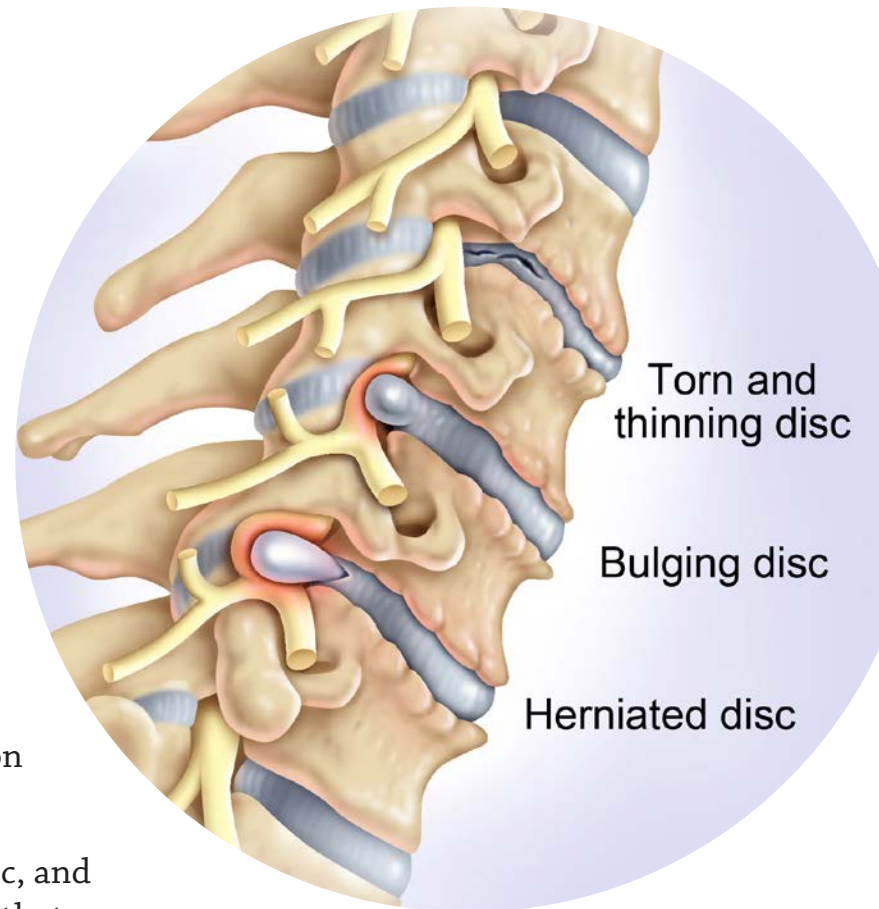
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Cervical Disc Herniation

A number of conditions can cause chronic or persistent neck pain, and many can occur simultaneously. While some neck pain is caused by injury, many degenerative conditions that result from ordinary wear and tear over time can also be to blame.

Among the more common conditions that cause cervical spine pain are a **herniated or slipped disc, a ruptured disc, and/or a pinched nerve**. Spinal discs are rubberlike cushions located between the vertebrae. In childhood, these discs are gel-like. As we age, the gel solidifies, and then over time hardens, making it less pliable. Stress or injury can result in disruption of the disc, which can cause the disc to protrude in spots. When the protruding disc pushes on a nerve, it can cause severe pain.

Often the terms herniated disc, slipped disc, ruptured disc, bulging disc, and pinched nerve are used interchangeably to describe painful conditions that occur in the cervical spine. At Neurosurgery One, we use the term **displaced disc** to refer to conditions in which the disruption of the disc is causing pain or other symptoms.



Tests to Diagnose and Pinpoint Your Neck Pain



To determine the exact origins of your pain, your physician will take your medical history, asking you about the location, frequency, and duration of your pain. You also will be checked for muscle weakness, numbness, range of motion, and pain during movement. In addition, your doctor or specialist may recommend imaging and/or other diagnostic tests to help arrive at a precise diagnosis of the pain's origin. Depending on your symptoms, your doctor or specialist may choose from several diagnostic tests, including:

