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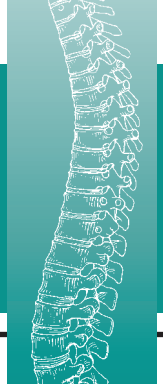

Surgical Treatment Strategies for the Previously Operated Lumbar Spine

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LEARNING OBJECTIVES: After participating in this CME activity, the spine surgeon should be better able to:

1. Evaluate etiologic causes and factors that are responsible for failed back surgery syndrome.
2. Analyze the advantages of surgical versus nonsurgical treatment with regard to etiologic causes and potential clinical outcomes.
3. Manage technical difficulties and challenges of reexploration surgery related to some of the newer spinal devices.

This review will focus on some contemporary surgical treatment strategies for the previously operated lumbar spine. Patients who fail to improve after spine surgery or those who develop new symptoms after initially "successful" surgery are commonly labeled with failed back surgery syndrome (FBSS). Multiple factors may be responsible for this complex syndrome, and various therapeutic approaches should be employed for structural anatomic and nonstructural problems in the previously operated spine. Any surgical intervention should be considered with a specific etiologic cause in mind. Newer technologies in spine surgery are discussed with an emphasis on technical difficulties involved in the revision surgery.

The incidence of FBSS is estimated at 5% to 39%.[1-4] Possible etiologies include recurrent or persistent disc herniation, central canal lateral recess or neuroforaminal stenosis, spondylolisthesis, epidural fibrosis, arachnoiditis, other musculoskeletal or neuropathic pain syndromes, and psychologic disorders. According to some authors,[5] inappropriate or inadequate surgery is the most likely explanation for FBSS.

The time frame in which postoperative symptoms develop can be indicative of etiology. If symptoms are unchanged from the preoperative state, inadequate neural decompression, wrong-level operation, or incorrect diagnosis are strongly suspected. If new or recurrent symptoms develop with in days to weeks of the operation, the possibility of surgical complications (eg, infection, hematoma, postlaminectomy fracture of the pars interarticularis, discitis) should be considered. Recurrent disc herniation, epidural fibrosis, or arachnoiditis may take months to become symptomatic. Progressive spinal stenosis or adjacent-level degeneration is commonly noticed in patients who have recurrent or new symptoms months or years after the initial surgery. Unfortunately, the diagnosis is almost never that simple, as FBSS is most often a multifactorial biopsychosocial condition.

Reoperation in patients who have had previous spinal surgery can be very challenging for the treating physician. Clinical outcomes are generally expected to be worse in patients undergoing subsequent surgery.[6-9] Even if outcomes

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The authors have disclosed that some artificial discs, fixation devices, dynamic stabilization devices, and the use of recombinant bone morphogenetic protein-2 for the indications discussed in this article have not been approved by the U.S. Food and Drug Administration.

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are initially satisfactory, long-term results are usually poor,[10] and the likelihood of successful surgery declines with the number of subsequent interventions.[11] Repeat surgeries also add to structural changes in the nerve tissue (so-called battered root syndrome). Biochemical and morphologic reactions caused by muscle injury result in decreased muscle endurance, reduced strength, and increased pain.[12,13] Even minimal tissue damage may provoke an afferent reflex that causes muscle spasm and triggers nociceptive or neuropathic pain mechanisms.

Treatment of FBSS should be approached with careful consideration and with clear and reasonable goals in mind. Surgery is not always the best solution for all patients. Iatrogenic causes of FBSS such as wrong-level operation, inadequate technical skills of the operating surgeon, and poor indications for surgery need to be explored as potential causes.[14,15] Overdependence on imaging technologies often results in inappropriate surgery when not correlated with patient history and physical examination findings.

Correlation of clinical symptoms and diagnostic imaging continues to be controversial,[16-18] or rather, there are no diagnostic imaging procedures that are specifically characteristic of a specific diagnosis.[19] This issue becomes even more complicated if studies of the previously operated spine are performed during the first 6 months after the surgery, because there are no reliable criteria to distinguish pathologic findings from normal postoperative changes (eg, mass effect, scar enhancement, deformity).

CT myelography with a water-soluble contrast can sometimes be helpful in identifying structural problems amenable to reoperation, and it provides information about spatial associations among soft tissues and bony structures. This can be especially valuable in patients who have undergone multiple previous surgeries. MRI studies in patients with instrumentation are often obscured by metallic artifact. Newer instrument-scatter reduction software provides better resolution and can be helpful in such cases.

