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Determining Reasons for Failed Lumbar Spine Surgery

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The success of lumbar spine surgery is not guaranteed. In fact, although 300,000 new laminectomies are performed yearly in the United States, 45,000 of these patients (15%) remain disabled (1). The patient who has undergone multiple surgeries with persistent or worsening pain and disability presents more frequently now than ever before. This complicated condition is termed *failed back surgery syndrome* (FBSS). As our aged population swells in the upcoming decades, the problem and likewise the cost will also expand. This presents an obvious problem in an era of rigid cost containment. The complexity of a multiply operated patient necessitates a methodical, precise, and cost-efficient evaluation.

It is worth restating the best chance for an excellent outcome from spine surgery is appropriate indications for that surgery. Conversely, surgery with inaccurate or inappropriate indications must be avoided due to its dismal chance for successful outcome (2,3). Precise correlation of symptoms and the physical findings with diagnostic imaging studies is essential, due to the high incidence of clinically false-positive myelograms, discograms, computed tomograms (CT), and magnetic resonance imaging (MRI) studies (4,5 and 6). Surgical exploration of the spine is no longer acceptable. The pathology must be well-defined and consistent with data gathered from the examination and advanced imaging. Due to increasing complexity with each revision operation, the first surgical procedure has the greatest chance for success.

The first decision in the evaluation of FBSS is to separate mechanical from nonmechanical pathology. Mechanical pathology includes herniated discs, segmental instability, and spinal stenosis. These conditions often respond favorably to surgical treatment because they directly compress the neural elements. Nonmechanical causes of lumbar spine pain include surgical scar, psychosocial conditions, and general medical problems. Nonmechanical conditions will not improve with surgery and, in fact, will probably further deteriorate. Differentiating between the two is critical in selecting surgical candidates.

The foundation to establishing a good outcome from the treatment of lumbar spine pathology is obtaining an accurate diagnosis. Although this seems intuitive, failure to accomplish this primary goal will lead to treatment failures.

EVALUATION

An organized approach to the evaluation of a multiple-operated low back patient is required both to simplify the evaluation and to prevent missing significant details. The history can be quite detailed and complex. Many patients desire to relate their chronology of back problems, and it is best to allow them the opportunity to do so. After deciphering the complex history, three historical points must be gathered.

The first is to clearly define the number and nature of previous operations on the spine. The number of previous surgeries correlates with the future outcome. The odds of successful results fall dramatically with additional operations. Historically, a second procedure for a given problem had only a 50% success rate, and further procedures often worsened the patient's condition (7,8 and 9).

The length of the pain-free interval is the second important historic point that must be obtained. If the patient awoke from the previous operation with the exact pain that brought the patient to surgery, it is likely that the nerve root was not decompressed completely, or the improper nerve root was decompressed. However,

if the interval was 6 months or greater, the new pain may result from a recurrent disc herniation at the same or a different level. If the pain-free interval is 1 to 6 months, and the new symptoms gradually progressed, scar tissue is suspected (7,10). Epidural fibrosis and arachnoiditis cause this pain pattern.

The third essential historic point is the patient's pain pattern. If leg pain predominates, a new or recurrent herniated disc or spinal stenosis is likely the diagnosis. Scar tissue may also result in predominantly leg pain. Back pain, however, is suggestive of infection, instability, tumor, or scar tissue, but it may also be idiopathic. When back and leg pain are present in approximately equal intensity, spinal stenosis or scar tissue are suggested.

While gathering historic information, signs of psychosocial problems or psychiatric illnesses should be sought out and probed. Specifically, a history of substance abuse or the presence of known psychiatric diagnoses is of concern. Also, symptoms indicative of depression or anxiety, and the overdramatization of symptoms and physical findings should be noted and weighed during treatment. The presence of unsettled litigation or workers' compensation claims may portend a poor outcome for the treatment of spinal disorders.

After a thorough and detailed history, the physical examination is the next most important aspect of evaluation. Objective neurologic findings and the presence of a tension sign, such as the sitting straight-leg raise, must be sought. A documented and dependable presurgical examination from office notes and medical records is very helpful, as it allows comparison with the current examination. If the neurologic examination is unchanged from before the surgery and no tension sign is present, mechanical compression is unlikely. However, if a new neurologic deficit exists and a tension sign is also present, then radiculopathy is likely. However, as it may also be caused by epidural or perineural fibrosis, the tension sign is not pathognomonic for radiculopathy from a herniated disc or stenosis.