- › **X-ray.** An X-ray (radiograph) provides a picture of the bones, and that picture can be used to identify degenerative disease, fractures, or even tumors.
- › **CT scan.** CT scans combine computer-guided X-rays taken from many different directions and views to produce detailed, cross-sectional images of the internal neck. These images can reveal bulging or herniated discs, as well as more subtle changes in bones.
- › **MRI.** An MRI uses radio waves and a strong magnetic field to create detailed images — unlike X-ray, MRI can show tissue as well as bone. The MRI detects variations in anatomical structures, and produces a series of detailed cross sections of the soft tissues and bones, which can reveal a bulging, protruding, or herniated disc.
- › **Myelogram.** In this test, a special dye is injected into the area around the spinal column, to allow better viewing of the spinal canal, discs, and the condition of nerves in and around the spine. A CT scan is often combined with a myelogram to get a view of what's going on with the bones, discs, and nerves.
- › **Electrodiagnostic testing.** A study of your nerve conduction, which tests the electrical activity of nerves in the arms and legs. This test often is followed by an electromyogram, which tests electrical activity in the muscles. Both tests measure the speed of the electrical signals being sent along nerves, which can help your physician pinpoint the location of any nerve problems.

Many causes of back pain resolve with conservative treatments. Patients and physicians should consider imaging only if **the pain has persisted after 4-6 weeks of treatment**, according to a [2010 Norwegian study](#).¹



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Before Considering Cervical Spine Surgery

In certain cases, such as spinal compression, surgery must be performed as soon as possible. But in most cases, surgery isn't the first treatment that should be considered to treat neck pain. At Neurosurgery One, we are dedicated to helping patients alleviate pain in the most conservative way possible. That's why we have board-certified and highly experienced physiatrists on staff who specialize in nonsurgical pain relief options.

If therapies such as over-the-counter pain medication, massage, and following an anti-inflammatory diet don't work, our physiatrists may treat your neck pain using:

- › Spinal injections to reduce inflammation, resulting in less pain
- › Therapeutic nerve blocks, which use intense numbing to keep the nerves from sending pain signals to the muscles
- › Radiofrequency ablation, which involves heating the nerves to block pain signals

These treatments are highly effective in many patients, and are less invasive and less expensive than surgery. But nonsurgical options don't work for everyone. At Neurosurgery One, our physiatrists are specially trained in electromyography, a diagnostic test that helps them determine the root of your neck pain and the best treatment to relieve your pain.

If nonsurgical treatments aren't right for you or neck pain is negatively affecting your quality of life, it may be time to consider spine surgery.



Immediate surgery for certain types of neck conditions is recommended. These conditions include blunt or penetrating trauma that damages the spinal column, according to a [study published in the journal PLOS ONE](#).²



Are You a Candidate for Surgery?

Using the most advanced surgical procedures, including minimally invasive surgery and image-guided procedures, cervical spine surgery is now safer and more effective than ever before.

Are you a candidate for cervical spine surgery?

If you answer “yes” to several of these questions, cervical spine surgery might be right for you.

- › Have you tried physical therapy?
- › Have you tried medications?
- › Have you tried steroid injections?
- › Have you had imaging tests (X-ray, CT, MRI) of your spine and diagnostic injections?
- › Has a structural cause of your pain been identified?
- › Is your quality of life or activity level greatly diminished by your pain?



5%

More than 20 percent of Americans suffer from back and neck pain annually, yet less than 5 percent³ of people will require surgery.



Cervical Spinal Fusion Surgery

Anterior Cervical Discectomy and Fusion (ACDF)

Spine fusion is the most commonly performed surgery for displaced discs in the neck. In cervical fusion surgery, plates, screws, bone, and/or other materials are used to stabilize the spine by limiting motion between vertebrae.

The most common type of cervical fusion procedure is the anterior cervical discectomy and fusion, or ACDF. In 2013, the latest year for which data is available, there were nearly 130,000 ACDF surgeries performed nationally.⁴ ACDF removes damaged discs that are compressing the spinal cord and/or spinal nerves and replaces it with bone or other material that allows the vertebrae to grow together to stabilize the spine. Neurosurgery One performs this surgery with a minimally invasive technique through one small incision at the front of the neck.

ACDF is performed to relieve pain in patients who:

- › Have significant arm pain
- › Experience weakness in the hand or arm
- › Have pain that does not resolve after several months
- › Have pain that does not go away after less-invasive treatments
- › Have been diagnosed with herniated or degenerative discs, and the condition has not healed after several months



How ACDF Is Performed

Typically, surgeons access the cervical spine from the front (anterior aspect) of the neck to reach the disc without disturbing the spinal cord, spinal nerves, and the strong neck muscles. The neurosurgeon will then remove the degenerated or herniated disc.

The space left by the absent disc is then filled with bone or another material to prevent the vertebrae from collapsing and rubbing together. The material serves as a bridge between the two vertebrae to create a spinal fusion. The bone graft and vertebrae are fixed in place with metal plates and screws. After surgery, new bone cells will grow around the graft as part of the body's natural healing process.

