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Etiologies of Failed Back Surgery Syndrome

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ABSTRACT

Study Design. Retrospective chart review.

Objective. To report the epidemiologic data of nonsurgical and surgical etiologies of failed back surgery syndrome (FBSS) from two outpatient spine practices.

Summary of Background Data. FBSS has been offered as a diagnosis, but this is an imprecise term encompassing a heterogeneous group of disorders that have in common pain symptoms after lumbar surgery. The current literature primarily diagnoses for the various etiologies of FBSS from a surgical perspective. To our knowledge, there is no study that investigates the myriad of surgical and nonsurgical diagnoses from a nonsurgical perspective.

Methods. Specific inclusion and exclusion criteria were developed for a list of 42 nonsurgical and surgical differential diagnoses of FBSS. The determination of which category, surgical or nonsurgical, each diagnosis was placed into depended upon the categorization of those diagnoses in previously published literature on FBSS. Each of the authors reviewed the definitions, and they came to a unanimous agreement on each diagnosis' inclusion and exclusion criteria. Data extraction was then carried out in each of the two involved institutions by using the key words discectomy, laminectomy, and fusion to identify all the patients who had any combination of low back, buttock, or lower extremity pain after lumbar discectomy surgery. These charts were then individually reviewed to extract epidemiologic data.

Results. A total of 267 charts were reviewed. One hundred and ninety-seven (197) charts had a complete workup. Of these, 11 (5.6%) had an unknown etiology, and 186 had a known diagnosis. Twenty-three (23) various diagnoses were identified. There was approximately an equal distribution between the incidences of nonsurgical and surgical diagnoses; 44.4% had nonsurgical diagnoses and 55.6% had surgical diagnoses. The most common diagnoses identified were spinal stenosis, internal disc disruption syndrome, recurrent/retained disc, and neural fibrosis.

Conclusion. FBSS is a syndrome consisting of a myriad of surgical and nonsurgical etiologies. Approximately one half of FBSS patients have a surgical etiology. Approximately 95% of patients can be provided a specific diagnosis.

Key Words. Failed Back Surgery Syndrome; Chronic Low Back Pain; Lumbar Surgery; Spinal Stenosis; Internal Disc Disruption Syndrome; Neural Fibrosis; Recurrent Disc; Retained Disc; Discectomy

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This study was a multicenter study involving the above authors. They were involved in conception, design, and a round table discussion that was the basis for outlining of the inclusion and exclusion criteria for the 37 diagnoses.

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Introduction

It is estimated that more than five million Americans experience chronic low back pain, with approximately 50% of those afflicted being disabled [1]. Annually, direct medical costs are approximately US$25 billion [2]. The majority of low back pain patients that fail to improve after surgery are classified under the heterogenous disorder most commonly referred to as failed back surgery syndrome (FBSS) [1].

Cases of ruptured intervertebral discs have been reported as early as 1896 [3]. In 1911, Middleton and Treacher [4] of the United Kingdom and J.E. Goldwait [5] of Boston, independently described the entity known as the ruptured intervertebral disc. Then, in 1929, studies by Dandy [6] and Schmorl [7] provided evidence of the possible clinical significance of the ruptured disc, however, its association with sciatica had not yet been elucidated. Subsequently, in 1934, Mixter and Barr [8] reported a ruptured disc causing radicular pain. The following year, Mixter suggested that disc herniations may be symptomatic without obvious radicular involvement [9]. It has been stated that this 1935 article opened the gates for back surgery [10]. Since then, there has been a steady increase in the number of lumbar surgeries performed in the United States.

Between 1979 and 1987, the rates of lumbar laminectomies, discectomies, and arthrodesis increased by 23%, 75%, and 200%, respectively. During the 13-year period following 1987, the rate of operations on the lumbar spine increased an additional 100% to 26 per 100,000 [11]. It is estimated that over 250,000 new laminectomies are performed each year in the United States [11,12]. Each year, approximately 30,000-40,000 of laminectomy patients obtain either no relief of symptomatology or a recurrence of symptoms [13]. However, the frequency of a poor result after lumbar laminectomy surgery is decreased by over 66% compared with the national average when performed in modern comprehensive spine centers [12]. Outcome studies of lumbar disc surgery document a success rate of 49-90%, depending on the evaluation criteria used [14-17]. Results after open lumbar disc operations are poor in 10-30% of patients [12,18,19]. Percutaneous disc surgery revision rates have been reported as high as 65% [20].

FBSS has been offered as a diagnosis; however, this may be inaccurate. In our view, FBSS is an imprecise term. Instead of labeling a specific diagnosis, FBSS encompasses a heterogenous group of disorders that have in common pain symptoms after surgery [21-24]. As such, FBSS should be considered a syndrome with multiple possible explanatory etiologies [2,23,25-29].

The current literature examining the incidence of the various etiologies of FBSS identifies primarily surgical diagnoses [12,13,18,23,27,30]. Since the authors of these investigations are surgeons, such an emphasis is understandable. To our knowledge, there is no study that investigates the myriad of surgical and nonsurgical diagnoses. The purpose of this study is twofold. First, to make an initial attempt at defining nonsurgical etiologies of FBSS. Second, to report the incidence of nonsurgical and surgical etiologies of patients with FBSS following surgery for a herniated lumbar disc.

Methods

A listing of the potential nonsurgical and surgical differential diagnosis of FBSS was constructed. For each diagnosis, specific inclusion and exclusion criteria were developed. These criteria evolved from our own practice standard and incorporated information from published articles from a wide spectrum of medical specialties. Once this initial list of diagnoses and their preliminary definitions was formulated, a round table discussion by the authors of this report was conducted. Each of the authors reviewed the definitions, and they came to a unanimous agreement on each diagnosis' inclusion and exclusion criteria. This dialogue occurred during the 61st Annual meeting of the American Academy of Physical Medicine and Rehabilitation in Washington, DC. Prior to initiating a chart review, a list of the components of the epidemiologic data to be collected was constructed. These components were age, gender, diagnosis, number of previous surgeries, time of most recent surgery, duration of symptom relief after surgery, duration of overall symptoms, visual analog scale (VAS) pain score, location of pain, magnetic resonance imaging (MRI), electrodiagnostic study results, injection results, and provocative discography results.