Special attention should be paid to nonorganic physical findings. Red flags include nonanatomic pain distributions or distraction signs. Waddell showed that presence of three or more nonorganic signs predicts a poor outcome from repeat lumbar surgery (8). Formal psychologic testing, such as the Minnesota Multiphasic Personality Inventory, can be useful in detecting nonorganic pain but should not replace the surgeon's attempt to identify well-motivated and adjusted patients (11). These are the patients most likely to benefit from further surgery.

Diagnostic Imaging

The final phase of the diagnostic workup of FBSS is the analysis of imaging studies. The patient should bring all previous studies, especially the original preoperative studies. Plain radiographs, dynamic radiographs, CT, CT-myelograms, and MRIs are all helpful. Do not exclude the possibility that preoperative studies from the previous surgical procedure may indicate that an inappropriate or incorrect procedure was performed. That (potentially) is the reason for failure of that surgery.

The plain radiographs yield valuable information, such as the extent and level of the previous laminectomy and the presence of spondylolisthesis or stenosis. Medially placed or short pedicles, which are readily seen on plain films, may be an indication of stenosis. It should not be assumed that the previous decompression was at the appropriate level. The preoperative studies, the postoperative laminectomy defect, the operative report from the prior surgery, and the patient's neurologic examination all must correlate precisely. Dynamic radiographs, specifically the weightbearing, lateral flexion, and extension films, are useful for assessing iatrogenic instability (12).

Plain CT imaging can show bony stenosis but is rarely used alone in evaluation of FBSS. CT with myelographic enhancement is more sensitive and specific in demonstrating impingement on the thecal sac and the nerve roots, and it also demonstrates arachnoiditis (13). Standard metrizamide myelography without CT is of limited use in the evaluation of FBSS. It identifies compression but cannot distinguish between disc and scar (14).

MRI remains the most useful and most frequently obtained diagnostic imaging modality. Some patients cannot undergo MRI, however, due to the presence of medical implants. For these patients, the other modalities discussed previously are used. MRI clearly differentiates scar from herniated disc material (15). The vascular scar tissue enhances with the intravenous contrast material, gadolinium-labeled pentetic acid. The avascular disc will not enhance.

MRI findings must be reviewed cautiously in the 6 months after surgery. During this time, even asymptomatic patients may have pathologic-appearing changes on MRI that seem to indicate recurrent herniation or scar formation (16,17). This limits the usefulness of this modality in diagnosing recurrent lesions at the operative level during this critical period. Finally, MRI is an excellent screening tool for other pathologic conditions, such as infection or a neoplastic process (16).

Functional tests, such as provocative discography and diagnostic facet injection, are of limited value in this patient population. The predictive value of these expensive, invasive tests has never been proven. Selective nerve root injection is an exception, which can be both diagnostic (by determining the pain contribution of a particular nerve root) and therapeutic. However, selective nerve root injection does not differentiate scar tissue from disc material. The authors also believe electromyography adds little to a thorough physical examination. However, nerve conduction velocity testing can be useful to distinguish peripheral neuropathy from spinal root compression.

DIAGNOSIS

The primary goal in the evaluation of a patient with FBSS is to arrive at the correct diagnosis. Only then can treatment alternative be planned with a reasonable chance for success. The lesions most often responsible for FBSS include persistent or recurrent disc herniation (12 to 16%), lateral (58%) or central (7 to 14%) stenosis, arachnoiditis (6 to 16%), epidural fibrosis (6 to 8%), and instability (less than 5%) (10,18). To standardize and simplify the approach to treatment of this complex problem, an algorithm has been developed. The algorithm assists by organizing the diagnostic criteria, helping to identify the correct diagnostic category, and directing treatment principles. The algorithm is presented in Fig. 1. Also see Table 1.