After three to six months, the two vertebrae should be joined together as one solid piece of bone. This provides greater stability to the cervical spine.



Two years post-surgery, **84.4%** of multilevel ACDF patients reported good or excellent results, according to a study in [*Evidence-Based Spine-Care Journal*](#).⁵



Benefits and Risks of ACDF

Benefits of ACDF

Spinal fusion is not recommended for every patient, but the procedure can provide several benefits for properly selected candidates who have not found sustainable relief through nonsurgical treatment options.



Between 60 percent and 90 percent of spine fusion patients have significantly reduced neck pain or their neck pain has completely been eliminated after receiving a spine fusion, [according to numerous studies](#).⁶ Spinal fusion also has been shown to prevent neck pain recurrence.

Risks of ACDF

Like all surgeries, spinal fusion surgery carries risks, such as:

- › Anesthesia reaction
- › Infection
- › Negatively impacting other preexisting health conditions

These risks are minimized by careful consideration of your health history and also by partnering with select hospitals to ensure the highest level of quality standards.

Another risk is that new pain and/or degeneration of the discs above or below the fusion can occur.



Artificial Cervical Disc Replacement

Artificial cervical disc replacement is a much newer surgery, first introduced in the U.S. in [2000](#)⁷, and continuing to gain popularity with the evolution of implants. In artificial cervical disc replacement surgery, a one-inch incision is made, most often in the neck fold, and the degenerated or herniated disc is removed. Once the disc is removed, a new disc, specifically sized to fit the patient, is inserted. Many artificial discs consist of two metal end plates separated by a polyethylene — or plastic — spacer.

Good candidates for artificial cervical disc replacement (ACDR) are patients [who](#):⁸

- › Experience arm pain
- › Experience numbness and tingling in the arm and hands
- › Have good motion in the area where the neck bends
- › Have degenerative disc disease in one or two discs
- › Have exhausted conservative treatment options

ACDR is not recommended for patients [who](#):⁹

- › Have arthritis in the facet joint
- › Have instability in the cervical spine
- › Have an active infection
- › Have an allergy to stainless steel or other implant material
- › Have had previous fusion surgery in the area of the degenerated disc



Benefits and Risks of Artificial Cervical Disc Replacement

With artificial disc replacement surgery, most patients are discharged from the hospital within 24 hours.

A 2016 study published in PLOS ONE¹⁰ found that artificial disc replacement resulted in better function outcomes, less need for additional surgery, and fewer complications than fusion.

Other potential benefits¹¹ of artificial disc replacement over traditional fusion surgery include:

- › Maintains full range of neck motion¹²
- › Reduces the likelihood of degeneration in adjacent segments of the cervical spine¹³
- › Eliminates the potential complications associated with bone graft used in fusion surgery¹⁴
- › Shorter recovery time; most patients are able to resume normal activities within a few weeks
- › Most patients can resume full activity, including vigorous activities, such as jogging, as soon as three months

ACDR risks include:

- › Normal inherent risks of any surgery, such as surgical site infection
- › Less than 2 percent chance¹⁵ that the implanted disc will move out of place
- › Lack of long-term data showing how long the implanted disc will last

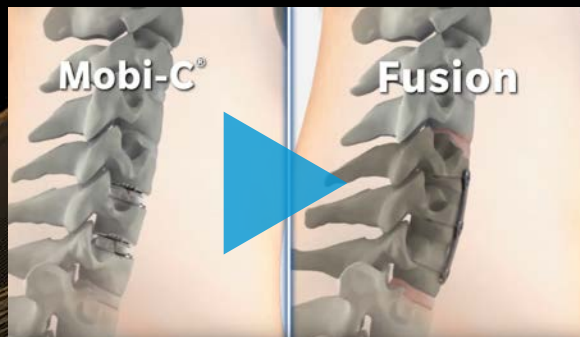
Several studies have shown that disc replacement has at least equivalent results to fusion in relieving neck pain, arm pain, patient function, and satisfaction, and with no increase in postsurgical complications.^{16, 17, 18}



Fusion vs. Replacement

The choice between anterior cervical discectomy and fusion (ACDF) and artificial cervical disc replacement (ACDR) is based on each individual patient's situation. If you are a candidate for both procedures, you will want to see a surgeon who performs both so that there is no bias in the decision. This table provides a general comparison that you can use to discuss the decision with your surgeon.