Data extraction proceeded in a similar manner at each of the two involved institutions. Zip® disks containing consecutive initial patient evaluation dictations stored in Microsoft® Word format were reviewed from a private practice orthopedic group in Arizona (AZ) and an academic spine center (ASC). These evaluations from AZ and ASC spanned 36 and 60 months, respectively. A search was conducted using the key words discectomy, laminectomy, and fusion to identify all the patients who had undergone prior surgery. Patients who had undergone discectomy/laminectomy for a herniated nucleus pulposus were included. Charts were reviewed by an independent reviewer to assess for

Table 1 The absolute number and percentage of each diagnosis as the etiology of FBSS

Diagnosis	Raw Number	Percentage*
Surgical		
Stenosis (total)	40	21.5
foramina	23	12.4
central	11	5.9
lateral	6	3.2
Internal disc disruption**	40	21.5
Recurrent/retained disc	23	12.4
Spondylolisthesis	3	1.6
Synovial cyst	2	1.1
Vascular claudication	2	1.1
Instability	1	0.5
Pseudomeningocele	1	0.5
Nonsurgical		
Fibrosis (total)	27	14.5
epidural	15	8.1
intraneural	12	6.5
Degenerative disc disease	17	9.1
Radiculopathy	10	5.4
Radicular pain	9	4.8
Deconditioning	7	3.8
Facet syndrome	5	2.7
Battered root syndrome	3	1.6
Sacroiliac joint syndrome	3	1.6
Reflex sympathetic dystrophy	2	1.1
Fibromyalgia	1	0.5
Discitis	1	0.5
Arachnoiditis	1	0.5
Unknown	11	5.6

*Percentage is based on number of diagnoses calculated over total number of patients, and not total number of diagnoses. Therefore, the total percentage is greater than 100%. There were 186 patients with 198 diagnoses
**Internal disc disruption syndrome is included in surgical diagnoses although a nonsurgical treatment may be available.

any combination of low back, buttock, or lower extremity pain after lumbar surgery and to extract epidemiologic data.

Results

The total number of charts reviewed was 267. There were 70 charts with an incomplete workup. The remaining 197 (73.8% of total) charts had a complete workup. Of these, 11 (5.6%) had an unknown etiology despite a complete workup. This resulted in 186 (94.4%) charts with a known diagnosis out of 197 total charts with a complete workup. Of the 186 charts with known diagnoses, six had two diagnoses and three had three diagnoses. This resulted in 186 total charts with 198 total diagnoses. The number of surgical versus nonsurgical diagnoses was 110 versus 88 (55.6% vs 44.4%). A chart of each diagnosis, the raw number of that diagnosis made, and the percentage out of the total number charts with a complete workup are demonstrated in Table 1.

Of the charts that had a complete workup, there were 108 (58.1%) male and 88 (41.9%) female patients. The mean age of these patients was 51.6 years (range 19-84). The mean number of prior surgeries was 1.6, with a range of 1 to 6. The average duration of symptoms prior to initial evaluation was 41.4 months, with a range of 1 to 360 months. The average duration of symptom relief after the most recent surgery was 155 weeks (3.1 years), with a range of 0 to 35 years. Seventy-three (73) of 186 (39.2%) patients experienced less than 20% relief of their back and/or leg symptoms after their most recent surgery. The duration of symptom relief after the most recent surgery for all diagnoses and the four most common diagnoses are demonstrated in Table 2. For spinal stenosis, 57% experienced recurrence of pain within six months of their surgery. In more than one half (54%) of patients diagnosed with internal disc disruption (IDD) syndrome, the symptoms were persistent prior to and following surgery. Those with recurrent/retained disc (Rec/Ret disc), had a bimodal distribution, with 30% experiencing symptoms within six months and 48% experiencing recurrence five or more years after surgery. The majority of the unknown diag-

Table 2 Duration of symptom relief after the most recent surgery

	N	No relief	<6 mo	6-12 mo	1-2 yrs	2-5 yrs	5-10 yrs	>10 yrs
All diagnoses	189	38.6% (73)	21.6% (41)	4.8% (9)	5.3% (10)	9.5% (18)	10.6% (20)	9.5% (18)
Stenosis	39	30.8% (12)	33.3% (13)	7.7% (3)	5.1% (2)	7.7% (3)	5.1% (2)	10.3% (4)
IDD syndrome	39	53.8% (21)	10.3% (4)	10.3% (4)	5.1% (2)	7.7% (3)	5.1% (2)	7.7% (3)
Rec/Ret disc	22	18.2% (4)	13.6% (3)	0%	4.5% (1)	13.6% (3)	31.8% (7)	18.2% (4)
Scarring	25	56% (14)	40% (10)	4% (1)	0%	0%	0%	0%
Unknown	11	54.5% (6)	27.3% (3)	0%	0%	9.1% (1)	9.1% (1)	0

For patients with multiple diagnoses, duration of symptom relief after the most recent surgery based on their principle diagnosis was used.

Table 3 Differential diagnosis based on predominant symptom

Predominantly Back Pain with or without referred pain to the lower limb	**Predominantly Leg Pain** with or without associated low back pain
Back Pain	Recurrent disc
Infection:	Retained disc
Discitis	Lateral stenosis
Osteomyelitis	Foraminal stenosis
Epidural abscess	Extraforaminal stenosis
Soft tissue	Far-out stenosis
Facet fracture	Meningocele
Tumor	Epidural hematoma
IDD	Seroma
Facet joint pain	Tumor
SI joint	Synovial cyst
Instability	Epidural fibrosis
Pseudoarthrosis	Intraneural fibrosis
Spondylolysis	Battered root syndrome
Spondylolisthesis	Central stenosis
Mechanical low back pain	Arachnoiditis
Buttock Pain	Piriformis syndrome
Iliac crest donor site	Iliotibial band syndrome
Cluneal neuropathy	Hip pathology
Miscellaneous	Knee pathology
Myofascial pain syndrome	Complex Regional Pain Syndrome Type 2
Fibromyalgia	Vascular claudication
Deconditioning	Unknown

noses (9/11) experienced either persistent symptoms or recurrence within six months of their surgery.

