

Motion-Sparing Spine Technology

Examining Disc Replacement and Low Back Pain

By Kern Singh, MD

Back pain is the most common ailment of the working-age adult, affecting more than 4 million individuals each year in the United States and weighing an economic burden on our health care system at up to \$100 billion. Approximately 80 percent of Americans experience significant back pain at least once in their lifetimes, and for many people, spinal disorders are a lifelong problem. While most acute episodes of low back pain are self-limiting and respond well to nonoperative therapies, the management of chronic low back pain remains a difficult challenge for the nonoperative and operative physician.

One cause of back pain is spinal disc degeneration. Disc degeneration can be painful and is often difficult to treat. A promising new surgical option for the management of discogenic pain is the artificial disc replacement.

What Is a Spinal Disc?

The spinal column is made of stacked bones called vertebrae. These bones are separated by a cushion at each level called a spinal disc. The spaces between each vertebra in the spine (spinal discs)

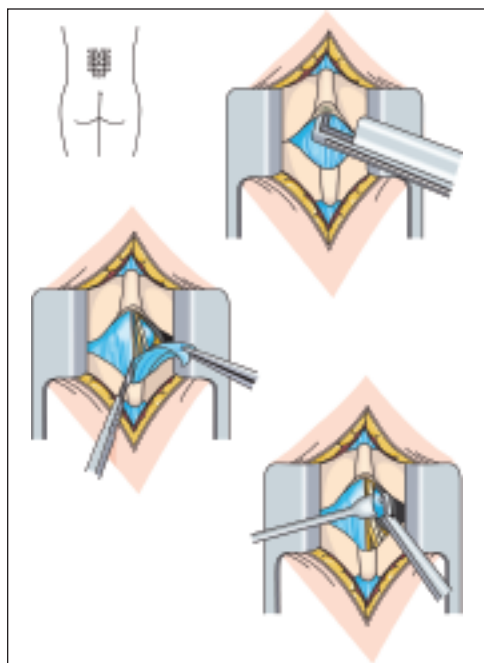


Figure 1: Excision of an intervertebral disc during discectomy

serve as shock absorbers and areas of motion. The disc is a tough but pliable tissue that helps maintain the position of the spine but also allows motion between the vertebrae. With this design, we have the stability to stand upright but also the flexibility to bend and twist.

As a natural part of aging, discs deteriorate. Unfortunately, pain may occur as the disc wears away. When the disc degenerates, it becomes more brittle and less flexible; and thus the disc becomes more prone to injury. As a result, the disc loses its shock-absorbing properties. Exactly what causes pain with lumbar disc degeneration is unknown, but we do know that some patients with worn-out discs have symptoms of low back pain (Figure 2).

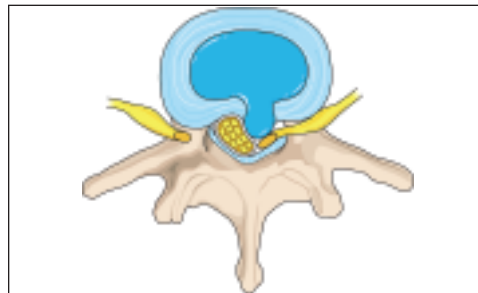


Figure 2: Posterior rupture of the inner portion of the intervertebral disc results in pressure on the nerve root.

Traditional Surgical Management

There are multiple conservative and minimally invasive treatment options available to manage moderately symptomatic degenerative disc disease. For those with severe symptoms not responding to nonoperative measures, there are several surgical techniques available:

- Intervertebral disc excision (discectomy) for the treatment of herniated discs (Figure 1)
- Intradiscal procedures including injections (epidurals), electrothermal exposure (IDET), and implantable neural stimulators and medication dispensers (spinal pumps)
- Arthrodesis (fusion) of the spine using posterior (from the back), anterior (from the front), or combined approaches.

When surgery is used to treat degenerative discs, the surgical treatment of choice has traditionally consisted of a lumbar spinal fusion. Unfortunately, fusion surgery is not without complications. First, the ability of the bone to heal or “fuse” varies. The average success rate of a lumbar spinal fusion is approximately 75% to 80%.

Failure of the fusion to heal is sometimes associated with continued symptoms. Second, a spinal fusion at one or more levels will cause stiffness and decreased motion of the spine. Third, having a spinal fusion at one or more levels will cause more stress to transfer to adjacent levels, which will then have to work harder to compensate for the loss of motion. The problem with the transferred stress is that it may cause new problems to develop at the other levels, which may also lead to additional back surgery.

Treatment Diversity

The diversity of approaches and the variation observed in treatment strategies for low back pain indicates an absence of evidence-based support for any single method. While the rate of back surgeries including fusion of the spine has increased by more than 600% between the years 1979 and 1990, there remains no operative treatment that has yielded reliable and reproducible positive results in patients affected by chronic low back pain. The common denominator is that few current techniques provide restoration of normal structure and function of the affected spinal motion segment.