	Anterior Cervical Discectomy and Fusion	Artificial Cervical Disc Replacement
History	Used since the 1950s	First used in U.S. in 2000; more widely used in the past 10 years
Procedure	“Welds” two vertebrae into one	Retains natural space between vertebrae
Better for ...	Multilevel cases or severe arthritis	One- or two-level involvement
Overall success rate (4 years post-surgery¹⁹)	72.5%	85.1%
Hospital stay	0-2 days	0-1 days
<u>Range of motion</u>²⁰	Significant reductions in range of motion	Retains range of motion
Rehabilitation and recovery	Physical therapy after 4 weeks; back to activities like golf and tennis <u>in 3 months</u> ²¹	Physical therapy after 2-3 weeks; back to full activities <u>in 4-6 weeks</u> ²²
Rate of adjacent segment disease (60 months post-surgery²³)	4.9%	2.9%



See the difference in range of motion between cervical disc replacement vs. cervical fusion surgery.



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Minimally Invasive Spine Surgery at Neurosurgery One

To relieve back pain and dysfunction, minimally invasive spine surgery uses a small incision and muscle-sparing techniques to target the problem area with less damage to nearby tissue.

In **traditional open spine surgery**, there is a large incision down the middle of the back through which the muscles are reflected off the bone so the surgeon can access the spine. The affected muscles can be damaged and weakened from being cut through. Some [research](#)²⁴ suggests the disruption to surrounding tissue may increase the risk of future problems in nearby areas of the spine, called adjacent segment disease.

By contrast, **minimally invasive spine surgery** uses a muscle-preserving technique by creating a space between muscle fibers instead of cutting through them. Specially designed surgical instruments are used, which allow the surgeon to see and work in the narrow surgical field.

While minimally invasive spine surgery is easier on the patient, it's actually harder for the surgeon. Because of the challenge presented by operating through a smaller working channel, it's important to find a surgeon who is trained and experienced in minimally invasive surgery techniques.

Not everyone can or should have minimally invasive spine surgery. For example, a fusion surgery of more than three levels is too complex to perform with minimal invasion. Talk to your spinal surgeon to find out what surgical approach is best for you and your condition.



The benefits of minimally invasive spine surgery²⁵ can include:

- › Smaller incision
- › Shorter operative time
- › Decreased blood loss
- › Less muscle damage
- › Reduced incidence of infection
- › Less postsurgical pain and faster recovery



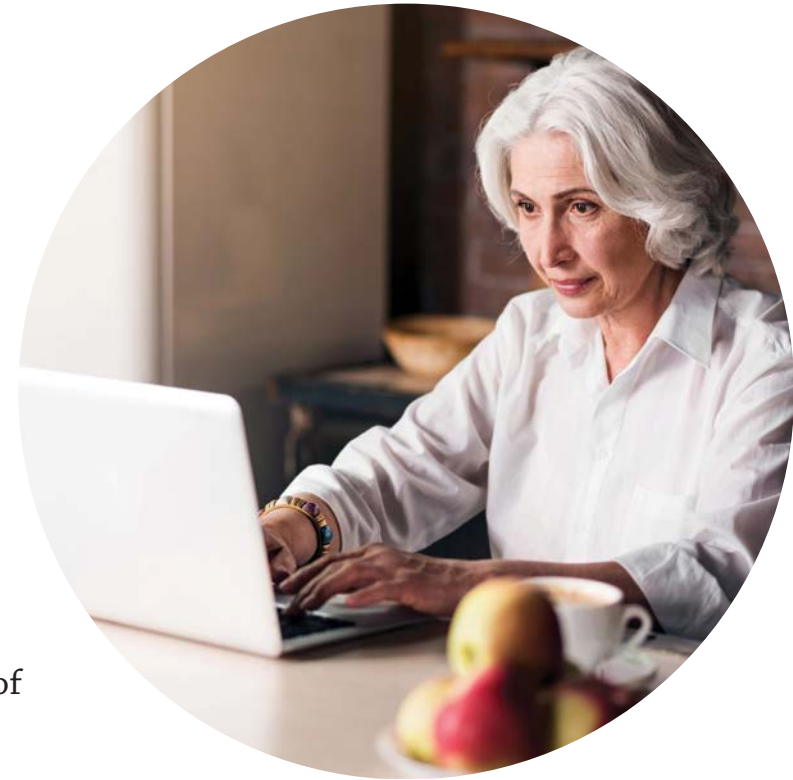
How to Select a Spine Surgeon

Neurosurgeon vs. Orthopedic Surgeon

While it's true that an array of surgeons can perform spine surgery, choosing a neurosurgeon to perform your spine surgery offers unique expertise and benefits. Neurosurgeons, like those at Neurosurgery One, undergo extensive training and have specific expertise to ensure consideration is given to the spinal cord and peripheral nerves during surgery, maximizing your success and minimizing pain.