Discussion

Numerous published reports have demonstrated that 90-95% of all episodes of low back pain cases are nonsurgical [31-34]. Interestingly, prior epidemiologic studies report that the nonsurgical etiologies of FBSS represent between 0 and 83% of the underlying causes of FBSS. See Table 4 for a comparison of diagnoses attributed to failed back surgery syndrome in prior studies. Burton and Kirkaldy-Willis reported the first epidemiologic study examining the underlying etiologies of FBSS [21]. This combined neurosurgical and orthopedic North American paper reported that the frequency of surgical diagnoses compared with nonsurgical diagnoses was greater than a 2:1 ratio. Burton's 10-year follow-up paper reviewed his prior reported causative factors and their status [12]. He stated that surgical etiologies remained the most frequent cause of FBSS [12]. Subsequently, a neurosurgical study by Long conducted in a population of patients in which 64 out of 78 underwent surgery, reported a 4.5:1 incidence of patients that had a nonsurgical versus surgical etiology of failure. A breakdown of etiologies in the patients who were operated on versus those who were managed nonoperatively was not provided [23,35]. In 1993, Bernard published the first orthopedic study. He indicated that greater than 90% of the causes of FBSS were surgical. In that study, arachnoiditis and degenerative spondylosis were the only nonsurgical etiologies identified [36]. The most recent epidemiologic study of FBSS was presented by Simmons at the North American Spine Societies' annual conference [37]. He reported upon 212 postoperative patients with FBSS. All the underlying diagnoses uncovered were surgical. A review of these papers and presentations reveals that none employed specific inclusion or exclusion criteria for the nonsurgical or surgical diagnoses.

While the aforementioned epidemiologic studies have elucidated the various surgical causes of FBSS, there has been no systematic analysis of the nonsurgical etiologies of FBSS. In this report, specific criteria had to be met for a patient to be given a particular diagnosis (Appendix). The value of utilizing specific inclusion and exclusion criteria is manifested by its use in clinical and academic settings. First, it allows the clinician to refer to a comprehensive list from which to offer a patient a diagnosis. Second, it allows for the performance of epidemiologic studies. Third, by using common criteria, outcome studies can be conducted.

We recognized prior to embarking upon this project that the most difficult aspect would be establishing objective definitions for the nonsurgical etiologies. Unlike surgical etiologies, there are no gold standard diagnostic tests with which the nonsurgical etiologies can be compared. Consequently, establishing definitions of nonsurgical etiologies of FBSS is inherently a difficult task. This process is further complicated because different clinicians employ variable criteria for the diagnoses listed in this report. In our opinion, this disparity in definition stems from differences in medical, specialty, and fellowship training; geography; practice setting; patient population; cultural/philosophical views; and individual bias. Although we anticipated this problem, we thought an initial attempt at providing objective defining criteria for the various nonsurgical etiologies to be a useful process.

There are several previously reported diagnoses that were excluded from our listing. There were several reasons for this decision. The authors of this report acknowledge somatoform, conversion reaction, and other psychologic disorders as significant causes of FBSS. These diagnoses were specifically not included in our list of etiologies because

Table 4 Comparison of studies on failed back surgery syndrome

	B & KW	B & KW2	Bernard	Long†	Simmons	Slipman
Surgical						
Spinal Stenosis, total	64	72	29	5	12	21.5
Stenosis, foraminal				1		12.4
Stenosis, central	7	14	29		12	5.9
Lateral spinal stenosis	57	58				3.2
Internal disc disruption			29			21.5**
Severe spondylosis				5		
Segmental instability			2			
Instability/disc degeneration					35	0.5
Spondylolisthesis			4		15	1.6
Recurrent or retained HNP	12	16	33	1	59	12.4
HNP at a new level			7			
Scoliosis				1	7	
Pseudoarthrosis	< 5		29		15	
Foreign body	< 5					
Surgery performed at the wrong level	< 5					
Traumatic meningocele				1		
Tarsal tunnel syndrome				1		
Fractured hip				1		
Compression fracture				1		
Synovial cyst						1.1
Vascular claudication						1.1
Pseudomeningocele						0.5
Nonsurgical						
Arachnoiditis	6*	16*	11	13		0.5
Epidural or intraneural fibrosis	6*	8*		14		14.6
Nerve injury during surgery/Battered root	< 5					1.6
Chronic mechanical pain	< 5					
Transitional syndrome	< 5					
Unknown	< 5					5.6
Normal				21		
Expected post-op changes				21		
Traumatic neuritis				6		
Cancer				4		
Musculoskeletal abnormality				3		
Degenerative spondylosis			9			
Mechanical low back pain						9.1
Radiculopathy						5.4
Radicular pain						4.8
Deconditioning						3.8
Facet syndrome						2.7
Sacroiliac joint syndrome						1.6
Complex regional pain syndrome						0.5
Fibromyalgia						0.5
Discitis						0.5

* It is unclear how the diagnosis of arachnoiditis or epidural fibrosis was defined in this report.
** Internal disc disruption syndrome is included in surgical diagnoses although a nonsurgical treatment may be available.
† Study by Long included 78 patients, 64 of which had surgery. A breakdown of the etiologies in patients who had surgery versus those that did not was not performed in this study.

the purpose of this study was to identify and report upon the physical causes of FBSS. Similarly, components of the chronic pain syndrome including psychologic, environmental, and socioeconomic issues were omitted from the list of etiologies. It has been suggested that the most frequent etiologies of FBSS include "wrong diagnosis," "wrong surgeon," and/or inappropriate patient selection [12,18,21, 36,38]. We do not consider these as diagnoses, but instead, pejorative statements that do not lead to a specific diagnosis or treatment algorithm. Given this view, we did not use these aforementioned "diagnoses."

The classification of FBSS varies according to the authors [12,13,21,23, 36,39-41]. This difference in categorization of FBSS relates to medical specialty, patient population, and location of practice. Although we have emphasized the differences between reports from various authors, there are similarities, which should be highlighted. This commonality relates to incorporating the time of symptom presentation into the probability analysis of the differential diagnosis. Gill and Frymoyer [2] proposed a classification scheme in which failed back syndrome is divided into four different subcat-

egories based on a temporal probability scale: Immediate failures, early recurrence, midterm failures, and long-term failures predicated upon the duration of symptom relief postoperatively. The common causes of immediate failure include wrong preoperative diagnosis or technical error. The common causes of early recurrence are infection and meningeal cysts. The common causes of midterm failures include recurrent disc prolapse, battered root, arachnoiditis, and paraspinal muscle denervation. The common causes of long-term failures include recurrent stenosis and instability [2]. This model classifying the surgical etiologies of FBSS temporally may be applied to the nonsurgical causes of FBSS.