An important step in the algorithm is identifying nonspinal causes for back pain. Important medical diagnoses to consider are pancreatitis, diabetes mellitus, and abdominal aneurysm. All can mimic FBSS. A general medical evaluation by an internist or equivalent physician should be routinely obtained. In addition, any psychosocial abnormality should be identified, evidenced by

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alcoholism, drug dependency, anxiety, or depression. A psychologic or psychiatric evaluation is necessary in these patients. It is worth restating that patients with unresolved litigation or compensation issues do not respond as favorably to further surgery (19).

Fig. 1 An algorithm for evaluating failed lumbar spine surgery patients. CT, computed tomography; DX, diagnosis; MRI, magnetic resonance imaging; RX, therapy. (From Boden SD, Wiesel SW, Laws ER Jr, et al. *The aging spine*. Philadelphia: WB Saunders, 1991, with permission.)

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TABLE 1. ***Differential diagnosis of the multiply operated back***[a]

History and physical radiographs	Original disc not removed	Recurrent disc at same level	Recurrent disc at different level	Spinal instability	Spinal stenosis	Arachnoiditis	Epidural scar tissue
Number of previous operations	—	—	—	—	—	>1	—
Pain-free interval	None	>6 mo	>6 mo	—	—	>1 mo but <6 mo	>1 mo gradual onset
Predominant pain (leg vs. back)	Leg pain	Leg pain	Leg pain	Back pain	Back and leg pain	Back and leg pain	Back and/or leg pain
Tension sign	+	+	+	—	—	May be positive	May be positive
Neurologic examination	+Same pattern	+Same pattern	+Different level	—	+After stress	—	—
Plain x-rays	+If wrong level	—	—	—	+	—	—
Lateral	—	—	—	+	—	—	—

motion x-rays							
Metrizamide myelogram	+But unchanged	+Same level	+Different level	—	+	+	+
Computed tomography scan	+	+	+	—	+	—	+
Magnetic resonance imaging	+	+	+	—	+	—	+

[a]Table format of algorithm for treatment of failed back surgery syndrome.
From Boden SD, Wiesel SW, Laws ER Jr, et al. *The aging spine*. Philadelphia: WB Saunders, 1991, with permission.

Of course, patients with psychiatric disorders may also have significant organic pathology. These patients are a particular therapeutic challenge and require careful coordination with the psychiatrist or psychologist. Ideally, addressing the psychosocial issues will reduce the somatic back symptoms and obviate the need for surgery. This is not always the case.

After eliminating those patients with medical or psychiatric diagnoses and those primarily motivated by secondary gain, the goal is to identify which patients have specific mechanical problems that may respond favorably to further surgery from those with symptoms resulting from scar tissue or inflammation.

Mechanical Lesions

Herniated Intervertebral Disc

Three possibilities exist if a herniated disc causes the symptoms associated with FBSS. The original pathologic disc may still be causing symptoms. This occurs when the proper level was insufficiently decompressed, when an incorrect level was decompressed, or when extruded disc material remains in the canal. Typically, leg pain predominates and is identical to the preoperative pain, as the nerve root remains mechanically compressed. The neurologic findings, tension signs, and radiographic pattern will be unchanged from the preoperative findings. The key historic point is the absence of a pain-free interval; the patient awoke in the recovery room with the identical, unrelieved pain. These patients benefit from a proper and complete decompression of the pathologic disc.

A recurrent herniation may also occur at the previous level, despite an adequate decompression at the index procedure. Typically, the patient awoke in the recovery room pain-free and remained so for at least 6 months. The recurrent herniated disc compresses the original nerve root, causing the identical symptoms. If contrast-enhanced CT or gadolinium-enhanced MRI demonstrate herniated disc material, further decompression is warranted. However, it is important to cautiously interpret advanced imaging studies for 6 months after surgery, as previously discussed.

Finally, a herniation may occur at a different level or on the contralateral side at the same level, causing a separate constellation of symptoms. The pain-free interval is typically greater than 6 months, but the process may occur at any time. Leg pain usually predominates, in an anatomic pattern consistent with mechanical compression of a newly affected nerve root. The tension sign should be positive. Again, if contrast-enhanced CT or gadolinium-enhanced MRI demonstrates a disc herniation consistent with the symptoms, the patient should benefit from decompression.