Why a neurosurgeon for spine surgery?

- › Two more years of training than most orthopedic surgeons
- › Typically perform more spinal procedures during their residency than orthopedic surgeons
- › Expertise in dealing with nerves and spinal cord, critical components of any surgery involving the cervical spinal cord or cervical spine area



How to Select a Spine Surgeon

Experience Matters

Experience matters when it comes to spine surgery. The experience of the surgeon and the outcomes of spine surgery are directly correlated.

Benefits of a more experienced surgeon:

- › **Reduced complication rates:** Complication rates are, on average, lower among more experienced surgeons. In surgeries for spinal stenosis, complication rates were 38 percent higher among surgeons with minimal experience (less than 15 operations in four years), compared to those who had performed more than 80 procedures during the same time period, according to a study published in [Neurosurgery](#).²⁶
- › **Lower infection rates:** Less experienced surgeons often take longer to perform surgery, which has been found to lead to increased infection rates, according to a study published by [The University of Chicago Press](#).²⁷
- › **Decreased length of hospital stays:** In general, more experienced surgeons are more accurate and efficient during surgery, resulting in less complications, anesthesia, and infections, all of which lead to shorter hospital stays.
- › **More careful patient screening:** Highly experienced spine surgeons (15 years or more in the field) are more likely to properly screen candidates for surgery, resulting in better outcomes, according to a survey published in the [Journal of Spinal Disorders and Techniques](#).²⁸
- › **Reduced reoperation rates:** Many reports highlight infection as a primary reason for reoperation, which a surgeon's experience plays a significant role in reducing, according to [2014 research](#)²⁹ on reoperation within 30 days of fusion surgery.

How much experience is needed?

There is no magic number when it comes to experience. The general consensus judges “experience” by one of two marks:

1. Five years of performing the procedure
2. Conducting at least 30 surgeries of the given procedure (i.e., 30 disc fusions)

All of Neurosurgery One's surgeons have extensive experience and meet these criteria.



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How to Select a Spine Surgeon

Interview Your Surgeon

Cervical spine surgery is rarely an emergency unless it occurred during a traumatic accident. In nonemergency situations before undergoing surgery, it's important to select a surgeon who is right for you and your condition. Take your time to interview possible surgeons and their staff to ensure you find the right fit.



Ask your potential surgeon the following questions:

- › Do you have extensive experience or fellowship training in spine surgery?
- › Have you completed this procedure before? If so, how many times?
- › What are the most common complications of this procedure?
- › What is your infection rate?
- › What is your success with this type of surgery?
- › What does recovery from this procedure entail?
- › Where do you perform surgery?

Additional things you should consider when choosing a cervical spine surgeon:

- › Do you have the surgeon's full attention?
- › Do you feel comfortable with the surgeon?
- › Does the surgeon discuss all options with you?
- › Does the surgeon's appearance reflect the attention to detail you hope to see in the operating room?
- › Are the surgeon and his or her team friendly and competent in addressing your concerns?
- › Are the staff helpful with paperwork, travel plans, scheduling, etc.?



About Neurosurgery One

The surgeons and staff of Neurosurgery One take pride in providing patients with unbiased information that is supported by medical research. We are committed to offering patients information on all treatment options, whether those options are delivered by our practice or we need to make a referral to another specialist.

Why choose Neurosurgery One?

- › Access to neurosurgeons who have completed hundreds of spine surgeries
- › A highly experienced surgical team
- › The latest surgical advancements, including minimally invasive surgery
- › Complication and infection rates equal or better than national averages
- › Unbiased information that is supported by medical research, offering patients information on treatment options regardless of whether they choose treatment at Neurosurgery One

Our Locations

Castle Rock 2352 Meadows Boulevard, Suite 300 • Castle Rock, CO 80109

Lakewood 11750 W. Second Place, Suite 255 • Lakewood, CO 80228

Littleton 7780 S. Broadway, Suite 350 • Littleton, CO 80122

Lone Tree 9980 Park Meadows Drive, Suite 101 • Lone Tree, CO 80124

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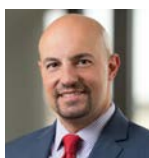
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Meet Our Neurosurgeons

Neurosurgery One is pleased to offer one of the top teams of spine surgeons in the nation.