Our results indicate that 61.2% of all patients experienced back and/or leg pain within six months of their most recent surgery. For spinal stenosis, 57% experienced pain within six months, and 54% of IDD syndrome patients had persistent back pain after surgery. As one would expect, retained/recurrent disc patients had a bimodal distribution in duration of symptom relief after surgery. Thirty (30) percent had pain within six months, and 48% experienced recurrence of their symptoms five or more years later. All patients with neural fibrosis experienced either persistent or recurrent pain within one year, but this was inherently biased, as the inclusion criteria defined fibrosis within this time frame. For those with unknown diagnoses despite complete workup, 9/11 experienced recurrence of pain within six months of their surgery.

Our results demonstrate that FBSS is a syndrome consisting of numerous surgical and nonsurgical etiologies for the population of FBSS patients presenting to a spine practice (Table 3). For that patient population, approximately 95% of patients with FBSS can be provided a specific diagnosis. The ratio of surgical to nonsurgical etiologies is approximately 1:1. This ratio differs substantially from the prior reports of Burton and Kirkaldy-Willis [21], Bernard [36], and Simmons [37]. There are differences in the results of prior published reports compared with our study, which in part relates to available technology, patient population, and the use of discography. In the study by Burton and Kirkaldy-Willis [21], MRI was not available, thereby affecting the accuracy of preoperative diagnoses. The Burton and Kirkaldy-Willis [12] study did not entertain the diagnosis of IDD, which requires confirmation by concordant provocative discography. In contrast, our study and those of Bernard [36] and Simmons included this diagnosis as one of the potential etiologies of FBSS.

These results carry specific implications for the spine specialist. Approximately one half of FBSS patients will have a surgical etiology. Therefore, the practicing spine specialist must be comfortable with diagnosing a surgical lesion in this patient population. The ability to detect an anatomic lesion by various types of radiographic spine studies, such as flexion/extension roentgenograms, MRI with and without gadolinium, multiplanar reformatted computed tomography (CT), discography, post-discography CT, and myelography, is required. When a surgical lesion is uncovered that fails to improve with conservative treatment, the spine specialist should not hesitate to make a referral to an orthopedic or neurosurgical spine surgeon.

Generalized statements for the practicing spine surgeon cannot be made based on this study because of differences in patient populations. However, it is reasonable to suggest that for those patients presenting to a spine surgeon for whom there is no surgical lesion present, a specific nonsurgical diagnosis can be provided.

This paper provides an initial framework from which to derive a differential diagnosis for a patient presenting with FBSS. We offer a retrospective analysis of the incidence of these various surgical and nonsurgical etiologies. Further study is required to refine the differential diagnosis listed, and prospective study is needed to confirm the epidemiologic data.

References

1 Bell GK, Kidd D, North BB. Cost-effectiveness analysis of spinal cord stimulation in treatment of failed back surgery syndrome. J Pain Symptom Man 1997;13:286–95.
2 Frymoyer JW, Cats-Baril WL. An overview of the incidences and costs of low back pain. Orthop Clin North Am 1991;22:263–71.
3 Kocher T. Die Verletzungen der Wirbelsaule zugleich als Beitrag zur physiologie des menschlichen Ruckenmarks. Mitt az Grenzgeb d Med u Chir 1896;1:415–80.
4 Middleton GS, Treacher JH. Injury of the spinal cord due to rupture of an intervertebral disc during muscular effort. Glasgow Med J 1911;76:1–6.
5 Goldwait JE. The lumbosacral articulation: An explanation of many causes of "lumbago", "sciatica", and paraplegia. Boston Med Surg J 1911;164:365–72.
6 Dandy WE. Loose cartilage from the intervertebral disc simulating tumor of the spinal cord. Arch Surg 1929;19:660–2.
7 Schmorl G. Ueber Knorpelknotchen an der Hinterflache der Wirbelsbandscheiben. Fortshr a.d Geb.d Rontgenstraheln 1929;40:629–34.