INDICATIONS

Martin et al[20] demonstrated that patients who undergo fusion surgery for indications other than spondylolisthesis (a primary diagnosis of degenerative disc or spinal stenosis) are more likely to have reoperations. This study investigated reoperation rates after lumbar spine surgery in almost 25,000 patients operated between 1990 and 1993 and revealed a 19% incidence (4.6% had 2 or more reoperations) of repeat surgery during the follow-up period of 11 years. The results of this study also indicated that 61.4% of reoperations after fusion were due to device-related complications or pseudarthrosis.

One may think that these numbers should have improved dramatically with the introduction of newer fusion technologies and development of new tools and devices. On the contrary, a 40% higher probability of reoperation was noted within the first year among patients who had fusion surgery between 1997 and 2000.[21] In addition, indications other than spondylolisthesis increased by more than 2 times in the late 1990s.[21]

Interesting conclusions were made in a population-based study by a group from Finland[22]: patients who undergo a reoperation after a discectomy procedure have a 25% cumulative risk for further

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surgery in the next 10 years, and probability of revision surgery declines in patients older than 50 years. Therefore, proper indications,[23] benefit-risk ratio, and patient age, with a long-term prognosis in perspective, should be carefully assessed before any surgical intervention is considered.

TREATMENT STRATEGIES

Various therapeutic approaches should be employed for structural anatomic and nonstructural problems in the previously operated spine. A structural cause of FBSS should be clearly identified radiographically, and appropriate surgical reintervention should be considered. General recommendations to perform decompression or fusion should be tailored to each patient to address the specific failures of previous surgery. A complete clinical patient evaluation should be performed.[24] Nonstructural (noncompressive) problems may be more amenable to spinal cord stimulation (SCS). Some chronic pain specialists regard SCS as "the best treatment option for FBSS" earlier in the course of chronic back pain and not as "a last option."[25] In our opinion and in the light of findings that up to 95% of FBSS causes can be identified, and 56% to 80%[15,26,27] of them have an anatomic explanation, a surgical intervention should be considered with a specific etiologic cause in mind. A prospective randomized clinical trial evaluated patients with symptoms of "surgically remediable" nerve root compression and radicular pain after failed lumbar back surgery.[28] A total of 45 patients were randomized to an SCS (19 patients) or reoperation group (26 patients) and were allowed to cross over. The patient groups were rather small (it is difficult to achieve a homogeneous patients sample in such small groups), and follow-up was too short to make a definite decision that SCS is more effective than reoperation, especially given that its effectiveness decreases over the time in up to 40% of patients.[25]

NEUROFORAMINAL AND CENTRAL CANAL STENOSIS

Neuroforaminal and central canal stenosis was the most often (29%) encountered structural cause of pain for patients with FBSS in a study performed by Waguespack et al.[26] Residual foraminal stenosis is typically due to inadequate exploration of the nerve root or recurrent disc herniation. Spinal stenosis develops over time (if not missed initially) and is often associated with neurogenic claudication. Decompression procedures including laminectomy, microdiscectomy, or foraminotomy with a nerve root decompression should be considered if radicular symptoms and imaging indicate compressive lesions. A randomized controlled clinical study compared decompression only with decompression and fusion and demonstrated no advantage of performing a more complex fusion procedure.[29] Therefore, fusion surgery should be considered only in patients with obvious instability.

PSEUDARTHROSIS AND INSTRUMENTATION FAILURE

Pseudarthrosis or segmental instability can be identified with CT 2- or 3-dimensional reconstructions and dynamic radiographs. Although pseudarthrosis is generally related to worsened clinical results, there are extensive data to show that excellent radiographic fusion does not necessarily correlate with relief of clinical symptoms.[30] It is also controversial as to whether pseudarthrosis can be a sole reason for postoperative back pain, and therefore other sources for the failed primary surgery should be considered before continuing with further surgical interventions. Cassinelli et al[6] reviewed 18 patients undergoing revision surgery for failed posterior lumbar interbody fusion with threaded titanium cage devices. The authors performed central/foraminal decompression, posterolateral fusion, and supplemental pedicle screw fixation. There was no statistically significant improvement in bodily pain (36-item short form health survey scale), and 61% of patients reported pain as being same or worse as before the revision surgery. Nine patients (50%) were dissatisfied or somewhat dissatisfied with the treatment they received. The authors concluded that despite a high rate of fusion (94%), minimal improvement in clinical patient status was achieved. Repeated attempts to achieve fusion should be undertaken very cautiously.

