

Failed Back Surgery: A Clinical Review

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ABSTRACT

Failed back surgery syndrome (FBSS, failed back syndrome) is a chronic disorder that has many impacts on the patients and health care systems. The predisposing factors may occur in the preoperative, intraoperative, and postoperative periods. The term FBSS is often misused. It is not actually a syndrome, but is a very generalized term that is often used to describe the condition of patients who had unsuccessful results with back surgery or spine surgery, or experienced continued pain after surgery. Patients describe uncontrolled persistent back, back/leg or leg pain with functional insufficiency with or without sciatica after 10-40% of the all spinal surgeries. Literature about the FBSS is insufficient, due to the complexity of this entity with variety of the underlying etiology and lack of high-quality clinical trials determining response to treatment modalities. This review aims to summarize current concepts in the findings of literature findings.

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Key words: Back surgery; Pain, lumbar disability; Rehabilitation

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INTRODUCTION

Back pain is a frequent health problem with a reported point prevalence in the general adult population of 37%^[1] and a lifetime prevalence of 60% to 85%^[1-3]. After all 80-90% of the patients that have low back pain, (70-93% according to some authors), get well without any treatment and only 1-2% of the patients may need further surgery. The number of spine surgeries has apparently increased in the past several decades^[4-6]. Lumbar disc hernia (LDH) ratio is only 5% in all patients with low back pain. According to Hanley et al. the operative treatment outcomes of herniated disks are poor in 14% of all cases^[7].

Failed back surgery syndrome (FBSS) is a clinical entity given to patients who complain of back and leg pain symptoms after unsuccessful lumbar surgery^[8]. FBSS is a syndrome of uncontrolled back, back and leg and leg pain with functional insufficiency after 10-40% of the spinal surgery^[9]. The incidence of reoperation following lumbar spine surgery ranges from 4% to 19%^[10,11]. Often the anatomic pain source is unclear.

Poor outcomes of surgical treatment might result from incorrect diagnosis, challenging surgical technique or inadequate debridement. Such findings may cause suspicions about real indications of disc surgeries^[12]. Boden *et al* analyzed the MRI reports of 67 asymptomatic and 37 symptomatic patients, and they found the spinal stenosis and lumbar disc hernia in 19 (28%) of asymptomatic patients^[13]. Jensen *et al* analyzed 98 asymptomatic patients' MRI reports and they found normal results in only 36% of the patients.^[14] Similar results have been reported in other studies of asymptomatic population^[15]. According to these results, it can be concluded that trusting only to imaging techniques is a wrong way of deciding surgery^[13-17].

The long term controlled studies claimed the necessity of establishing real surgical indications, and they also found no differences between conservative and surgical treatment for the lumbar disc hernias^[18,19]. Unsatisfactory surgical outcomes in the presence of a demanding worker's compensation have been a consistent finding throughout the spinal surgery literature^[20-24].

Microdiscectomy success rate is generally 75% to 80%^[25]. Some recent randomized control trials (RCTs) exhibited a success rate

of 81% at 8 weeks^[26,27]. The short-term results were superior to conservative treatment, but the conservative treatment group reached the similar level of success of the surgical group in 2 years^[26,27]. These results propose the failure rate for microdiscectomy to be less than spinal fusion (19-25%). There is no evidence to suggest any difference in clinical outcomes between microdiscectomy and open discectomy^[28-30].

According to the studies about surgical or conservative treatments for low back pain the treatment of choice still remains unclear, only cauda equina syndrome and progressive neurologic deficit are the absolute surgical treatment indications.

Etiology of the FBSS

The reasons of the FBSS are variable. Common identifiable reasons for FBSS include poor patient selection, incorrect initial diagnosis, incorrect or inadequate surgery, scarring, infection, and progression of disease. The frequent reasons of the FBSS are based on surgery and disc, psychosocial factors and uncommon lesion pattern. While some authors divide the reasons of the FBSS into two groups depending on surgery, another group of authors divide it into three groups including preoperative, intraoperative and postoperative factors (Table 1). The exact reason can not be found in some occasions^[31,32].