8 Mixter WJ, Barr JS. Rupture of the intervertebral disc with involvement of the spinal canal. New Engl J Med 1934;211:210–5.
9 Mixter WJ, Ayer JB. Herniation of rupture of the intervertebral disc into the spinal canal: report of thirty-four cases. New Engl J Med 1935;213:385–93.
10 Parisien RC, Ball PA. Historical perspective William Jason Mixter (1880-1958) Ushering in the dynasty of the disc. Spine 1998;23:2363–66.
11 Taylor VM, Deyo RA, Cherkin DC, Kreuter W. Low back pain hospitalization. Recent United States trends and regional variations. Spine 1994; 19:1207–13.
12 Burton CV. Causes of failure of surgery on the lumbar spine: Ten-year follow-up. Mt Sinai J Med 1991;58:183–7.
13 Keane GP. Failed low back surgery syndrome. In: Cole AJ, ed. The low back pain handbook. Philadelphia: Mosby; 1997:269–81.
14 Barrios C, Ahmed M, Arrotegui JI, Bhornsson A. Clinical factors predicting outcome after surgery for herniated lumbar disc: an epidemiological multivariate analysis. J Spinal Disord 1990;3:205–9.
15 Crock HV. Observations on the management of failed spinal operations. J Bone Joint Surg 1976;58:193–9.
16 Korres DS, Loupassis G, Stamos K. Results of lumbar discectomy: a study using 15 different evaluation methods. Eur Spine J 1992;1:20–4.
17 Pappas CT, Harrington T, Sonntag VK. Outcome analysis in 654 surgically treated lumbar disc herniations. Neurosurgery 1992;30:862–6.
18 Ekkehard FW, Heisel J, Rupp S. The failed back surgery syndrome: Reasons, intraoperative findings, and long term results: a report of 182 operative treatments. Spine 1996;21:626–33.
19 Kim SS, Michelsen CB. Revision surgery for failed back surgery syndrome. Spine 1992;17:8 957–60.
20 Chatterjee S, Foy PM, Findlay GF. Report of a controlled clinical trial comparing automated percutaneous lumbar discectomy in the treatment of contained lumbar disc herniation. Spine 1995;20: 734–8.
21 Burton CV, Kirkaldy-Willis WH, Yong-Hing K, Heithoff KB. Causes of failure of surgery on the lumbar spine. Clin Orthop 1991;157:191–99.
22 Crenshaw AH. Campbell's Operative Orthopaedics. Mosby: St. Louis; 7th ed., 1987:3300–1.
23 Long DM. Failed back surgery syndrome. Neurosurg Clin North Am 1991;2:899–919.
24 IASP Task Force on Taxonomy. Classification of Chronic Pain, Second Edition. Merskey H, Bogduk N, eds. IASP Press, Seattle, 1994.
25 Hanley EN, David SM. Lumbar arthrodesis for the treatment of back pain. J Bone Joint Surg 1999; 81A(5):716–30.
26 Herno A, Airaksinen O, Saari T, Sihvonen T. Surgical results of lumbar spinal stenosis: a comparison of patients with or without previous back surgery. Spine 1995;20(8):964–9.
27 Larequi-Auber T, Vader JP, Burknand B, et al. Appropriateness of indications for surgery of lumbar disc herniation and spinal stenosis. Spine 1997;22: 203–9.
28 North American Spine Society Phase III Clinical Guidelines for Multidisciplinary Spine Care Specialists. Version 1.0 Copyright 2000.
29 Fardon DF, Herzog RJ, Mink JH, Simmons JD, Kahanovitz N, Haldeman. Contemporary concepts in Spine Care. Nomenclature of lumbar disc disorders. North American Spine Society, La Grange, Ill.: 1995.
30 Frymoyer JW, Cats-Baril WL. An overview of the incidences and costs of low back pain. Orthop Clin North Am 1991;22:263–71.
31 Borenstein DG. Chronic low back pain: a critical look. Clin Orthop 1992;279:8–20.
32 Bueff HU, Van Der Reis W. Low back pain. Prim Care Clin North Am 1996;23:345–64.
33 Carey TS, Garrett J, Jackman A, et al. The outcomes and costs of care for acute low back pain patients seen by primary care practitioners, chiropracters, and orthopedic surgeons. N Engl J Med 1995;333:913–17.
34 Nachemson A. The lumbar spine – an orthopaedic challenge. Spine 1976;1:59–71.
35 Long M, Filtzer DL, Bendebba M, Hendler NH. Clinical features of the failed back syndrome. J Neurosurg 1988;69:61–71.
36 Bernard TN. Repeat lumbar spine surgery. Spine 1993;18:2196–200.
37 Simmons. North American Spine Society annual abstracts, 1998.
38 Crock HV. Internal disc disruption. A challenge to disc prolapse fifty years on. Spine 1986;11:650–3.
39 Grenier N, Kressel HY, Schiebler ML, Grossman RI, Dalinka MK. Normal and degenerative posterior spinal structures: MR imaging. Radiology 1987; 165:517–25.
40 Grossman RI, Yousem DM. Neuroradiology: the requisites. Mosby: St. Louis; 1994:470–5.
41 Rowlington J. Epidural steroids in treating failed back surgery syndrome. Anesthesia and Analgesia 1999;8:240–2.
42 Buschbacher RM. Deconditioning, conditioning, and the benefits of exercise. In Braddom RL, ed. Physical Medicine and Rehabilitation. Philadelphia: W.B. Saunders Co.; 1996:695.
43 Wolfe F, Smythe HA, Yunus MB, et al. The American College of Rheumatology 1990 criteria for classification of fibromyalgia: report of a multicenter criteria committee. Arthritis Rheum 1990; 33:160–172.
44 Travell JG, Simons DG. Myofascial Pain and Dysfunction: The Trigger Point Manual, vols I&I. Baltimore:Williams and Wilkins; 1983.
45 Schneiderman G, Flannigan B, Kingston S, Thomas J, Dillin WH, Watkins RG. Magnetic Resonance Imaging in the diagnosis of disc degeneration: correlation with discography. Spine 1987;12:276–81.

46 Yu S, Haughton VM, Sether LA, Ho KC, Wagner M. Criteria for classifying normal and degenerated lumbar intervertebral disks. Radiology 1989;170:523–6.
47 Bernard TN. Lumbar discography followed by computed tomography. Refining the diagnosis of low back pain. Spine 1990;15:690–707.
48 Hurme M, Alaranta H. Factors predicting the results of surgery for lumbar intervertebral disc herniation. Spine 1987;12:933–8.
49 Yu S, Haughton VM, Sether LA, Wagner M. Annulus fibrosus in bulging intervertebral disks. Radiology 1988;169:761–3.
50 Frymoyer JW. Magnetic Resonance Imaging of the spine. In Frymoyer JW, ed. The Adult Spine: Principle and Practice, 2nd edition. Philadelphia: Lippincott-Raven; 1997:581, 590–1.
51 Ross JS, Masaryk TJ, Modic MT, Delamater R, Bohlman H,Wilbur G, Kaufman B. MR imaging of lumbar arachnoiditis. AJR 1987;149:1025–32.
52 O'Conner D, Maskery N, Granville Griffiths WE. Pseudomeningocele Nerve Root Entrapment after lumbar discectomy. Spine 1998;23:1501–02.
53 Rosen C. Rothman S, Zigler J, Capen D. Lumbar facet fracture as a possible source of pain after lumbar laminectomy. Spine 1991;16:234–8.
54 Ross JS, Delamarter R, Hueftle MG, Masaryk TJ, Aikawa M, Carter J, VanDyke C, Modic MT. Gd-DTPA-enhanced MRI of the post-operative lumbar spine: time course and mechanism. AJR 1989;152: 825–34.
55 Castillo M, Harris JH. Imaging of the Spine. William and Wilkins: Baltimore; 1998, pp. 26.
56 Bertrand G. The "battered" root problem. Orth Clin North Am 1975;6:305–10.
57 Posner I, White AA, Edwards WT, Hayes WC. A biochemical analysis of clinical stability of the lumbo-sacral spine. Spine 1982;7:374.
58 Spengler DM, Freeman DW. Patient selection for lumbar discectomy: An objective approach. Spine 1979;4:129–34.
59 Drury BJ. Clinical evaluation of back and leg pain due to irritation of the superior cluneal nerve. J Bone Joint Surg 1967;49:199.
60 Maigne JY, Doursounian L. Entrapment neuropathy of the medial superior cluneal nerve: nineteen cases surgically treated, with a minimum of 2 years follow-up. Spine 1997;22(10):1156–59.
61 Wieel SW, Feffer HL, Borenstein DG. Evaluation and outcome of low-back pain of unknown etiology. Spine 1988;13:579–80.
62 Stanley JH, Schrabel SI, Frey GD, Hungerford GD. Quantitative analysis of the cervical spinal canal by computed tomography. Neuroradiology 1986; 28:139–43.