Indications for Disc Replacement

Intervertebral disc replacement is indicated for patients with degenerative disc disease at one or two levels of the spine. In order to avoid complications that may arise from artificial disc replacement surgery, careful patient selection by the surgeon is critical.

Based on the current research, the clinical diagnoses that seem the most fitting for artificial disc replacement include symptomatic degenerative disc disease and postdiscectomy syndrome. Postdiscectomy syndrome is persistent back pain

following a previous surgery to remove a herniated disc. Patients are candidates for artificial disc replacement if they meet the following conditions:

- Diagnosis of degenerative disc disease or postlaminectomy syndrome at either L4-L5 or L5-S1 levels of the lumbar spine
- Patients who are between the ages of 18 and 60 years old
- Patients who suffer from low back pain as the major complaint (rather than leg pain)
- Patients who have not responded to a minimum of six months of conservative treatments (nonsurgical care such as physical therapy, pain medications, etc.)
- Patients who are candidates for spine surgery (such as a lumbar fusion)
- Patients who have only one level disc disease (either bottom disc level, L5-S1, or the second to the bottom, L4-L5)

Patients with the following diagnoses are not candidates for disc replacement:

- Active infection
- Spinal stenosis
- Spondylolisthesis (or other types of instability in the spine, such as a fracture or tumor). Patients who have only minor slippage of the vertebrae (0.3 mm or less) may still be candidates.
- Scoliosis
- Posterior facet joint disease (i.e., facet joint osteoarthritis)
- Significant radiculopathy (pain radiating down the leg)
- Osteoporosis or poor bone quality (osteopenia)
- Pregnancy

Other factors in selecting candidates for disc implant may apply in certain circumstances. For instance, the surgeon may recommend against the procedure if the patient is morbidly obese, has specific allergies, or has another medical condition.

Certain psychological and emotional factors and other circumstances may also at times play a factor in deciding who may potentially benefit from the disc replacement surgery. Therefore, it is best for the patient to fully discuss his or her

medical history and medical options thoroughly with the treating spine surgeon before deciding on the surgery.

Intervertebral Disc Design

There are a variety of factors designers must keep in mind as they develop an artificial disc. The device must be able to maintain proper intervertebral spacing, allow for the full range of motion, and provide stability. It must also come in a variety of sizes to accommodate patient height and spacing needs.

Like a natural disc, the artificial disc must act as a shock absorber, especially if it is used in several levels of the spine at one time. Finally, the artificial disc must be very durable. The average age of a patient needing a lumbar disc replacement is about 35 years.

This means that to avoid revision surgery, the artificial disc must last at least 50 years. It is estimated that an individual takes two million steps per year and bends 25,000 times; therefore, over the 50-year life expectancy of the artificial disc, there are more than 106 million cycles. This estimate does not even include the subtle disc motion that occurs with breathing.

The material from which an artificial disc is made is also an important factor in the development of this technology. It requires materials that are safe for human body implantation.

It must not cause allergic reactions, and it must not damage other parts of the spine. Also, it is ideal if the artificial disc is made of a material that is easily seen on an x-ray or other imaging test. This makes it easier for the surgeon to monitor the effectiveness of the artificial disc over time.



Figure 3: CHARITÉ™ disc replacement (DePuy Spine, Inc)

The CHARITÉ™ Artificial Disc (DePuy Spine, Inc., a Johnson & Johnson company), (Figure 3), is composed of two metallic endplates and a polyethylene core that moves between them. During the surgery, the degenerated disc is removed and a pair of endplates made of cobalt chromium are

inserted in the space between the vertebrae and attached to the vertebrae above and below the disc. A polyethylene material is then inserted between the plates to create a disc-like structure that mimics the normal disc by providing a normal level of separation between the vertebrae and by allowing the usual range of motion and flexibility for that segment of the spine (Figure 4).



Figure 4: Diagram of disc in the spine

Theoretical Advantages of Disc Replacement

The CHARITÉ disc implant is designed to mimic the functionality of the patient's own intervertebral disc. The prosthesis is intended to maintain the normal movement between the vertebral bodies and

prevent them from collapsing (and thereby irritating or damaging the nerve root) by maintaining the disc space height between the bones.

One of the main theoretical advantages of artificial discs (vs. spine fusion surgery) is to preserve the mobility of the patient's adjacent discs and delay the onset of arthritic changes adjacent to a fused level. The procedure may substitute spinal fusion, which eliminates the motion from a painful motion segment by fusing the vertebrae together. Spinal fusion does tend to place increased stress on the adjacent vertebral segments (Figure 5).