Zain Allison, MD, specializes in neuro-oncology, craniotomy, vascular surgery, and minimally invasive spine fusion and decompression surgeries.



Wissam Asfahani, MD, FAANS, has 12 years of experience treating brain and spine disorders using surgical and nonsurgical therapies, including minimally invasive spine surgery.



Joshua M. Beckman, MD, FAANS, specializes in minimally invasive spine surgery, including lateral access to the thoracic and lumbar spine and other emerging advanced spine surgery techniques.



Angela M. Bohnen, MD, FAANS, specializes in treatment of primary, skull base, and metastatic brain tumors, as well as surgery for spine disorders and deformities.



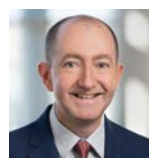
Abhijeet Gummadavelli, MD, specializes in epilepsy surgery as well as minimally invasive and traditional brain tumor and spine surgeries.



John Hudson, MD, PhD, FAANS, is an expert in neuroendoscopic and other minimally invasive approaches to brain surgery. He also provides treatment for general spinal disorders.



Jason E. McGowan, MD, FAANS, specializes in degenerative spinal disorders, including scoliosis, and performs minimally invasive spine surgery and complex spinal reconstruction procedures.



Lloyd Mobley III, MD, FAANS, specializes in nonsurgical management and minimally invasive surgery for spine disorders, as well as complex surgical procedures for spine and brain conditions.



J. Adair Prall, MD, is a national expert on trigeminal neuralgia and also specializes in treating complex tumors, vascular malformations, and spinal disorders.



David VanSickle, MD, PhD, FAANS, is one of the country's preeminent surgeons pioneering the use of Asleep DBS surgery. He specializes in functional neurosurgery and also provides treatment for brain tumors, spinal disorders, and neuromodulation for pain.

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Meet Our Physiatrists

Neurosurgery One is pleased to offer comprehensive spine care, including interventional pain management with our board-certified physiatrists.



Erasmus G. Morfe, DO, FAAPMR, is a board-certified physiatrist with 14 years of experience in interventional pain management. He treats spine pain using nonsurgical techniques and performs electrodiagnostic studies (EMG/NCS) as well as ultrasound-guided injections.



Jason Peragine, MD, FAAPMR, is board-certified in physical medicine and rehabilitation as well as pain medicine. He performs a wide variety of complex pain management procedures, with extensive experience in cervical spine treatments.



Esther D. Yoon, MD, FAAPMR, is a fellowship-trained and board-certified physical medicine and rehabilitation physician who specializes in interventional spine and musculoskeletal medicine, and pain management. She treats a wide range of spine and joint disorders.

Many types of neck pain respond well to nonsurgical pain relief, including:

- › Headaches
- › Whiplash
- › Bulging discs
- › Facet joint syndrome
(the breakdown of cartilage in the spine and neck)

To learn more, visit us at **neurosurgeryone.com** or call us today at 720.638.7500.



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Questions and Notes

Use this space to gather more information from your primary care physician to better understand if spine surgery is for you.

Can my back or neck pain be pinpointed to a structural issue? _____

What reservations might you have about recommending spine surgery for my condition? _____