Appendix Inclusion Criteria

Diagnosis	History	Examination	Testing
Deconditioning [42]	Back pain with or without less intense lower extremity pain, intensifying as the day progresses. NSAIDs and a nonspecific physical therapy program provide symptom resolution.		
Fibromyalgia [43]	Widespread pain (right side of body, left side of body, above the waist, below the waist, and in the axial skeleton) for at least three months.	Eleven out of 18 tender points on digital palpation with palpation pressure approximately 4 kg, enough to blanch examiner's finger nail.	
Myofascial Pain Syndrome [44]	Presence of five major criteria and one of three minor criteria. The five major criteria include: 1) A regional pain complaint; 2) A palpable taut band; 3) An exquisite focus of tenderness within the taut band; 4) Referred pain; and 5) Altered sensation in an expected distribution elicited from the tender spot and accompanied by some restricted range of motion. The three minor criteria include: 1) Reproduction of the pain or sensation complaint with pressure of the tender spot; 2) Local twitch response; and 3) Pain relief with stretching or an injection of the tender spot. The patient has complete pain relief with trigger point injection in conjunction with physical therapy. Proviso: It is understood that there are patients with underlying myofascial pain syndrome who do not improve with trigger point injection. However, for the purpose of this study, these patients will be categorized under deconditioning.		
Mechanical Low Back Pain [45,46]	Back pain with or without less intense lower extremity pain intensified with sitting or lumbar flexion and relieved with standing in a neutral position. Treatment with NSAIDs and active physical therapy fails to provide symptomatic relief. Fluoroscopically guided steroid epidural space installations in conjunction with physical therapy use results in symptom abatement.	Physical examination reveals increased pain with pelvic rocking[DD] and/or sustained hip flexion[EE].	Plain lateral roentgenograms demonstrate loss of disc height of a low lumbar disc. In the absence of plain lateral roentgenograms, CT demonstrates disc degeneration of a low lumbar disc. In the absence of CT, MRI demonstrates decreased signal intensity within a lower lumbar disc on T2-weighted images.
Internal Disc Disruption Syndrome [47,22]	Back pain with or without less intense lower extremity that fails to improve with NSAIDs, physical therapy, and fluoroscopically guided steroid epidural space installations.		Provocation discography reproduces concordant back pain and postdiscography CT reveals an annular tear extending to the outer one third of the annulus of the symptomatic disc.
Recurrent disc herniation [48,49]	Ipsilateral lower extremity pain, occurring in the radicular distribution of the nerve root at the level of the initial surgery, with or without less intense back pain occurring after a period of postoperative symptom relief. The pain is provoked with sitting and relieved with ambulation or changing positions.	Physical examination reveals a corroborative myotomal strength deficit or reflex change of the involved nerve root.	CT/MRI demonstrates a posterior bulging of the annulus greater than 2.5 mm[a] or an alteration in the morphology of the periphery of the disc resulting in a focal protrusion of the disc beyond the margins of the vertebral end-plates[b]. In the absence of a positive physical examination, a positive electrodiagnostic study of the involved nerve root[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Retained Disc	Postoperative symptoms in the exact distribution as preoperatively with no period of complete symptom relief. The lower extremity pain is of the same or lower intensity level.	Physical examination reveals a corroborative myotomal strength deficit or reflex change of the involved nerve root.	CT/MRI evidence of a retained disc. In the absence of a positive physical examination, a positive electrodiagnostic study of the involved nerve root[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.

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Appendix Continued

Diagnosis	History	Examination	Testing
Central Stenosis	Developmental: Defined as lower extremity symptoms (occurring in the radicular distribution of the involved nerve root or roots that are below the level of the central stenosis) with or without less intense back pain. Symptoms worsen with prolonged standing, ambulation, or lying prone and are relieved with sitting, lumbar flexion, or lying in the fetal position. Acquired: Defined as lower extremity symptoms, occurring in the radicular distribution of the involved nerve root or roots, with or without less intense back pain.	Physical examination reveals a corroborative myotomal strength deficit or reflex change not present prior to surgery.	CT/MRI demonstrates central stenosis[FF]. In the absence of a positive physical examination, a positive electrodiagnostic study of the involved nerve root[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root or roots.
Lateral Recess Stenosis	Ipsilateral lower extremity pain (ocurring in the radicular distribution of the involved nerve root) with or without less intense back pain. The pain worsens with sitting or ambulation and is relieved with rest.	Physical examination reveals a corroborative myotomal strength deficit or reflex change that may not be present prior to surgery.	CT/MRI evidence of lateral recess stenosis. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Foraminal Stenosis [5]	Ipsilateral lower extremity pain, occurring in the radicular distribution of the involved nerve root, with or without less intense back pain. The pain worsens with ambulation and is relieved with rest.	Physical examination reveals a corroborative myotomal strength deficit or reflex change not present prior to surgery.	CT/MRI demonstrating loss of fat within the intervertebral canal and compression of the exiting nerve root. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Far-out Lateral Stenosis [50]	Symptoms in the L5 distribution of the ipsilateral lower extremity with or without less intense back pain.	Physical examination reveals weakness of the ipsilateral L5 myotome.	In addition, CT and/or MRI evidence of stenosis secondary to apposition of the base of the transverse process of L5 to the sacral ala. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Extraforaminal Stenosis [50]	Symptoms in the L5 distribution of the ipsilateral lower extremity with or without less intense back pain.	Physical examination reveals weakness of the ipsilateral L5 myotome.	CT and/or MRI evidence of exit zone stenosis secondary to osteophytic spurs projecting off the inferior endplate of L5 or superior endplate of S1. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.