Lumbar Instability

Segmental instability is a poorly understood entity that may be implicated as an etiology in FBSS. *Instability*, defined as the abnormal motion between two vertebral bodies, results from the inability of the spinal motion segments to bear normal physiologic loads. Although deformity and neurologic deficits are potential complications of instability, pain is the most frequent result (20). The cause of instability in the FBSS patient may be related to the underlying degenerative process, spondylolisthesis or iatrogenic. The common iatrogenic causes are excessive surgical facet resection and pseudarthrosis, particularly when the fusion was

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performed for instability present at the time of the index procedure (e.g., degenerative spondylolisthesis) (21). Less common causes are a frank facet fracture or fracture through the pars.

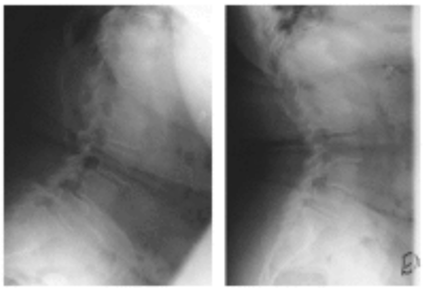

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Fig. 2 Flexion and extension lateral radiographs showing instability in a patient who has had multilevel laminectomy.

The pain felt from segmental instability may be episodic. Particular activities, such as rising from a chair or straightening after forward bending, may provoke symptoms. Less commonly, instability can produce a dynamic stenosis, creating leg pain with certain movements. The physical examination is often normal, although a characteristic reversal of normal spinal rhythm may be noted on return from forward bending (22).

Diagnosis usually is based on weight-bearing and lateral flexion and extension radiographs (Fig. 2). Relative sagittal translation of 12% or angulation of 11 degrees is considered diagnostic for instability at L-1 to L-4 or L-5. At L-5 to S-1, however, 25% of translation or 19 degrees of angulation is considered a positive test (12). Progressive scoliosis or listhesis on serial postoperative radiographs is also indicative of instability. Instability has also been identified at previous discectomy levels at long-term follow-up (23). In one study, 30% of patients had excessive motion. The most common pattern was in women with a previous L-4 to L-5 discectomy.

Radiographic evidence of abnormal motion should be interpreted cautiously, because not all patients with this finding are symptomatic. In the absence of another identifiable mechanical cause for pain, patients with both pain and abnormal motion may benefit from fusion of the affected levels (14). Additionally, exploration of a pseudarthrosis may be indicated if abnormal motion can be documented. When abnormal motion is not present, surgery to fuse a pseudarthrosis has a low probability of success (24).

Spinal Stenosis

Lumbar spinal stenosis may produce back and leg pain in any patient, including patients with FBSS. The pain may result from progression of a degenerative spinal disorder, a previous incomplete decompression, or by overgrowth of a fusion mass.

The pain-free interval varies depending on the circumstances. If the previous surgery failed to completely decompress a stenotic canal, there may be no pain-free interval. Alternatively, the patient may be free of symptoms for months to years before the canal becomes sufficiently stenotic to again produce symptoms.

In general, the history and physical examination should be similar to any patient with lumbar spinal stenosis. Back and leg pain are typically present. The leg pain often is exacerbated by walking, although this is not essential to the diagnosis. The neurologic examination is typically normal, unless neurogenic claudication can be produced during an exercise stress test. Tension signs are generally absent (25,26). It is crucial to differentiate true neurogenic claudication from pain produced by vascular insufficiency.

Plain radiographic findings suggestive of stenosis are facet hypertrophy and degeneration, decreased interpedicular distance, decreased sagittal canal diameter, and degenerated and narrow disc spaces. Spondylolisthesis is commonly associated with central and lateral stenosis. Although it occurs most commonly at the L-4 to L-5 level, it can occur at the previous operative level. MRI clearly shows thecal sac narrowing and, with gadolinium enhancement, can help differentiate between compression caused by epidural scar and by hypertrophied soft tissue structures. Postmyelographic CT provides excellent visualization of bony encroachment on the neural elements centrally, as well as in the lateral recesses and foramina. However, CT cannot reliably differentiate scar from hypertrophied soft tissue (27).