Preoperative Factors

Some studies showed that psychosocial risk factors are more efficient in predicting low back pain disability than structural abnormalities^[33]. Some studies demonstrated that psychological factors are related to poor outcome of spinal surgery^[20,34-36]. So psychosocial factors (including state of mind, belief, behaviour about back pain and the presence of and depressive syndrome) can be counted in the reasons of the FBSS^[31,37-41]. Besides, these factors are very important for recovery. Wrong comments about pain can cause less physical and social activity, ending with loss of physical condition. In this situation chronic pain syndrome may lead to learning difficulties, depression related pain, anger^[12,42].

Repeated surgery is associated with higher failure rates. In a recent review, it has been reported that initial success rates decreases from 50% to 30% after second surgery, to 15% after the third, and to 5% after the fourth^[43]. Spinal instability can be seen in 12% of second operations and it is greater than 50% after four or more revisions^[44].

Table 1 Etiology of failed back surgery syndrome.

Preoperative factors
• Patient
• Psychological: Anxiety, depression, poor coping strategies, hypochondriasis
• Social: litigation, Compensation claim
• Surgical
• Repeated surgery
• Candidate selection (e.g., micro discectomy for axial pain)
• Surgery selection (e.g., inadequate decompression in multilevel pathology)
Intraoperative factors
• Poor technique (e.g., inadequate lateral recess decompression, misplaced screw)
• Wrong surgery level
• Inability to achieve the aim of surgery (e.g., far lateral discectomy)
Postoperative factors
• Recurren disc herniation
• Epidural fibrosis
• Arachnoidit, Discitis, Pseudomeningocele
• Nerve injury, infection, and hematoma
• Spinal instability (e.g., vertical stenosis)
• Myofascial pain development

Intraoperative Factors

Some surgical causes including wrong level, misplaced grafts and screws, inefficient or overaggressive decompression, leaving disc remnants may lead to persistent pain^[45,46]. Insufficient decompression, often in the lateral recess and vertebral foramens, is a potential reason of FBSS^[47]. On the other hand, excessive decompression may lead to spinal instability and pain^[45]. Multilevel discectomy is a risk factor for re-herniation of disc due to segmental discectomy. Pain usually starts after surgery in 6 months and new neurologic symptoms may be seen^[31,32]. When lateral recess or foraminal narrowing on CT and multilevel dural sac compression on MRI are established, diagnosis is certain. Symptoms usually do not get better without reoperation^[31,32,38,48]. So if uninterrupted pain or neurologic deficit continues after surgery, reoperation must be thought^[31,32].

Postoperative Factors

Postoperative etiologic factors include recurrent disc hernia (12-17%), arachnoidit (1.1-16%), central stenosis (7-29%), epidural fibrosis (20-36%), instability (5%), pseudoarthrosis (14.8%), discitis (0.1-3%), and psychological problems (3%)^[49-52].

Especially after discectomy, stenosis may occur due to facet joint overriding and subarticular narrowing of the lateral recess^[53,54]. It may cause leg and back pain. More than one spinal surgery is a risk factor for abnormal scar formation. Furthermore, recurrent disc hernia and following discectomy may happen either at the site of the operation or in the adjacent segment. This complication is seen up to 15% of patients^[49]. Some factors may predispose pain and progression of the disease like spondylolisthesis, and may induce pain at adjacent sites^[55].

If any surgery involves manipulation of the epidural space, then epidural fibrosis may be unavoidable. According to some studies, epidural fibrosis may be the reason or inductive factor for persistent pain in 20-36% of FBSS patients^[50,51,56-58]. If nerve roots' nutrition is damaged by perineural fibrosis due to cerebrospinal fluid circulation deficiency, then it may result in hypersensitivity of nerve roots^[59]. Additionally, perineural fibrosis may cause vascular hypoxia due to the compromise of vascular supply to nerve roots^[54].

Spinal surgery may cause a new instability due to altered biomechanics of the spine. The surgery alters the distribution of weight among the structures of the spine. Lumbar instability may happen due to loss of the normal range of motion of spinal segment. Intrinsic back disease, excessive bilateral laminectomy and pseudoarthrosis of the fusion might cause lumbar instability. Instability is increased within time because of the ligament and bone damage. Laminectomy causes inadequate facet joints in axial pain^[52]. Discectomy may result in partial collapse and decreasing of the intervertebral space.