Malpositioned or broken instrumentation, especially in long constructs, can be responsible for pseudarthrosis and frequently is attributed to an improper implant or patient selection. Surgical exploration and removal of instrumentation can be considered in cases of recurrent low back pain (see case 1) in the absence of pseudarthrosis and no obvious pain generators.[31]

PERIDURAL FIBROSIS

Peridural fibrosis inevitably occurs after operations but rarely manifests as the sole reason for FBSS. Excessive scarring can cause tethering of neural elements and radicular symptoms. It also leads to higher incidental durotomy rates during revision surgeries[32] and could result in poorer clinical outcomes.[33] It is generally recommended that peridural fibrosis be treated with SCS because of the reported reasonably good clinical outcomes.[34] However, fusion should be considered in some cases if significant scar tissue is present in combination with instability (see case 2).

ADJACENT SEGMENT DISEASE

Adjacent segment disease can occur even after the most technically successful operation. It could be accelerated secondary to biomechanical changes that rigid fusion introduces to a mobile spinal segment. A study performed by Ghiselli et al[35] estimated that 36% of patients with a successful fusion surgery would undergo revision at a segment adjacent to the fusion at 10 years after the original procedure. Some surgeons routinely fuse adjacent to the proposed fusion segments that have radiologic signs of degeneration.[36] This inevitably extends the fusion and results in inferior fusion rates and poorer clinical outcomes. Posterior dynamic stabilization or fixation devices are currently being used along with spinal instrumentation, with the intention of possibly delaying degeneration at the adjacent levels. Long-term prospective clinical studies will be needed to confirm their use for this indication.

Case 1. A 74-year-old woman previously underwent transforaminal lumbar interbody fusion at L3–L4 followed by L4–L5 fusion 2 years later. The instrumentation at L3–L4 was removed at that time. For the next 2 years, she had difficulty with her right lower extremity, starting with numbness in her right foot and the medial aspect of her right calf, which gradually turned into hyperesthesia. Electrodiagnostic studies demonstrated chronic L5 radiculopathy, which was refractory to multiple epidural corticosteroid injections. CT was performed, and a malpositioned screw was noted at the right L4 pedicle (Figure 1).

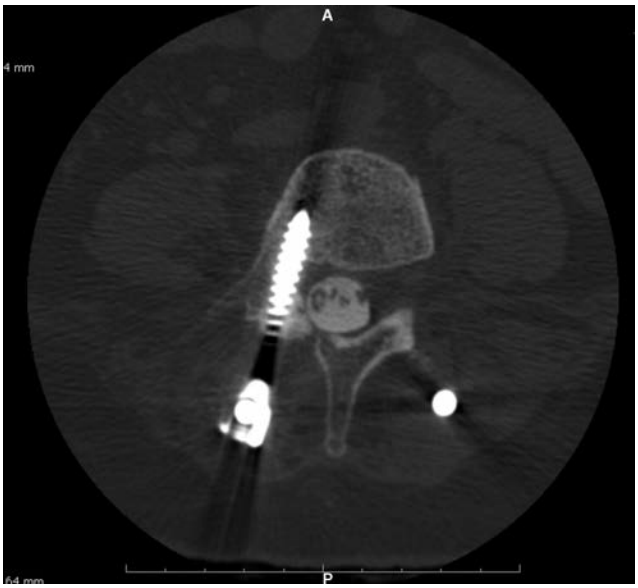

Fig. 1 *CT myelogram showing right medial malpositioning at L4.*

She underwent removal of bilateral posterior pedicle fixation at L4–L5 via minimally invasive incisions. The patient noted an improvement in pain and ability to walk at about the 1-month follow-up visit.

Case 2. A 63-year-old woman underwent laminectomy at L4 with left-sided L4–L5 microdiscectomy for radiculopathy and spinal stenosis symptoms. At a 1-year follow-up visit, the patient reported back pain that was aggravated from movement, particularly when she went from a sitting to a standing position. Flexion-extension films were stable, but MRI demonstrated evidence of significant scar tissue in the L4–L5 area and recurrent disc herniation (Figure 2). The patient's clinical symptoms