How can I better prepare my body for spine surgery? _____

What surgeons in the area would you recommend? _____

I have additional questions about ... _____

My biggest concerns are ... _____



Sources

1. Kvistad, K. A., and A. Espeland. "Diagnostic Imaging in Neck and Low Back Pain." *Tidsskrift for Den Norske Lægeforening : Tidsskrift for Praktisk Medicin, Ny Raekke.*, U.S. National Library of Medicine, 18 Nov. 2010, www.ncbi.nlm.nih.gov/pubmed/21109849.
2. Fehlings, Michael G., et al. "Early versus Delayed Decompression for Traumatic Cervical Spinal Cord Injury: Results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS)." *PLOS ONE*, Public Library of Science, 23 Feb. 2012, www.journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0032037.
3. Neighmond, Patti, and Richard Knox. "Pain In The Back? Exercise May Help You Learn Not To Feel It." NPR, 13 Jan. 2014, www.npr.org/blogs/health/2014/01/13/255457090/pain-in-the-back-exercise-may-help-you-learn-not-to-feel-it.
4. Saifi C, Fein AW, Cazzulino A, Lehman RA, Phillips FM, An HS, Riew KD. "Trends in resource utilization and rate of cervical disc arthroplasty and anterior cervical discectomy and fusion throughout the United States from 2006 to 2013." *Spine Journal*, vol. 18, no. 6, 1 Jun. 2018, pp. 1022-1029. [https://www.thespinejournalonline.com/article/S1529-9430\(17\)31149-X/fulltext](https://www.thespinejournalonline.com/article/S1529-9430(17)31149-X/fulltext)
5. Kepler, Christopher K., et al. "Cervical Artificial Disc Replacement versus Fusion in the Cervical Spine: A Systematic Review Comparing Multilevel versus Single-Level Surgery." *Evidence-Based Spine-Care Journal*, AOSpine International, Feb. 2012, www.ncbi.nlm.nih.gov/pmc/articles/PMC3519403/.
6. Lied, Bjarne, et al. "Anterior Cervical Discectomy with Fusion in Patients with Cervical Disc Degeneration: A Prospective Outcome Study of 258 Patients (181 Fused with Autologous Bone Graft and 77 Fused with a PEEK Cage)." *BMC Surgery*, BioMed Central, 21 Mar. 2010, www.ncbi.nlm.nih.gov/pmc/articles/PMC2853514/.
Nishizawa, Kazuya, et al. "Operative Outcomes for Cervical Degenerative Disease: A Review of the Literature." *International Scholarly Research Notices*, Hindawi, 16 Jan. 2012, www.hindawi.com/journals/isrn/2012/165050/.
Radcliff, Kris, et al. "Five-Year Clinical Results of Cervical Total Disc Replacement." *J Neurosurg Spine*, 25 Mar. 2016, www.thejns.org/doi/pdf/10.3171/2015.12.SPINE15824.
7. Blumenthal, Scott L. "The History of Artificial Disc Replacement." *SpineUniverse*, 10 Sept. 2012, www.spineuniverse.com/blogs/blumenthal/history-artificial-disc-replacement.
8. Goldstein, Jeffrey A. "Indications for an Artificial Cervical Disc." *Spine-Health*, Veritashealth.com, 2 Dec. 2015, www.spine-health.com/treatment/artificial-disc-replacement/indications-artificial-cervical-disc.
9. "Artificial Cervical Disc Surgery." American Association of Neurological Surgeons, www.aans.org/Patients/Neurosurgical-Conditions-and-Treatments/Artificial-Cervical-Disc.
10. Hu, Yan, et al. "Mid- to Long-Term Outcomes of Cervical Disc Arthroplasty versus Anterior Cervical Discectomy and Fusion for Treatment of Symptomatic Cervical Disc Disease: A Systematic Review and Meta-Analysis of Eight Prospective Randomized Controlled Trials." *PLOS ONE*, Public Library of Science, 12 Feb. 2016, www.journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0149312
11. Lanman, Todd. "Artificial Disc Replacement in 2-Level Cervical Disease: Long Term Outcomes." *Clinical Pain Advisor*, Haymarket Medical, 5 Aug. 2016, www.clinicalpainadvisor.com/neck-pain/artificial-disc-replacement-in-2-level-cervical-disease-long-term-outcomes/article/514218/.
12. Hisey, M. S., et al. "Prospective, Randomized Comparison of Cervical Total Disk Replacement versus Anterior Cervical Fusion: Results at 48 Months Follow-up." *Journal of Spinal Disorders & Techniques.*, U.S. National Library of Medicine, 28 May 2015, www.ncbi.nlm.nih.gov/pubmed/25310394.
13. Hisey, M. S., et al. "Prospective, Randomized Comparison of Cervical Total Disk Replacement versus Anterior Cervical Fusion: Results at 48 Months Follow-up." *Journal of Spinal Disorders & Techniques.*, U.S. National Library of Medicine, 28 May 2015, www.ncbi.nlm.nih.gov/pubmed/25310394.