A new arrangement of the facet joints may compromise the nerve roots between the superior pedicle and the inferior pedicle, and this finding has been termed "vertical stenosis"^[52]. Discectomy may also create new adjacent disc degenerations due to changes in the biomechanics of the spine^[60] which is termed "transition syndrome". It has been reported to occur up to 36% of patients following lumbar spinal fusion^[60]. Some complications of spinal surgery including disc space infection, spinal or epidural hematoma, pseudomeningocele, and nerve root injury can cause persistent pain in the postoperative period^[49]. Arachnoid membrane inflammation (arachnoidit) may result in persistent irritation of the nerve roots if persists^[52]. Early identification and treatment of these complications are very important to prevent from permanent neurological deficits^[61].

Postsurgical pseudomeningocele is an uncommon complication of spinal surgery^[62]. The reasons of the pseudomeningocele include dural rupture or insufficient closure during surgery^[61,63]. Persistent

radicular pain following lumbar spinal surgery may be accompanied by pseudomeningocele and this condition is known as “battered root syndrome”^[64]. Risk factors of this condition include prolonged and aggressive root retraction, extreme bleeding and presence of a conjoined nerve root^[64].

Sahin *et al* have conducted electrophysiologic nerve conduction studies and recorded sympathetic skin response on the symptomatic sides of 29-FBSS-diagnosed patients. They reported that, these patients have higher latency durations when compared to 13 healthy population, which in term may depict the reason of intensity and chronicity of pain in this group of patients via dysfunction of the sympathetic nervous system^[65].

The pain following spinal surgery may source from paraspinal muscles^[66-69]. Muscle dissection, aggressive and prolonged retraction of the paraspinal musculature result in denervation and atrophy^[66-68]. This intraoperative behavior to the muscles may be increased by postural changes after surgery. Lose of lumbar lordosis may cause spasm and atrophy of the paraspinal and hamstring muscles^[52]. This kind of myofascial pain is called “fusion disease”^[66-68].

DIFFERENTIAL DIAGNOSIS OF THE FBSS

Diagnosis of FBSS, must start with historical timeline and characteristics of the pain. A comprehensive history must include onset, location, pattern and source of the pain. Pain-free period following surgery is an important historical point to consider. Other pathologies that may cause back pain must be excluded. Further workup to rule out non-orthopedic reasons such as pelvic and abdominal inflammatory conditions, urinary tract or kidney infections, gallbladder diseases, Reiter syndrome, ankylosing spondylitis, thoracic and abdominal malignancy and infections, and aortic aneurysm must be investigated^[70] as well as psychosocial instability, alcoholism, drug dependence, and depression^[71].

The onset characteristics of pain are good guides. If pain happens immediately following surgery, the reasons may include wrong level surgery, traction on the nerve root during placement of the implant or inadequate surgery including incomplete nerve root decompression or retained disc fragment. Partial pain relief can be addressed to incomplete or inadequate procedure that did not sufficiently solve the real symptomatic pathology. If an intervertebral cage or pedicle screws is placed, implant position should also be controlled with image intensifier to confirm correct placement.

If patients complain about recurrent pain within 1 to 6 months, investigation of the pain pattern is necessary to discriminate new type of pain. If the new symptoms initiate gradually, either arachnoiditis or epidural fibrosis due to scar formation, should be considered. If the symptoms are sudden in onset, like an accident, then recurrent disc herniation or hardware or graft failure should be considered.

Discitis is an uncommon complication of disc surgery. The symptoms of discitis usually start several weeks after surgery. Most patients complain severe back pain and fever. If discitis is suspected, some laboratory studies including blood cultures, erythrocyte sedimentation rates, and C-reactive proteins can further guide diagnosis and management.

Late postoperative pain in 6 months is likely due to pseudoarthrosis or recurrent disease either at the same level or at a different level. In these patients a revision operation can be beneficial. Insufficient fusion may cause pseudoarthrosis and can be the reason of pain due to instability.

A thorough spinal physical examination should be performed, including posture analysis, sagittal and coronal balance, vertebral

range of motion, and gait analysis. A complete neurologic examination including sensory and motor components must be done and reflex examination must be performed to assess any focal neurologic deficits or pathologic reflexes. Peripheral vascular examination, e.g. pulses, should also be checked for any vascular disease. The hips and knees should be checked as well as any nerve irritation findings.