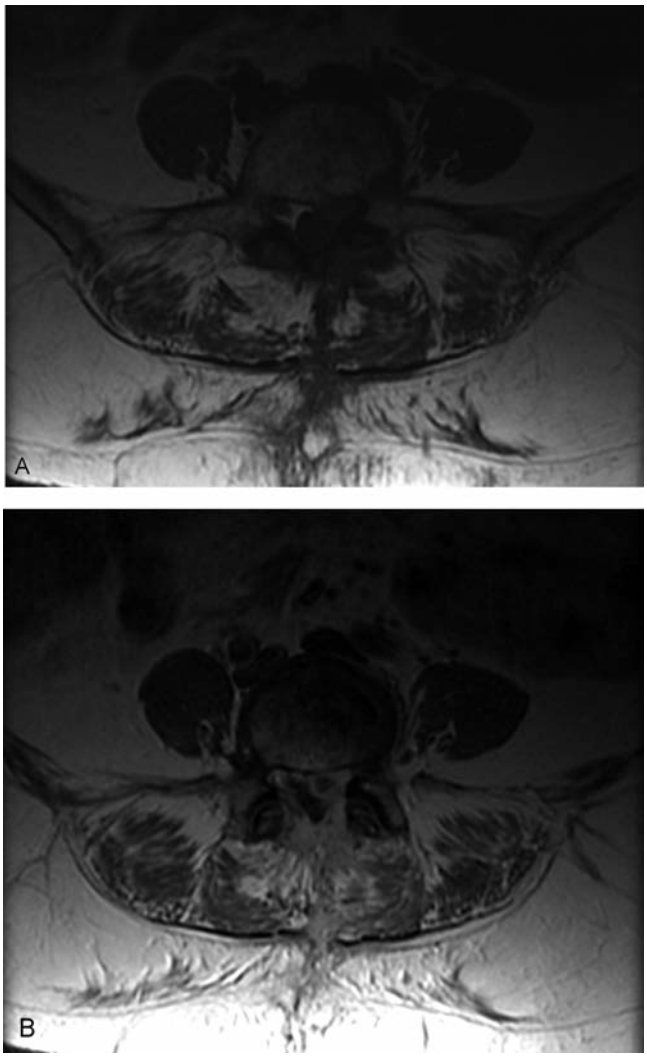

Fig. 2 *T1-weighted MRI scans precontrast* ***(A)*** *and postcontrast* ***(B)*** *showing epidural scar tissue around the unenhancing portion of the prolapse at L4–L5.*

suggested that she was having constant radicular irritation secondary to microinstability. This was thought to be caused by scar tissue adhering to the nerve roots and the facet joint, which transmits pressure to the nerve roots with movement. Evacuation of recurrent disc and dissection of scar tissue were performed. The spinal segment was then stabilized with pedicle screws, fusion at L4–L5 via a transforaminal approach, and an off-label use of bone morphogenetic protein. The patient experienced significant improvement after surgery.

TOTAL DISC REPLACEMENT

Total disc replacement (TDR) surgery introduces a slightly different range of problems if there is a need for reoperation. A major concern of disc arthroplasty is the ability for safe revision, including prosthesis replacement and removal for arthrodesis. The optimal patient age at the time of TDR surgery has been reported to be less than 45 or 50 years[37]; thus, even with initially successful surgeries and best-case-scenario predictions, there is a high likelihood that many patients will require additional surgery during their lifetime.

Lumbar arthroplasty procedures require an anterior approach, and reexploration surgery introduces not only technical difficulties generally associated with abdominal surgery (proximity to the aorta and iliac vessels, scarring of the great vessels and nerves, etc) but also device-related technical difficulties. Removal of the prosthesis can be technically very difficult regardless of the type of implant, but especially if a keel-type artificial disc has been used.

More information has recently become available on salvage options and potential complications. Results from a prospective, randomized, multicenter FDA investigational device exemption study of the Charité artificial disc indicated that almost 9% of patients who underwent TDR required reoperation.[38] Although approach-related difficulties are not TDR-revision-surgery specific, a 5-fold increase of vascular injuries (3.4% vs 16.7%) in revision cases compared with index surgical procedures is concerning. The authors concluded that the Charité disc did not preclude any further procedures at the operated level, but they recommend posterior fusion with transpedicular fixation if the device is functional and stable. This study analyzed reasons for reoperations from a technical perspective, in contrast to a study by Punt et al[8] that looked into etiologic causes and had longer follow-up. Subsidence, wear, adjacent disc degeneration, facet joint degeneration, and migration were reported among complications after Charité artificial disc replacement surgery. Theoretically, by preserving normal motion at the index level, additional stress and load sharing at the adjacent levels is minimized, thus reducing accelerated degeneration to the adjacent levels associated with arthrodesis. According to this study, 48% of patients (36 of 75) demonstrated adjacent levels degeneration, which authors attributed to "unphysiological motion and functioning of the disc prosthesis."

