INNOVATIONS
IN SPINE & BRAIN TREATMENT

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BOULDER NEUROSURGICAL ASSOCIATES

Minimally Invasive Lumbar Fusion: Using Advanced Technology to Return Superior Results

Back pain is one of the most common causes of disability, and discogenic pain is one of the most difficult conditions to diagnose and treat. For some patients, anti-inflammatory medications, exercises and therapy can alleviate pain. Others respond to interventional treatments. Unfortunately, if these methods fail, surgery is the only option.

Lumbar fusion surgery for back pain caused by degenerative disc disease is an option for patients who have failed to improve after extensive conservative treatment, who continue to have low back pain that limits their ability to function and who have a confirmed diagnosis that a specific disc space is the pain generator.

Lumbar fusion involves placement of bone either in the disc space and/or along the posterolateral gutter so that the bone segments grow together. By linking together two or more vertebrae, this procedure eliminates the motion that occurs within that portion of the spine – and thus the source of the back pain.

There are numerous approaches to spinal fusion, including the anterior lumbar interbody fusion (ALIF), posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF) or a combination anterior/posterior approach. These are traditionally open procedures that require incisions along the middle of the back; bands of muscle tissue are stripped from the underlying spinal elements, including the spinous process, lamina and facets. The tissues are retracted during surgery to provide the surgeon a good view of the spine and room for performing the procedure. During complex spine surgeries, the surrounding paraspinous tissues are retracted for long periods of time, which can contribute to postoperative pain and prolong the patient's recovery. For these reasons, a lumbar fusion procedure has always been considered a major surgery that can take up to several months to recover.

Minimally invasive techniques have revolutionized many surgical disciplines, and neurosurgery is no exception. In the case of lumbar fusion, minimally invasive procedures reduce the approach-related morbidity associated with traditional techniques yet allow the surgery to be performed in a safe and effective manner. Advantages of minimally invasive techniques include:

- *Smaller surgical incisions*
- *Avoidance of excessive muscle stripping*
- *Less tissue retraction*
- *Less blood loss & reduced operative time*
- *Less postoperative pain*
- *Shorter hospital stays & quicker recovery.*

Figure 1. The Aspen device. Postoperative X-rays, lateral (A) and AP views (B)

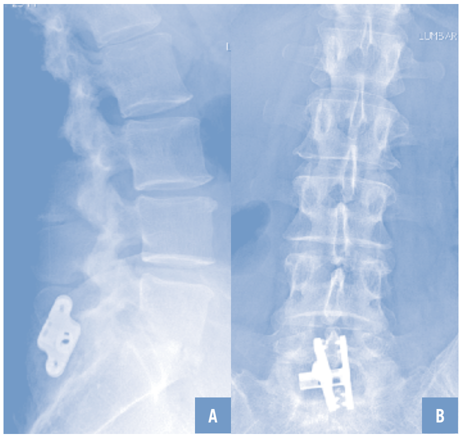
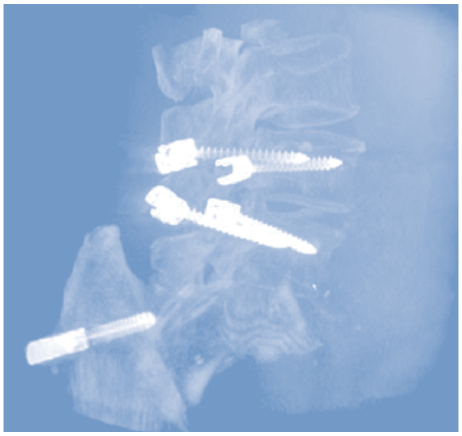


Figure 2. Intraoperative 3D real-time images (O-ARM).



Fusion With Less Risk of Neural Injury

Recent clinical investigations have concluded that altered biomechanics and subsequent pain can be caused by the surgical approach or even spinal fixation. Pedicle screw fixation has been extensively utilized and, although it increases arthrodesis rates and stabilizes the spine, it is associated with the risk of neural injury, increased radiation exposure and prolonged OR time. The Aspen Spinous Process System (Lanx) is a new alternative to pedicle screw fixation. It can be directly attached to spinous processes to achieve supplemental fusion (Figure 1). This procedure can be performed in less than an hour because it requires a smaller incision and no additional lateral exposure. The most technically challenging part of the procedure, pedicle screw insertion, can be eliminated, thereby potentially decreasing the risks associated with this part of the procedure.