Standard biplanar radiographs with the patient standing and flexion and extension lateral views are useful in evaluating overall alignment, amount of degeneration, and presence of instability^[70,71]. Laminectomy levels and borders can be established with X-rays. Spinal implants, e.g. screws, cages, are checked with plain radiographies for any loosening, subsidence, and malposition.

MRI with and without contrast material is a useful guide to determine the differentiation between the disc hernia and epidural scar tissue. MRI can discover residual spinal stenosis, facet joint pathologies, and synovial cysts. Neural MRI imaging has been shown to be the most sensitive test for evaluating neural compression in FBSS patients^[72]. Although extradural compression can be recognized with myelography or CT, they can't differentiate disc hernia and epidural scar tissue formation^[60]. CT with fine-section coronal and sagittal reconstructions can help to evaluate fusion status and pseudoarthrosis, the size of the spinal canal, the correct level of decompression, and early postoperative discitis via hypodense findings of the affected disc space. Diagnostic studies such as electromyograms (EMGs), diagnostic blocks, discography should be considered in relation with history and physical examination findings to better elucidate the cause of FBSS.

If patients present constitutional symptoms like fever, chills, or wound drainage, infection must be suspected. Complete blood count (CBC), erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) levels should be checked. The surgeon must be careful because these findings may be false positive in the postoperative time period. While predicting early postoperative infection regardless of operation CRP is more applicable, predictable, and sensitive in the early postoperative period when compared to ESR^[73].

REHABILITATION OF THE FAILED BACK SURGERY SYNDROME

Literature on the rehabilitation management of the FBSS is lacking due to the complexity of this entity with diversity of the underlying etiology, and lack of high-quality clinical trials that evaluate responses to different treatment modalities^[74]. Prevention of the FBSS is more important than management. So selecting the right patient, establishing correct diagnosis and applying appropriate surgery are very important subjects for the success of the treatment^[75].

The aim of the rehabilitation is to reduce complications that are related to pain. These complications include wrong comments about pain, increased stress related pain, increased anxiety level, reduced social and physical activity and reduced physical condition. The patients are taught as active coping mechanisms to pain that gives them a sense of control over their predicament^[76].

So these problems must be recovered by multidisciplinary treatment approach^[77]. First week, month and year CT scans on discectomy patients showed the powerful relation between anatomic findings and severity of the back and leg pain. These findings can be explained with complex interaction between anatomic failure, physical irregularity and psychological factors^[78].

A number of patients with FBSS may become deconditioned, leading to weakness of the musculature (e.g., transvers abdominal or paraspinal muscles) responsible for maintaining spinal stability.

Though different approaches exist, the general aim of exercise therapy is to decrease pain, improve posture, stabilize the hypermobile segments, improve fitness, and reduce mechanical stress on spinal structures^[79]. Recent reviews about chronic low back pain (CLBP) defined exercise therapy to be mildly to moderately superior to no-treatment for pain relief, at early follow-ups^[80,81]. This finding was supported by different systematic reviews^[82-84]. There are many exercise therapy programs described in the literature but no evidence exists to support one form of exercise therapy over another in terms of outcomes^[85]. If a program is composed of individualized supervision, stretching, and strengthening modalities, then it is associated with good functional outcomes^[81]. More recent studies recommend core muscle strengthening to improve stability of the spine and to reduce pain^[86].

Attending surgeon's first aim in the early postoperative period, must be avoiding scar formation and recurrent herniation. Several studies have shown that lumbar extension-flexion and abdominal exercises during this early period, have positive effects on pain relief, mobility, psychological status, time to reoccupate and shortening or endurance of lumbar muscles^[87,88]. Aerobic exercises should also be added to the exercise program to achieve a more successful rehabilitation^[89].

The rehabilitation of the chronic pain must be integrated with psychological treatment modalities. This combination is called "cognitive behavioral treatment" (CBT). When incorrect behaviours are shown and corrected, then proper cognitive and behavioral responses are improved^[90]. Although some CBT modalities may have differences in attitude, they mainly include strategies and treatment options to avoid any rise of symptoms like education of self-relaxing or education of coping with pain which later on must be a permanent habitual manner both at home or at work^[90].