If direct evidence of bony encroachment or mechanical pressure from hypertrophied soft tissue can be found on advanced imaging, good results can be expected from further decompression in at least 70% of properly selected patients. However, if gadolinium-enhanced MRI shows substantial scar tissue is present, the likelihood of pain relief is less certain. Perhaps related to this fact, patients who have undergone previous laminectomy and fusion respond less well to repeated surgical decompression (28). This point reiterates that the best chance for a successful outcome occurs at the time of the index procedure.

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Nonmechanical Spinal Lesions

The previously discussed entities are all caused by direct compression of the neural elements, causing pain. Scar tissue and **discitis** are nonmechanical sources of recurrent pain in the failed back surgery patient. Although the pathology and anatomic location of these lesions are distinct, they are commonly discussed in conjunction because neither improves with additional surgery, and the treatment approach is the same. Postoperative scar formation in the spine is divided into two categories. Scar tissue that forms within the dura is referred to as *arachnoiditis*. Scar tissue that forms outside the dura is appropriately termed *epidural fibrosis*. Finally, the explosion of the use of segmental spinal instrumentation in this country in the past decade introduces a new component to the evaluation of nonmechanical back pain after surgery.

Arachnoiditis

Arachnoiditis is strictly defined as inflammation of the pia-arachnoid membrane surrounding the spinal cord or cauda equina (18). The extent of scarring may vary. At its most severe, the subarachnoid space is obliterated, and the flow of cerebrospinal fluid (and contrast agents) is obstructed. Although the precise cause is uncertain, previous lumbar spine surgery, intraoperative dural tears, and the injection of oil-based contrast agents are known precipitating factors (29). Postoperative infection may also play a role in the pathogenesis of arachnoiditis (30,31).

There is no consistent clinical presentation for arachnoiditis. The typical patient has back and leg pain that developed after a brief pain-free interval, classically between 1 and 6 months after the initial surgery. A history of multiple surgeries is common. The physical examination is generally not helpful, with any neurologic deficits attributable to previous surgery or pathology. CT myelography and MRI usually confirm the diagnosis.

At present, there is no effective treatment for arachnoiditis. Surgery has proved ineffective at relieving pain or reducing further scar formation. Several nonoperative therapies may succeed when combined with much-needed encouragement (2,18,31,32). The administration of epidural steroids, transcutaneous electrical nerve stimulation, spinal cord stimulation, operant conditioning, bracing, and patient education have all been tried. None of these therapies cures the condition, but all may relieve the symptoms for varying periods. All narcotics should be eliminated and amitriptyline hydrochloride (Elavil, Astra-Zeneca, Wilmington, DE) begun to help treat the symptoms. Encouraging the patient to remain as active as possible is also important. Treating these patients remains a significant challenge, requiring devotion and patience by both the physician and patient.

Epidural Fibrosis

Formation of scar outside the dura, on the cauda equina or directly on the nerve roots, is relatively common after decompressive spine surgery (33). The epidural scar tissue may act as a constrictive force on the neural elements and cause postoperative pain. However, whereas most postsurgical patients have some extent of epidural scar formation, only an unpredictable few are symptomatic.

Patients with epidural scarring may present with symptoms at any time, from several months to more than 1 year after surgery. The onset is insidious, and patients often report back or leg pain. New neurologic deficits are uncommon, but a tension sign may be present due to constriction and scarring around the nerve root. The condition is best differentiated from a recurrent herniated disc with a gadolinium-enhanced MRI (Fig. 3).

As with arachnoiditis, there is no definitive treatment for epidural scar formation. Therefore, prevention may be the best strategy. Until recently, a free-fat interpositional graft was used after laminectomy to hopefully reduce scar formation (34). However, a study comparing the use of Gelfoam (Upjohn, Kalamazoo, MI), interposed free fat, and placebo showed no statistical difference in preventing or promoting epidural fibrosis (35). Adcon-L, a recently introduced biodegradable gel matrix that was approved by the U.S. Food and Drug Administration for use after single-level laminectomy or laminotomy, reduces epidural scar formation in experimental studies. Although its use is attractive, its clinical efficacy is not entirely proven. Although Adcon-L is available for patients felt to be high risk for scarring, its routine use should be avoided until further studies show a distinct benefit in outcomes (36).