14. Goldstein, Jeffrey A. "Artificial Disc vs. Anterior Cervical Discectomy and Fusion." *Spine-Health*, Veritashealth.com, 2 Dec. 2015, www.spine-health.com/treatment/artificial-disc-replacement/artificial-disc-vs-anterior-cervical-discectomy-and-fusion.
15. Skovrlj, Branko, et al. "Reoperations Following Cervical Disc Replacement." *Asian Spine Journal*, Korean Society of Spine Surgery, 9 June 2015, www.ncbi.nlm.nih.gov/pmc/articles/PMC4472600/.
16. Sasso, R. C., et al. "Results of Cervical Arthroplasty Compared with Anterior Discectomy and Fusion: Four-Year Clinical Outcomes in a Prospective, Randomized Controlled Trial." *The Journal of Bone and Joint Surgery: American Volume*, U.S. National Library of Medicine, 21 Sept. 2011, www.ncbi.nlm.nih.gov/pubmed/21938372.
17. Burkus, J. K., et al. "Clinical and Radiographic Analysis of an Artificial Cervical Disc: 7-Year Follow-up from the Prestige Prospective Randomized Controlled Clinical Trial: Clinical Article." *Journal of Neurosurgery, Spine*, U.S. National Library of Medicine, 21 Oct. 2014, www.ncbi.nlm.nih.gov/pubmed/25036218.
18. Phillips, F. M., et al. "Long-Term Outcomes of the US FDA IDE Prospective, Randomized Controlled Clinical Trial Comparing PCM Cervical Disc Arthroplasty with Anterior Cervical Discectomy and Fusion." *Spine.*, U.S. National Library of Medicine, 15 May 2015, www.ncbi.nlm.nih.gov/pubmed/25955086.
19. Sasso, R. C., et al. "Results of Cervical Arthroplasty Compared with Anterior Discectomy and Fusion: Four-Year Clinical Outcomes in a Prospective, Randomized Controlled Trial." *The Journal of Bone and Joint Surgery: American Volume*, U.S. National Library of Medicine, 21 Sept. 2011, www.ncbi.nlm.nih.gov/pubmed/21938372.
20. Mummaneni, Praveen V., et al. "Cervical Artificial Disc Replacement versus Fusion in the Cervical Spine: A Systematic Review Comparing Long-Term Follow-up Results from Two FDA Trials." *Evidence-Based Spine-Care Journal*, AOSpine International, 3 Feb. 2012, www.ncbi.nlm.nih.gov/pmc/articles/PMC3519406/.
Wu, Xiao-Dong, et al. "The Effect of Multilevel Anterior Cervical Fusion on Neck Motion." *European Spine Journal*, Springer-Verlag, 21 July 2012, www.ncbi.nlm.nih.gov/pmc/articles/PMC3389104/.
21. DeWitt, David. "3 Weeks to 3 Months After ACDF Surgery." *Spine-Health*, Veritashealth.com, 28 Oct. 2015, www.spine-health.com/treatment/spinal-fusion/3-weeks-3-months-after-acdf-surgery.
22. "Cervical Spine Surgery 101." *Johns Hopkins Medicine Health Library*, Johns Hopkins University, www.hopkinsmedicine.org/healthlibrary/test_procedures/neurological/cervical_disc_replacement_surgery_135,6/.
23. Mummaneni, Praveen V., et al. "Cervical Artificial Disc Replacement versus Fusion in the Cervical Spine: A Systematic Review Comparing Long-Term Follow-up Results from Two FDA Trials." *Evidence-Based Spine-Care Journal*, AOSpine International, 3 Feb. 2012, www.ncbi.nlm.nih.gov/pmc/articles/PMC3519406/.
24. Rihn, J. A., et al. "Adjacent Segment Disease after Cervical Spine Fusion." *Instructional Course Lectures.*, U.S. National Library of Medicine, 2009, www.ncbi.nlm.nih.gov/pubmed/19385583.
25. Highsmith, Jason M. "Advantages of Minimally Invasive Spine Surgery." *SpineUniverse*, Vertical Health, LLC, www.spineuniverse.com/treatments/surgery/minimally-invasive/advantages-minimally-invasive-spine-surgery.
26. Dassenbrock, H. H., et al. "The Impact of Provider Volume on the Outcomes after Surgery for Lumbar Spinal Stenosis." *Neurosurgery*, U.S. National Library of Medicine, June 2012, www.ncbi.nlm.nih.gov/pubmed/22610361.
27. Wurtz, Rebecca, et al. "Do New Surgeons Have Higher Surgical-Site Infection Rates?" *Infection Control and Hospital Epidemiology*, vol. 22, no. 6, 1 June 2001, pp. 375-377, www.jstor.org/stable/10.1086/501916.
28. "Survey Shows Spine Surgeons Need to Screen More Patients for Anxiety and Depression." *Johns Hopkins Medicine*, Johns Hopkins University, 1 Apr. 2014, www.hopkinsmedicine.org/news/media/releases/survey_shows_spine_surgeons_need_to_screen_more_patients_for_anxiety_and_depression.
29. Li, Zheng, et al. "Unplanned Reoperation within 30 Days of Fusion Surgery for Spinal Deformity." *PLOS ONE*, Public Library of Science, 4 Mar. 2014, www.journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0087172.



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