Spinal cord stimulation (SCS) is suggested for the treatment of pain of the FBSS. SCS is a technique that involves placement of electrodes in the epidural space to produce an electrical current by means of a pulse generator, which is placed subcutaneously^[91]. The main effect is a "door control mechanism" that was described by Melzack and Wall in 1965^[92]. The other effects of the SCS include suppression on tactile allodini, protection against peripheral ischemia and GABA mediation inhibition on dorsal horn. SCS is very effective on neuropathic pain, besides additional effects can be seen such as improvement in functional status, decreasing of drug usage. SCS must be performed in early stages. Studies showed that SCS has long term effects^[93,94].

Some studies have also showed that phototherapy may be effective for the treatment of the entesopathy in FBSS patients^[95]. Suggested treatments including epidural steroid injections, lumbar percutaneous adhesiolysis, spinal cord stimulation, and intrathecal pumps have a moderate evidence and they don't remedy consistent solution.

CONCLUSION

FBSS is a disorder of complex mechanisms and different modalities. The exact treatment of choice for FBSS seems to be dependable on the etiology of symptoms. Not one current therapy is superior than the other. There is no gold standard for the treatment of the FBSS. Nevertheless it is sure that any treatment of FBSS must be multidisciplinary, containing surgical interventions, rehabilitation, and psychotherapy.

CONFLICT OF INTERESTS

There are no conflicts of interest with regard to the present study.

REFERENCES

- Schmidt CO, Raspe H, Pflingsten M, Hasenbring M, Basler HD, Eich W, Kohlmann T (2007) Back pain in the German adult population: prevalence, severity, and sociodemographic correlates in a multiregional survey. *Spine* 32:2005-2011. DOI 10.1097/BRS.0b013e318133fad8
- Patel AT, Ogle AA (2000) Diagnosis and management of acute low back pain. *American family physician* 61:1779-1786, 1789-1790
- Kelsey JL, White AA, 3rd (1980) Epidemiology and impact of low-back pain. *Spine* 5:133-142
- Gray DT, Deyo RA, Kreuter W, Mirza SK, Heagerty PJ, Comstock BA, Chan L (2006) Population-based trends in volumes and rates of ambulatory lumbar spine surgery. *Spine* 31:1957-1963; discussion 1964. DOI 10.1097/01.brs.0000229148.63418.c1
- Deyo RA, Gray DT, Kreuter W, Mirza S, Martin BI (2005) United States trends in lumbar fusion surgery for degenerative conditions. *Spine* 30:1441-1445; discussion 1446-1447
- Gray D, Deyo, R., Kreuter, W., Mirza, S., Martin, B. (May 30-June 5, 2004) Population-based rates of inpatient and outpatient lumbar spine surgery in the United States. In: Paper presented at: International Society for the Study of the Lumbar Spine. Porto, Portugal.
- Hanley EN, Shapiro DE (1989) The Development of Low-Back-Pain after Excision of a Lumbar-Disk. *J Bone Joint Surg Am* 71A:719-721
- North RB, Campbell JN, James CS, Conover-Walker MK, Wang H, Piantadosi S, Rybock JD, Long DM (1991) Failed back surgery syndrome: 5-year follow-up in 102 patients undergoing repeated operation. *Neurosurgery* 28:685-690; discussion 690-681
- Randy VC (1993) Failed Back Surgery Syndrome. *Dynamic Chiropractic* 11
- Martin BI, Mirza SK, Comstock BA, Gray DT, Kreuter W, Deyo RA (2007) Reoperation rates following lumbar spine surgery and the influence of spinal fusion procedures. *Spine* 32:382-387. DOI 10.1097/01.brs.0000254104.55716.46
- Malter AD, McNeney B, Loeser JD, Deyo RA (1998) 5-year reoperation rates after different types of lumbar spine surgery. *Spine* 23:814-820
- Block A (1993) Psychological screening of spine surgery candidates. In: Hochschuler SH, Cotler, H.B., Guyer, R.D. (ed) *Rehabilitation of The Spine Science and Practice*. Mosby, St. Louis. pp. 617-625.
- Boden SD, Davis DO, Dina TS, Patronas NJ, Wiesel SW (1990) Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects. A prospective investigation. *J Bone Joint Surg Am* 72:403-408
- Jensen MC, Brant-Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS (1994) Magnetic resonance imaging of the lumbar spine in people without back pain. *The New England journal of medicine* 331:69-73. DOI 10.1056/NEJM199407143310201
- Weishaupt D, Zanetti M, Hodler J, Boos N (1998) MR imaging of the lumbar spine: prevalence of intervertebral disk extrusion and sequestration, nerve root compression, end plate abnormalities, and osteoarthritis of the facet joints in asymptomatic volunteers. *Radiology* 209:661-666. DOI 10.1148/radiology.209.3.9844656
- Block AR (1993) Psychological screening of spine surgery candidates. In: Hochschuler SH, Cotler, H.B., Guyer, R.D. (ed) *Rehabilitation of The Spine Science and Practice*. Mosby, St. Louis. pp. 617-625.
- Rodrigues FF, Dozza DC, de Oliveira CR, de Castro RG (2006) Failed back surgery syndrome: casuistic and etiology. *Arquivos de neuro-psiquiatria* 64:757-761
- Dzioba RB, Doxey NC (1984) A prospective investigation into the orthopaedic and psychologic predictors of outcome of first lumbar surgery following industrial injury. *Spine* 9:614-623