Once epidural fibrosis has formed, surgical treatment is not beneficial. More scar, in fact, forms from repeated surgical exploration. The treatment program described for arachnoiditis should also be used for epidural fibrosis.

Discitis

Discitis is an uncommon but debilitating complication of lumbar spine surgery. It is a localized inflammatory lesion of the intervertebral disc that follows a discectomy. The pathogenesis, although not completely understood, is thought to be direct inoculation of the avascular disc space (37). Severe back pain, usually beginning approximately 1 month after surgery, is the usual presentation. Signs on physical examination that may corroborate the diagnosis are fever, presence of a tension sign, and a superficial abscess.

If discitis is suspected, plain radiographs, blood cultures, an erythrocyte sedimentation rate (ESR), and a C-reactive protein (CRP) should be obtained. CRP is more specific than ESR, especially in the early phases of infection. Also, it normalizes more quickly than the ESR and in other orthopedic infections is commonly used as a marker of response to treatment. The classic plain radiographic findings of disc-space narrowing and endplate erosion may not be present early in the disease, but a contrast-enhanced MRI should confirm the diagnosis.

The treatment of discitis remains controversial (37). Most commonly, the patient is restricted to short-term bed rest and immobilized with a brace or corset. With symptomatic improvement and normalization of the ESR and CRP, the patient may resume ambulation. Typically, the affected level undergoes autofusion in 6 months to 1 year (38). If pain progresses despite immobilization or constitutional symptoms develop, a needle aspiration is recommended. If an organism is isolated by the aspiration, appropriate intravenous antibiotics are administered, usually for 6 weeks. Often, an organism is not identified and broad-spectrum treatment is required. In an occasional patient, constitutional symptoms persist despite antibiotics, and radiographs show progressive disc space and vertebral destruction. These patients require open débridement and grafting.

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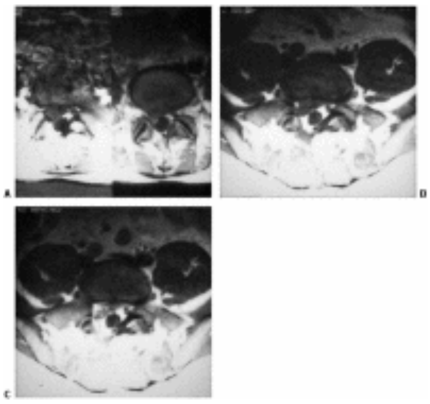

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Fig. 3 Recurrent herniated disc preoperative (*left*) and postoperative (*right*) gadolinium enhancement **(A)**, scar-mimicking disc without enhancement **(B)**, and enhancing scar **(C)**.

Instrumentation

The use of instrumentation as an adjunct to lumbar spinal fusion has exploded in the last 10 years, almost exclusively in the form of pedicle-screw-based implants. This complicates the approach to the FBSS patient. It is the authors' anecdotal experience that more patients are undergoing lumbar spine fusion without objective indications, resulting in a high failure rate of clinical success. The presence of the implant itself raises several technical considerations relating to possible revision surgery, including the significance of screw breakage, implant loosening, infection, and aberrant screw placement. Finally, because of adverse publicity surrounding the use of these devices, their presence raises legal implications that at times further cloud a complicated clinical picture.

Pedicle screw instrumentation systems are inert orthopedic implants with an exceedingly low incidence of true allergy. Mechanical failure of the implant does not always represent an indication for removal or revision. The most dramatic mode of failure is breakage of the screw, typically at the shank-thread junction, which has been reported at a rate of 0.5 to 2.5% (39,40). Screw failure was historically quite common, even early in the postoperative period. With advances in material science and manufacturing, implant failure is now far less common. Furthermore, a broken screw often has questionable clinical significance and does not eliminate the possibility of a successful fusion. However, a recent study by Lonstein reported a correlation between screw breakage and pseudar-throsis. In this study, 12 of 19 patients who had a fractured

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screw had a pseudarthrosis (39). The authors recommended that all symptomatic patients with broken pedicle screws have the implants removed.

Other mechanisms of failure of these systems include screw loosening in the pedicle and vertebral body. This is a more common long-term finding, typically noted as a small zone of radiographic lucency above the screw. Again, no correlation between loosening and symptoms has been reported. Therefore, asymptomatic loosening, in the absence of pseudarthrosis with instability, warrants observation.