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Appendix Continued

Diagnosis	History	Examination	Testing
Arachnoiditis [51]	Back pain and/or lower extremity pain not present prior to surgery occurring within one year postoperatively. If back pain only or back pain greater than lower extremity pain, then a negative discography must be present in order to rule out internal disc disruption syndrome. If lower extremity pain only or lower extremity pain greater than back pain, patient must have physical examination revealing a corroborative myotomal strength deficit or reflex change of the involved nerve root.		MRI or myelographic evidence of abnormal morphology and position of the nerve roots with either central clumping, peripheral adhesions (empty sac), or, with MRI, marked distortion of the thecal sac on T2-weighted images. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Postoperative pseudomeningocele [52]	Ipsilateral lower extremity pain, occurring in the radicular distribution of the nerve root at the level of the initial surgery, with or without less intense back pain. This pain occurs after a period of complete postoperative symptom relief, is provoked with sitting, and is relieved with ambulation or changing positions.	Physical examination reveals a corroborative myotomal strength deficit or reflex change of the involved nerve root.	MRI evidence of a fluid-filled sac connecting with the dural canal mechanically compressing the involved nerve root. In the absence of a positive physical examination, a positive electrodiagnostic study of the involved nerve root[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Epidural Hematoma [50]	Lower extremity pain, occurring in the radicular distribution of the involved nerve root, greater than back pain.	Physical examination reveals a corroborative myotomal strength deficit or reflex change.	MRI evidence of a soft-tissue hyperintense mass on T1- and T2-weighted images. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Seroma	Lower extremity pain, occurring in the radicular distribution of the involved nerve root, greater than back pain.	Physical examination reveals a corroborative myotomal strength deficit or reflex change.	MRI evidence of a soft-tissue mass that is hyperintense on T2-weighted images and of low intensity on T1-weighted images, that is not connected with the thecal sac, and that fills the area prior to surgery. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Infection Discitis		MRI evidence of: 1) Decreased signal of the bone marrow adjacent to the affected disc on T1-weighted images; 2) Increased marrow and disc signal intensity on T2-weighted images; 3) Gadolinium enhancement of the disc space and adjacent marrow. In the absence of a positive MRI, a positive culture of the involved disc.	

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Appendix Continued

Diagnosis	History	Examination	Testing
Vertebral Body Osteomyelitis	Defined by unremitting low back pain/spasms with constitutional symptoms and signs consistent with infection (i.e., fever, chills, sweats, malaise, weight loss).	MRI evidence of: 1) Confluent decreased signal intensity in the vertebral bodies and intervertebral disc with inability to discern a margin between the disc and adjacent vertebral bodies on T1-weighted images; 2) Increased signal intensity in the vertebral bodies adjacent to the intervertebral disc on T2-weighted images; and 3) Abnormal configuration and increased signal intensity of the intervertebral disc, along with absence of the intranuclear cleft on a T2-weighted image. In the absence of a positive MRI, a positive culture of the involved vertebral body.	
Epidural Abscess		MRI evidence of: 1) Delineated margins of the abscess on axial T2-weighted images; 2) Iso- or hypointense on T1-weighted images; 3) Hyperintense on T2-weighted images; 4) Enhancing with gadolinium. In the absence of a positive MRI, a positive culture of the abscess.	
Soft Tissue		MRI evidence of infection within a soft tissue structure (i.e., muscle). In the absence of a positive MRI, a positive culture of the suspected source.	
Tumor	Low back pain of constant intensity not alleviated with change in position or lower extremity pain, occurring in the radicular distribution of the involved nerve root, greater than back pain.	Physical examination reveals a corroborative myotomal strength deficit or reflex change.	MRI evidence of a primary or metastatic lesion. In the absence of a positive MRI, a positive histologic diagnosis of tumor. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Facet Joint Syndrome	Low back pain with or without lower extremity pain in a nonradicular distribution.		A positive ipsilateral facet joint diagnostic block[BB] and relief with subsequent therapeutic facet joint blocks. For those in whom ipsilateral therapeutic facet joint injections do not provide relief, a positive double-blind diagnostic screen of the ipsilateral facet joint and a negative discogram to rule out internal disc disruption syndrome.
Synovial Cyst	Ipsilateral lower extremity pain, occurring in the radicular distribution of the involved nerve root, greater than back pain.	Physical examination reveals a corroborative myotomal strength deficit or reflex change.	In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root. In addition, a negative ipsilateral facet joint diagnostic block[BB], but puncture and aspiration of the cyst provides relief of symptoms.
Facet fracture [53]	Low back pain greater than ipsilateral lower extremity pain provoked with lumbar extension and relieved with flexion.	Physical examination reveals point tenderness over the level of the fracture.	Plain roentgenogram/CT/ MRI evidence of facet fracture.

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Appendix Continued

Diagnosis	History	Examination	Testing
Radiculopathy	Ipsilateral lower extremity pain, occurring in a radicular distribution of the involved nerve root, with or without less intense back pain.	Physical examination reveals corroborative myotomal strength deficits in two different muscle actions supplied primarily by the involved nerve root but innervated by different peripheral nerves.	In the absence of a positive physical examination, a positive lectrodiagnostic study[AA] of the involved nerve root.
Radicular Pain	Ipsilateral lower extremity pain, occurring in a radicular distribution of the involved nerve root, with or without less intense back pain.	Physical examination is negative (no myotomal strength deficits in two different muscle actions supplied primarily by the involved nerve root but innervated by different peripheral nerves).	A negative electrodiagnostic study of the involved nerve root. A positive diagnostic block on the involved nerve root[BB].
Nerve Root Scarring/Fibrosis			
Intraneural [54]	Ipsilateral lower extremity pain, occurring in the radicular distribution of the involved nerve root, which is a continuation of part or all of the preoperative symptoms of the same or lower intensity than that prior to surgery.		MRI demonstrates loss of signal intensity of the perineural fat on T1-weighted images. Status postintravenous administration of gadolinium demonstrates increased signal intensity in perineural fibrosis. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Epidural [55]	Ipsilateral lower extremity pain, occurring in the radicular distribution of the involved nerve root, greater than back pain, occurring after less than one year of postoperative symptom relief.	Physical examination reveals a corroborative myotomal strength deficit or reflex change.	MRI demonstrates hypointense to isointense on T1-weighted images, bright on T2-weighted images, and enhances after gadolinium administration. In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the involved nerve root.
Battered Root Syndrome [56]	Lower extremity pain, occurring in the radicular distribution of the nerve root in question, greater than back pain beginning immediately postoperatively. The pain is constant in duration, dysesthetic in character, and is exacerbated by movement.	Physical examination reveals a corroborative myotomal strength deficit or reflex change.	In the absence of a positive physical examination, a positive electrodiagnostic study[AA]. In the absence of a positive electrodiagnostic study, a positive diagnostic block[BB] of the nerve root in question.
Spondylolysis	Must be accompanied by a clinical diagnosis in order to be considered an etiology of FBSS. Clinical diagnoses include instability, internal disc disruption syndrome, deconditioning, mechanical low back pain, radicular pain, radiculopathy, foramenal stenosis, central spinal stenosis.	Physical examination reveals pain is provoked with lumbar extension.	A radiologic diagnosis defined by either a positive bone scan[CC] or MRI evidence of edema in the pars interarticularis.
Spondylolisthesis	Must be accompanied by a clinical diagnosis (instability, internal disc disruption syndrome, deconditioning, mechanical low back pain, radicular pain, radiculopathy, foramenal stenosis, central spinal stenosis) in order to be considered an etiology of FBSS.		A radiologic diagnosis defined by evidence of an anterior slippage of one vertebral body on the inferior adjacent level by radiographs.