19. Weber H (1983) Lumbar disc herniation. A controlled, prospective study with ten years of observation. *Spine* 8:131-140
20. Voorhies RM, Jiang X, Thomas N (2007) Predicting outcome in the surgical treatment of lumbar radiculopathy using the Pain Drawing Score, McGill Short Form Pain Questionnaire, and risk factors including psychosocial issues and axial joint pain. *The spine journal: official journal of the North American Spine Society* 7:516-524. DOI 10.1016/j.spinee.2006.10.013
21. Bosacco SJ, Berman AT, Bosacco DN, Levenberg RJ (1995) Results of lumbar disk surgery in a city compensation population. *Orthopedics* 18:351-355
22. Klekamp J, McCarty E, Spengler DM (1998) Results of elective lumbar discectomy for patients involved in the workers' compensation system. *Journal of spinal disorders* 11:277-282
23. Taylor VM, Deyo RA, Ciol M, Farrar EL, Lawrence MS, Shonard NH, Leek KM, McNeney B, Goldberg HI (2000) Patient-oriented outcomes from low back surgery: a community-based study. *Spine* 25:2445-2452
24. Waddell G, Main CJ, Morris EW, Di Paola M, Gray IC (1984) Chronic low-back pain, psychologic distress, and illness behavior. *Spine* 9:209-213
25. Asch HL, Lewis PJ, Moreland DB, Egnatchik JG, Yu YJ, Clabeaux DE, Hyland AH (2002) Prospective multiple outcomes study of outpatient lumbar microdiscectomy: should 75 to 80% success rates be the norm? *Journal of neurosurgery* 96:34-44
26. Peul WC, van Houwelingen HC, van den Hout WB, Brand R, Eekhof JA, Tans JT, Thomeer RT, Koes BW (2007) Surgery versus prolonged conservative treatment for sciatica. *The New England journal of medicine* 356:2245-2256. DOI 10.1056/NEJMoa064039
27. Peul WC, van den Hout WB, Brand R, Thomeer RT, Koes BW (2008) Prolonged conservative care versus early surgery in patients with sciatica caused by lumbar disc herniation: two year results of a randomised controlled trial. *BMJ* 336:1355-1358. DOI 10.1136/bmj.a143
28. Katayama Y, Matsuyama Y, Yoshihara H, Sakai Y, Nakamura H, Nakashima S, Ito Z, Ishiguro N (2006) Comparison of surgical outcomes between macro discectomy and micro discectomy for lumbar disc herniation: a prospective randomized study with surgery performed by the same spine surgeon. *Journal of spinal disorders & techniques* 19:344-347. DOI 10.1097/01.bsd.0000211201.93125.1c
29. Henriksen L, Schmidt K, Eskesen V, Jantzen E (1996) A controlled study of microsurgical versus standard lumbar discectomy. *British journal of neurosurgery* 10:289-293
30. Lagarrigue J, Chaynes P (1994) [Comparative study of disk surgery with or without microscopy. A prospective study of 80 cases]. *Neuro-Chirurgie* 40:116-120
31. Waguespack A, Schofferman J, Slosar P, Reynolds J (2002) Etiology of long-term failures of lumbar spine surgery. *Pain Med* 3:18-22. DOI 10.1046/j.1526-4637.2002.02007.x
32. Pate D (1992) Failed Back Surgery Syndrome.. *Dynamic Chiropractic* 10
33. Carragee EJ, Alamin TF, Miller JL, Carragee JM (2005) Discographic, MRI and psychosocial determinants of low back pain disability and remission: a prospective study in subjects with benign persistent back pain. *The spine journal: official journal of the North American Spine Society* 5:24-35. DOI 10.1016/j.spinee.2004.05.250
34. Spengler DM, Freeman C, Westbrook R, Miller JW (1980) Low-back pain following multiple lumbar spine procedures. Failure of initial selection? *Spine* 5:356-360
35. Celestin J, Edwards RR, Jamison RN (2009) Pretreatment psychosocial variables as predictors of outcomes following lumbar surgery and spinal cord stimulation: a systematic review and literature synthesis. *Pain Med* 10:639-653. DOI 10.1111/j.1526-4637.2009.00632.x