Finally, the risk of infection appears to be increased and has been reported as high as 5% (41). Although infection in the perioperative period is more readily diagnosed, late-onset infection has been reported and may represent a source of recurrent back pain after a pain-free interval. The patient with worsening pain several months or even years after an otherwise successful fusion may be manifesting late infection and should be evaluated accordingly. Some abnormality of the complete blood count, ESR, or CRP would raise suspicions of a chronic infection. These laboratory values have been critically evaluated in the total joint arthroplasty literature for their usefulness in identifying chronic, and otherwise undetectable infection, of an indwelling implant (42). A CT scan may reveal a fluid collection around the implant. Aspiration and culture of the wound or the fluid collection may further aid in accurate diagnosis.

SURGICAL TECHNIQUES IN THE MULTIPLY OPERATED SPINE

Surgery on the previously operated lumbar spine can be a considerable technical challenge. The actual technique of a repeat laminectomy is different than the initial procedure. There is increased morbidity, with increased risk of damage to the dura and neural elements. The specific technique for repeated laminectomy and repair of a dural tear are presented.

Repeated Decompression

The goal of decompression in the multiply operated back patient is identical to the goal for any spinal decompression: to safely and completely free the neural elements, without causing excessive hemorrhage. After previous decompression, however, the anatomic relationships are no longer normal, and the presence of scar tissue may complicate exposure and ease of decompression. Thus, several technical aspects of performing a repeated laminectomy are different from those for a primary procedure.

The first difference involves the operative approach. Stripping the paraspinal muscles away with impunity is not possible, because often no lamina or ligamentum flavum is present at the previously operated sites to protect the neural elements. This means the approach must begin at an adjacent anatomic level, which is normal and protected. This allows the surgeon to find the correct depth of the cauda equina (neural elements).

The surgeon may also be tempted, after the depth of the neural elements is determined, to remove the extradural scar tissue directly from the dura. Technically, this is difficult, and there is a great deal of hemorrhage and a high possibility of injury to the dura. Even if the scar tissue is successfully removed, there is no good way to prevent its reformation. Therefore, it is recommended that, in most cases, that extradural scar tissue should be left intact. Only tissue that is covering the area of pathologic change should be removed. Usually, the operative plane can be developed by elevating the scar (and dura) away from the bone at the lateral margin of the old laminectomy.

Finally, the nerve roots must be visualized laterally and any mechanical pressure on them removed. This is accomplished by extension of the laminectomy from the new level down the lateral gutters, leaving the central scar tissue intact. As each nerve root is then identified, any bony encroachment or herniated disc material at that level can be easily removed. It is essential not only to visualize the nerve root to the dorsal root ganglion and to enlarge the foramen, but also to ensure that the root is mobile.

Routine fusion in a multiply operated back patient is not necessary. If there are preoperative signs of instability on the lateral, weight-bearing flexion and extension radiographs, a fusion is indicated. Also, widening the laminectomy so that bilaterally 50% of the facet joints are destroyed at any one level or the pars interarticularis is thinned potentially destabilizes the spine. A bilateral, lateral fusion is recommended in these circumstances. The preoperative patient counseling and the surgical planning should reflect this possibility.

The integrity of a previous fusion mass should be checked during all revision surgeries for the possibility of a pseudarthrosis. A pseudarthrosis can be extremely difficult to detect, even by direct visualization. Unless there are objective signs of instability on flexion-extension radiographs, a nonunited fusion mass can be easily missed. After identifying the fusion mass laterally, an osteotome is used to shave off the outer surface. In a solid fusion, the bone is contiguous throughout. If a defect is identified, the area should be decor-ticated and new bone graft added. However, even a proven pseudarthrosis may not be responsible for a patient's symptoms. As stated previously, many pseudarthroses are asymptomatic, and caution must be used when deciding to treat an apparently painful pseudarthrosis with revision surgery and fusion.

Repair of Dural Tears

The rate of dural injury or tear is definitely increased in FBSS. The surgeon must be skilled in handling this complication. Although each dural tear is unique, certain basic principles always should be applied.