As revision and explantation strategies are being further defined, reports of clinical outcomes after such revisions are still lacking. The removal of a disc prosthesis resulted in slightly better clinical outcomes when 22 patients who underwent disc removal surgery with subsequent anterior-posterior fusion were compared with 15 patients who had posterior fusion only without disc removal.[8] The success of repeat surgery would be considered clinically significant (a 20-point change in visual analog scale score and 20% change in Oswestry Disability Index scores) in only 45% vs. 41% of patients (10 vs. 9 of 22 patients) who underwent device removal in addition to anterior-posterior fusion. Similar results were reported by Cinotti et al:[39] only 3 (43%) of 7 patients had satisfactory clinical outcomes after posterolateral fusion was performed with the device left in place. Therefore, judging by the existing preliminary reports, clinical outcome after supplementary instrumentation and fusion, leaving the implant in place, does not compare favorably with arthroplasty alone, fusion, or device replacement.

FIXATION AND DYNAMIC STABILIZATION DEVICES

Fixation and dynamic stabilization devices are among the newest additions to the modern spine armamentarium. These include posterior spinous process fixation, interspinous process, and pedicle-based dynamic rod devices. Clinical indications are currently being developed because most of the devices are being tested in clinical trials for approval or have received limited FDA clearance. Very limited clinical evidence is available at this time, and the available evidence is based primarily on nonrandomized retrospective reviews and case series.

The devices that are used in the treatment of symptomatic lumbar degenerative disc disease (eg, Wallis and Dynesys—Zimmer Spine; X-Stop and DIAM—Medtronic; Coflex—Paradigm Spine) offer a less-invasive approach, generally leaving the intervertebral disc intact; therefore, preserving the natural anatomy and motion of the spinal segment but limiting excessive motion. Although some authors have opined that clinical outcomes for dynamic stabilization systems are comparable with those of fusion,[40] the fact that good efficacy has been achieved without fusion is definitely worth further in-depth clinical exploration. Some physicians have suggested using dynamic stabilization procedures for FBSS treatment.[41] Long-term clinical outcomes and further-defined patient selection criteria will confirm or disprove these statements as data from prospective controlled clinical trials become available. After reading this article, the spine surgeon should have learned the principal surgical treatment strategies, challenges and expected clinical outcomes associated with surgeries for the previously operated spine.

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1. Which of the following factors can be responsible for FBSS?
- A. Inadequate surgery
- B. Disc herniation
- C. Arachnoiditis
- D. Epidural fibrosis
- E. All of the above

2. According to the literature, which one of the following is the *most* common cause of pain for patients with FBSS?
- A. Pseudarthrosis
- B. Neuroforaminal and central canal stenosis
- C. Instability
- D. Neuropathy
- E. Psychologic disorders

3. If new symptoms develop within a week postoperatively, which of the following is/are the most likely cause(s) of FBSS?
- A. Inadequate neural decompression
- B. Epidural fibrosis
- C. Hematoma
- D. All of the above

4. If clinical symptoms are unchanged from the preoperative status, which of the following is/are the likely cause(s)?
- A. Inadequate neural decompression
- B. Incorrect diagnosis
- C. Wrong-level surgery
- D. All of the above

5. Which of the following factors reduce(s) the probability of successful surgery in subsequent interventions?
- A. Structural changes in the nerve tissue
- B. Decreased muscle endurance and strength
- C. Triggered neuropathic pain mechanisms
- D. All of the above

6. When considering surgery for FBSS, the decision should be based on imaging studies, clinical symptoms, and patient history.
- A. True
- B. False

7. According to the literature, the cumulative risk for further surgery in the next 10 years for patients who have a single reoperation after discectomy is
- A. 10%
- B. 25%
- C. 40%
- D. 50%

8. Subsidence, facet joint degeneration, accelerated adjacent level degeneration, and migration all are common causes of lumbar artificial disc replacement surgery failure.
- A. True
- B. False

9. Which one of the following was the rate of vascular injuries reported in the FDA investigational device exemption study of the Charité artificial disc for the patients undergoing disc removal surgery?
- A. Up to 0.5%
- B. Up to 1.7%
- C. Up to 10.7%
- D. Up to 16.7%

10. The best revision strategy in terms of clinical outcome for patients who need reoperation after failed lumbar artificial disc surgery is leaving the implant in place and performing supplementary posterior fixation.
- A. True
- B. False