36. Mannion AF, Elfering A (2006) Predictors of surgical outcome and their assessment. *European spine journal: official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 15 Suppl 1:S93-108. DOI 10.1007/s00586-005-1045-9
37. Trappe AE, Frank AM (1994) [Postoperative spondylodiscitis as the cause of failed-back syndrome--clinical aspects, diagnosis, therapy]. *Zentralblatt fur Neurochirurgie* 55:156-161
38. Yaksich I (1993) Failed back surgery syndrome: problems, pitfalls and prevention. *Annals of the Academy of Medicine, Singapore* 22:414-417
39. Yong-Hing K (1994) The failed back syndrome: personal opinions and experiences. *La Chirurgia degli organi di movimento* 79:131-132
40. Long DM (1991) Failed back surgery syndrome. *Neurosurgery clinics of North America* 2:899-919
41. Marchetti PG, Binazzi R, Vaccari V, De Zerbi M, Landi S (1994) Failed back syndromes: opinions and personal experiences. *La Chirurgia degli organi di movimento* 79:127-130
42. Main CJ (2000) The nature of disability. In: Waldman SD (ed) *Intervention Pain Management*. Churchill Livingstone, Edinburgh. pp. 89 -106.
43. Nachemson AL (1993) Evaluation of results in lumbar spine surgery. *Acta orthopaedica Scandinavica Supplementum* 251:130-133
44. Fritsch EW, Heisel J, Rupp S (1996) The failed back surgery syndrome - Reasons, intraoperative findings, and long-term results: A report of 182 operative treatments. *Spine* 21:626-633. DOI 10.1097/00007632-199603010-00017
45. Guyer RD, Patterson M, Ohnmeiss DD (2006) Failed back surgery syndrome: diagnostic evaluation. *The Journal of the American Academy of Orthopaedic Surgeons* 14:534-543
46. Jutte PC, Castelein RM (2002) Complications of pedicle screws in lumbar and lumbosacral fusions in 105 consecutive primary operations. *European spine journal: official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 11:594-598. DOI 10.1007/s00586-002-0469-8
47. Phillips FM, Cunningham B (2002) Managing chronic pain of spinal origin after lumbar surgery: the role of decompressive surgery. *Spine* 27:2547-2553; discussion 2554. DOI 10.1097/01.BRS.0000032128.28335.E6
48. Epstein BS, Epstein, J.A., Jones, M.D. (1997) Lumbar spinal stenosis. *Radiol Clin North Am* 15:227-239
49. Carroll SE, Wiesel SW (1992) Neurologic complications and lumbar laminectomy. A standardized approach to the multiply-operated lumbar spine. *Clinical orthopaedics and related research*:14-23
50. Ross JS, Robertson JT, Frederickson RC, Petrie JL, Obuchowski N, Modic MT, deTribolet N (1996) Association between peridural scar and recurrent radicular pain after lumbar discectomy: magnetic resonance evaluation. *ADCON-L European Study Group. Neurosurgery* 38:855-861; discussion 861-853
51. Trescot AM, Chopra P, Abdi S, Datta S, Schultz DM (2007) Systematic review of effectiveness and complications of adhesiolysis in the management of chronic spinal pain: an update. *Pain physician* 10:129-146
52. Onesti ST (2004) Failed back syndrome. *The neurologist* 10:259-264
53. Coskun E, Suzer T, Topuz O, Zencir M, Pakdemirli E, Tahta K (2000) Relationships between epidural fibrosis, pain, disability, and psychological factors after lumbar disc surgery. *European spine journal: official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 9:218-223
54. Jayson MI (1992) The role of vascular damage and fibrosis in the pathogenesis of nerve root damage. *Clinical orthopaedics and related research*:40-48