A dural tear usually occurs as the surgeon is gaining visualization of the spinal canal. After the tear is visualized, the surgeon places a piece of absorbable gelatin sponge (Gelfoam) over the injury site'with a large Cottonoid (Codman, Raynham, MA) covering the entire area'and obtains adequate exposure of the tear. The patient's head should be tilted down to decrease the flow of cerebrospinal fluid in the wound.

After adequate exposure is obtained, the surgeon's attention can be focused on repairing the tear with a watertight closure. If this cannot be accomplished, a cerebrospinal fluid fistula potentially may form, raising the risk of meningitis or the development of a subarachnoid cyst. A subarachnoid cyst can exert mechanical pressure on the neural elements.

The technique used to close the dura depends of the size and location of the tear. For simple lacerations, 4-0 silk sutures on a tapered, one-half circle needle are used. A running locking suture (Fig. 4A) or simple sutures incorporating a free fat graft (Fig. 4B) give a

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watertight closure. If a large tear is present, a graft from the lumbar fascia is obtained and sutured in place with interrupted dural silk sutures (Fig. 4C). If the defect is in an inaccessible area, a small tissue plug of muscle or fat is introduced through a second midline durotomy and pulled against a tear from the inside of the dura.

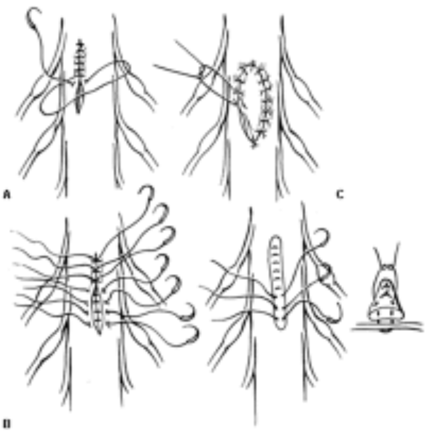

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Fig. 4 Technique for dural repair. (From Eismont FJ, Wiesel SW, Rothman RH. Treatment of dural tears associated with spinal surgery. *J Bone Joint Surg* 1981;63A:1132-1137, with permission.)

To test the repair, the patient is placed in the reverse Trendelenburg position, and the Valsalva maneuver is performed. This maneuver increases intrathecal pressure and stresses the watertight closure. If no leak is present, the fascia is then closed with a heavy nonabsorbable suture to create another watertight barrier to the egress of cerebrospinal fluid. Drains should not be used, as drains may promote fistula formation. Postoperatively, the patient should be kept flat, on strict bed rest, for at least 3 days. The repair should heal by this time.

Prevention of dural tears is best achieved by excellent visualization and meticulous technique during exposure. Complete hemostasis should always be maintained. If there is any question about the presence of dura in the jaws of a bone-biting instrument, a Cottonoid patty should be placed between the dura and the bony structures to prevent dural injury. This is an easy and safe preventive measure.

CONCLUSION

FBSS will likely continue to rise with the high rate of lumbar spine surgery in our society. Prevention of FBSS is unquestionably more beneficial to the patient, because successful treatment of this condition is limited. Properly selecting candidates for lumbar spine surgery leads to more successful operations; however, many patients with FBSS were inappropriately selected for their original surgery, and further surgery only worsens their conditions. When considering revision surgery in these patients, a clear-cut diagnosis of nerve root compression or instability should be present. Nonoperative measures should be exhausted before operating.

The evaluation of a patient with FBSS is the critical step in the patient's treatment. The cause of the patient's symptoms must be accurately localized and identified, and a thorough investigation of the patient's psychosocial and general medical status is needed. Critical historic points are the number of previous operations, predominance of back or leg pain, and the duration of the pain-free interval. New neurologic deficits and tension signs are sought on physical examination. All imaging studies available should be thoroughly reviewed to corroborate the history and physical examination findings. When all the information is integrated, the physician can usually identify patients with correctable mechanical problems from those with epidural fibrosis, arachnoiditis, and discitis.

Physicians involved in the treatment of FBSS should realize there is little likelihood the patient will return to a pain-free state. Some level of permanent pain or disability generally remains. These patients should be counseled and encouraged to resume as functional a role as possible in society.

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