Laser-Assisted Spine Surgery

Boulder Neurosurgical Associates surgeons are at the cutting edge of minimally invasive spine surgery. We recently acquired the BeamPath™ CO_2 laser (OmniGuide®), currently the most advanced spinal laser system that makes ablation of the tissue in the lateral recess of the spinal canal precise and efficient. In addition, it thoroughly cauterizes branches of the nociceptive (pain-generating) nerve within the wall of the annulus, which leads to less postoperative pain in our patients. The CO_2 lasers are among the safest and most precise lasers available. CO_2 energy is absorbed in water, leading to minimal thermal effect to the adjacent tissues, including nerves. The BeamPath CO_2 laser combines the capability of precise dissection, ablation and microvascular coagulation, all in a single flexible no-touch microsurgical tool. However, instead of making false claims that laser techniques can cure all back problems, we are using every single innovative and clinically proven method to make back surgeries safer, less invasive and more efficient to our patients. The laser is only one tool in our armamentarium that allows us to treat patients with the least invasive procedure and the most potential benefit.

Evaluating Minimally Invasive Lumbar Fusion Procedures

While minimally invasive lumbar fusion procedures have only recently been developed, the surgeons at Boulder Neurosurgical Associates have long ago proved that posterior or transforaminal interbody fusion (TLIF) theoretically achieves comparable results with a single posterior incision, less morbidity and better scores on a variety of outcome measures *(Villavicencio et al., Perioperative Complications in Transforaminal Lumbar Interbody Fusion versus Anterior-Posterior Reconstruction for Lumbar Disc Degeneration and Instability, J Spinal Disord Tech 2006;19:92-97)*. We have compared 124 consecutive TLIF cases to 42 anterior-posterior (A/P) cases. A/P surgery was associated with a more than 2 times higher (77%) complication rate, significantly increased blood loss (550 mL on average), longer operative time (7.6 hours on average) and more extensive hospitalization time (7.2 days average).

Our own clinical experience in the use of minimally invasive access technology demonstrated that all patients who underwent a lumbar fusion procedure using a minimally invasive approach at Boulder Neurosurgical Associates had equivalent long-term clinical outcomes *(Burneikiene S, Villavicencio AT, Nelson EL, Minimally Invasive versus Open Transforaminal Lumbar Interbody Fusion, Spine Week 2008, Geneva, Switzerland)*. It is important to note that a faster recovery and less pain medication use in the immediate post-operative period were associated with the minimally invasive technique.

Applying Image-Guided Technology to Spinal Fusion

A growing tendency toward increased safety and accuracy in spinal surgery is evident in recent years, but that would be impossible without innovations in the field of intraoperative image guidance technology. Standard intraoperative fluoroscopy lacks the ability to reconstruct axial images of the spine. This results in the need to constantly reposition the C-arm and take repeated images, which increases radiation exposure. Real-time image guidance technology has revolutionized the traditional surgical techniques by providing surgeons with a way to navigate through the body using three-dimensional (3D) images as their guide. Furthermore, those images can be changed, manipulated and merged to provide a level of detail not seen before in the operating room. At Boulder Neurosurgical Associates, we are using some of the latest image-guided technology to help perform our minimally invasive lumbar fusion surgeries. The StealthStation® image-guided surgery system along with isocentric fluoroscopy (Siemens) and the O-arm (Medtronic) allows surgeons to visualize the patient's spinal anatomy (Figure 2). In the operating suite, these systems produce 3D real-time images of the procedure in progress and can even merge images from multiple sources, allowing physicians to view them from any angle.

Images of the instruments can also be seamlessly rendered within the images of the patient's anatomy, allowing the surgeon to see the exact location of the instruments, in 3D and in real time, on the monitor.

Boulder Neurosurgical Associates was one of the first neurosurgical groups to evaluate the clinical feasibility and accuracy of intraoperative fluoroscopic guidance for placement of hardware in complex spinal minimally invasive procedures. A total of 279 spinal instrumentation screws and cannulations were performed in 69 patients using this technology, and only four percutaneous transpedicular screws were malpositioned. We believe that this technology provides excellent visualization of three-dimensional relationships, which results in increased accuracy of screw positioning and the ability to detect misplaced screws prior to wound closure. This technique also results in significant reduction of radiation exposure for both the patient and the staff *(Villavicencio et al. Utility of Computerized Isocentric Fluoroscopy for Minimally Invasive Spinal Surgical Techniques, Journal of Spinal Disorders and Techniques, 2005 Aug; 18, 369-375)*.

At Boulder Neurosurgical Associates, we are making positive changes in how chronic spine conditions are treated. Our minimally invasive techniques enhanced by image-guidance systems not only compare to the best and most advanced surgical centers in the world but also set new safety standards for the procedures that not so long ago were performed as major reconstructive surgeries. The technique, such as intraoperative three-dimensional fluoroscopy-based computerized tomography guidance for percutaneous kyphoplasty and reduction of vertebral fractures, was developed by Dr. Villavicencio *(Intraoperative Three-Dimensional Fluoroscopy-Based Computerized Tomography Guidance for Percutaneous Kyphoplasty, Neurosurgical Focus 18(3):E3,2005)*.

Even with the vast number of lumbar surgeries performed today, each case is a highly individual challenge that requires close focus and unwavering commitment. As a center of excellence, we pride ourselves on being able to offer some of the region's best results by tailoring our care to each patient's unique circumstances.

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