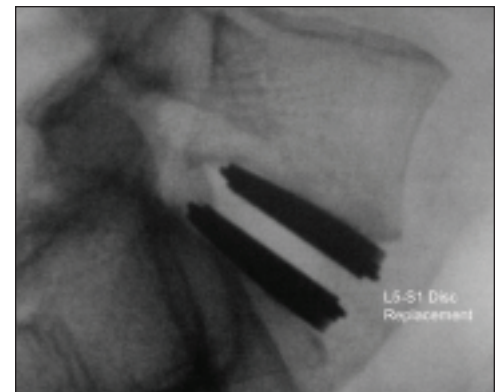


Figure 5: A postoperative lateral radiograph of a patient with an L5-S1 disc replacement

Potential Disc Replacement Drawbacks

In addition to the potential complications associated with undergoing surgery and general anesthesia, the complications associated with artificial disc replacement may include breakage of the metal plate, dislocation of the implant, and infection.

To help minimize complications associated with the implant itself, proper selection of patients and

implant size are very important. Otherwise, patients may not improve following the procedure and may require additional surgery.

Finally, like joint replacement surgery, artificial implants may fail over time due to wear of the materials and loosening of the implants. Therefore, long-term studies that track the life span of the implants are needed.

Artificial Disc Surgery

The goal of the lumbar artificial disc procedure is to restore the intervertebral disc height and neuroforaminal height while restoring physiologic motion (similar to that of a healthy disc) in

extension, side bending, and rotation) can closely approximate the normal motion of a healthy disc.

Postoperative Course

Most patients spend one or two nights in the hospital. Patients may require an extra day or two if for some reason they are having extra pain or unexpected difficulty. Patients generally recover quickly after the artificial disc procedure.

Patients should be able to get out of bed and walk within a few hours. Patients can move carefully and comfortably and must remember to avoid extending their backs (bending backward). Patients may need to wear a corset-type brace or

replacement using the CHARITÉ artificial disc allows natural motion in the part of the spine where the disc is implanted. This is because the prosthesis is designed to imitate normal movement between adjacent vertebrae.

A successful result means that back symptoms are better but not necessarily perfect. Most studies show that 70% to 90% of patients have significantly less back pain and greatly improved function with the operation. More than 70% are able to discontinue the use of strong medications.

Recent studies show greater satisfaction among people who have had disc replacement surgery compared with those treated with lumbar fusion. While still in its infancy, artificial disc replacement offers an alternative solution to the difficult problem of chronic discogenic pain. 🌟

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that segment of the spine. The surgery requires complete removal of the unhealthy disc in order to implant the new artificial disc. Surgery details include:

- The CHARITÉ artificial disc surgery is approached from the front, with a relatively small incision in the abdomen (usually below the belly button).
- The abdominal organs are then gently moved to the side so that the surgeon can visualize the spine while protecting important anatomic structures. A general surgeon or vascular surgeon with the appropriate skills usually does this part of the surgery.
- The spine surgeon then removes the collapsed, degenerated disc.
- The artificial disc is then implanted — first the two endplates, then the core in the middle — using specialized instruments. The two endplates (made of a cobalt chromium alloy) are pressed into the vertebrae above and below the disc space, and teeth along the border of the endplate grip the vertebral bone. A polyethylene core is then placed between the endplates.

The artificial disc is held in place by the spinal ligaments and the remaining part of the anulus of the disc as well as the compressive force of the spine. Bending x-rays of patients after the surgery show that the motion of the artificial disc (flexion,

elastic bandage for up to two weeks following the surgery to support the abdominal muscles after the operation.

As patients recover in the hospital, a physical therapist will visit to start him or her on a few gentle exercises. The patient will also start a walking program that is encouraged following the hospital stay.

When leaving the hospital, patients are usually safe to sit, walk, drive, and ride a bike. The surgeon will see the patient a week later to take an x-ray, ensuring the prosthesis is in place and holding steady.

However, patients should avoid lifting items for at least four weeks. The surgeon will approve a release back to work in three to four weeks as long as the work is fairly light. If the job requires moving and lifting heavy items, a longer period of recovery is required. The surgeon may give the OK to do all activities by the eighth week after surgery.

Initial experience with composite prostheses in Europe suggests safety and efficacy of these devices. Prospective randomized studies compared with traditional fusions will offer an evidence basis for the role of disc replacement in the current and future management of degenerative disc disease. Artificial disc replacement offers an alternative to lumbar fusion for some patients who have chronic low back pain from degenerative disc disease.

While fusion stops pain by eliminating movement in the problem spinal segment, artificial disc



Kern Singh, MD, received his medical degree from Jefferson Medical College. Dr. Singh completed his orthopaedic residency at Rush-Presbyterian-St. Luke's Medical Center. He completed a fellowship in spinal surgery at Emory University in Atlanta, Georgia. Dr. Singh will join the team of physicians at Midwest Orthopaedics at Rush in September 2005. He specializes in treating complex degenerative disorders of the cervical, thoracic, and lumbar spine and has a particular interest in minimally invasive, motion sparing spinal technology.