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Appendix Continued

Diagnosis	History	Examination	Testing
Instability [57]	Back pain and/or leg pain provoked with prolonged standing.		Standing flexion compared with extension lateral roentgenograms demonstrates greater than 4.5 mm of horizontal translation or greater than 15 degrees of angulation at a particular level when compared with the adjacent motion segment.
Pseudoarthrosis	Back pain greater than lower extremity pain beginning post-operatively. The pain occurs with changing position or activity and is relieved with sitting or side lying with hips and knees flexed.	Physical examination reveals pain provoked with extension.	Flexion/extension roentgenograms, multiplanar, reformatted CT, or surgery demonstrate instability or failure of fusion.
Complex Regional Pain Syndrome	Extremity pain with associated change in color/temperature of the involved limb, skin changes, swelling, marked sensitivity to touch, atrophy, or change in sweat pattern.		In addition, a positive lumbar sympathetic block[BB] or triple-phase bone scan.
Sacroiliac Joint Syndrome [58]	Symptoms of low back pain with or without lower extremity pain in a nonradicular distribution that are not relieved with physical therapy.		A positive ipsilateral sacroiliac joint diagnostic block[BB] and relief with subsequent ipsilateral therapeutic sacroiliac joint blocks. For those in whom therapeutic sacroiliac injections do not provide relief, a positive double-blind diagnostic screen of the ipsilateral sacroiliac joint and a negative discogram to rule out internal disc disruption syndrome.
Graft-donor Site Pain [59]	Constant pain not present preoperatively beginning immediately postoperatively at the graft donor site.	Physical examination reveals regularly reproducible with palpation over the donor site.	
Piriformis Syndrome	Pain and/or paresthesia in the posterior aspect of the ipsilateral thigh or posterior or lateral calf with or without buttock pain and lower extremity symptoms greater than back pain.	Physical examination reveals reproduction of symptoms with deep palpation by the gluteal or rectal route, or with pelvic examination.	Symptom relief with ipsilateral piriformis muscle stretching program. In the absence of relief with piriformis stretching, a positive diagnostic block[BB]. In the absence of a positive diagnostic block, symptom relief with piriformis ligation.
Medial Superior Cluneal Nerve Entrapment Neuropathy [60]	Unilateral low back pain and/or posterior iliac crest and buttock pain. In the region of the iliac graft donor site.	Physical examination reveals a trigger point localized on the posterior iliac crest at a distance of 7 cm from the midline.	In addition, either a positive diagnostic block of the ipsilateral medial superior cluneal nerve or relief of symptoms with nerve release.
Iliotibial Band Syndrome	Pain in the lateral aspect of the ipsilateral lower extremity greater than back pain not relieved postoperatively.	Physical examination reveals a positive ipsilateral Ober's sign.	In the absence of a positive physical examination, symptoms that improve with iliotibial band stretching[EE].
Undiagnosed Hip Disease	Pain in the ipsilateral buttock, groin, or low back with or without less anterior and/or medial thigh pain not extending below the knee. The pain is worsened by rising from a seated position, walking, or going upstairs.	Physical examination reveals pain at end range of flexion or internal rotation or some degree of loss of internal rotation.	Plain roentgenogram or MRI evidence of intrinsic hip disease. If plain films demonstrate absent or mild disease, a positive diagnostic hip injection[BB].
Undiagnosed Knee Disease	Pain in the ipsilateral knee that is worsened by repetitive loading.	Physical examination reveals pain with passive range of motion.	Plain roentgenogram or MRI evidence of intrinsic knee disease. If plain films demonstrate absent or mild disease, a positive diagnostic knee injection[BB]

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Appendix Continued

Diagnosis	History	Examination	Testing
Vascular Claudication	Lower extremity cramping, greatest below the knee, with or without less intense back pain. Symptoms worsen with strenuous activity, alleviate with rest, and are not affected with change in position. Standing is asymptomatic.	Physical examination reveals absent ipsilateral lower extremity pulses.	In the absence of a positive physical examination, doppler or arteriographic evidence of vascular insufficiency.
Unknown	Back and/or lower extremity symptoms not fulfilling the diagnostic criteria of one of the above etiologies.		

[AA] A positive electrodiagnostic study is defined by electrodiagnostic evidence of acute denervation as represented by positive sharp waves and/or fibrillation potentials seen at rest on needle exam in two muscles that share innervation by a nerve root yet are supplied by different peripheral nerves and in the ipsilateral paraspinal muscles [61].

[BB] A positive diagnostic block is defined as at least 80% improvement in the intensity of the symptomatology in question as reported by the patient on a VAS 10-15 minutes after the procedure [62].

[CC] A positive bone scan is defined by the presence of radioisotope uptake in the region in question.

[DD] Pelvic rocking is a lower lumbar disc stress maneuver. It is performed in the supine position. The patient flexes the hips and knees to the point that the anterior thigh comes in contact with the chest. Then, the examiner proceeds to "rock" the flexed lower extremities to the right, then to the left, then back to the right. This maneuver is considered positive if the patient reports reproduction of the usual low back pain.

[EE] Sustained hip flexion is a lower lumbar disc stress maneuver. With the patient supine, the examiner passively flexes the patient's hips, with the knees extended, to approximately 45 degrees to the plane of the table. The patient is then instructed to actively maintain this position. The examiner then asks about reproduction of the patient's usual low back pain. The examiner then passively lowers the lower extremities approximately 10 degrees. The patient is asked to actively maintain this position. Again, the examiner asks about reproduction of the patient's usual low back pain. This is continued until the lower extremities come in contact with the examining table. This maneuver is considered positive if the patient complains of an onset of, or an increase in, the usual low back pain as the lower extremities are progressively lowered.

[FF] Imaging criteria for central stenosis [58]: 1) Relative stenosis—defined as one standard deviation below average, therefore, less than a 12.5-mm midline sagittal diameter (as measured from the middle of the posterior surface of the vertebral body to the junction point of the base of the spinous process and the laminae) and 2) Absolute stenosis—defined as two standard deviations below average, which comes to less than a 10.5-mm midline sagittal diameter.