55. Schaeren S, Broger I, Jeanneret B (2008) Minimum four-year follow-up of spinal stenosis with degenerative spondylolisthesis treated with decompression and dynamic stabilization. *Spine* 33:E636-642. DOI 10.1097/BRS.0b013e31817d2435
56. Chopra P, Smith HS, Deer TR, Bowman RC (2005) Role of adhesiolysis in the management of chronic spinal pain: a systematic review of effectiveness and complications. *Pain physician* 8:87-100
57. Manchikanti L, Singh V (2002) Epidural lysis of adhesions and myelography. *Current pain and headache reports* 6:427-435
58. Kayaoglu CR, Calikoglu C, Binler S (2003) Re-operation after lumbar disc surgery: results in 85 cases. *The Journal of international medical research* 31:318-323
59. Rydevik BL (1992) The effects of compression on the physiology of nerve roots. *Journal of manipulative and physiological therapeutics* 15:62-66
60. Kumar MN, Baklanov A, Chopin D (2001) Correlation between sagittal plane changes and adjacent segment degeneration following lumbar spine fusion. *European spine journal: official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society* 10:314-319
61. Kaar GF, Briggs M, Bashir SH (1994) Thecal repair in post-surgical pseudomeningocele. *British journal of neurosurgery* 8:703-707
62. D'Andrea F, Maiuri F, Corriero G, Gambardella A, La Tessa G, Gangemi M (1985) Postoperative lumbar arachnoidal diverticula. *Surgical neurology* 23:287-290
63. Rinaldi I, Hodges TO (1970) Iatrogenic lumbar meningocele: report of three cases. *Journal of neurology, neurosurgery, and psychiatry* 33:484-492
64. Scott MR, Garfin, S.R. (2001) Recurrent lumbar disc herniation. In: Albert TJ, Vaccaro, A.R. (ed) *Master-cases: Spine Surgery*. Thieme, New York pp. 143-147.
65. Sahin N, Muslumanoglu L, Karatas O, Cakmak A, Ozcan E, Berker E (2009) Evaluation of sympathetic response in cases with failed back surgery syndrome. *Agri: Agri* 21:10-15
66. Kahanovitz N, Viola K, Gallagher M (1989) Long-term strength assessment of postoperative discectomy patients. *Spine* 14:402-403
67. Kawaguchi Y, Matsui H, Tsuji H (1994) Back muscle injury after posterior lumbar spine surgery. Part 2: Histologic and histochemical analyses in humans. *Spine* 19:2598-2602
68. Kawaguchi Y, Matsui H, Tsuji H (1996) Back muscle injury after posterior lumbar spine surgery. A histologic and enzymatic analysis. *Spine* 21:941-944
69. Gejo R, Matsui H, Kawaguchi Y, Ishihara H, Tsuji H (1999) Serial changes in trunk muscle performance after posterior lumbar surgery. *Spine* 24:1023-1028
70. Kim Y, Scott, D.B. (2008) Update on the History and Physical Evaluation of a Failed Back Surgery Syndrome. *Semin Spine Surg* 20:236-239
71. Borenstein DG, Wiesel, S.W., Boden, S.D (1995) *Low Back Pain: medical diagnosis and comprehensive management*. WB Saunders, Philadelphia.
72. Ross JS, Masaryk TJ, Schrader M, Gentili A, Bohlman H, Modic MT (1990) MR imaging of the postoperative lumbar spine: assessment with gadopentetate dimeglumine. *AJR American journal of roentgenology* 155:867-872. DOI 10.2214/ajr.155.4.2119123
73. Mok JM, Pekmezci M, Piper SL, Boyd E, Berven SH, Burch S, Deviren V, Tay B, Hu SS (2008) Use of C-reactive protein after spinal surgery: comparison with erythrocyte sedimentation rate as predictor of early postoperative infectious complications. *Spine* 33:415-421. DOI 10.1097/BRS.0b013e318163f9ee
74. Chan CW, Peng P (2011) Failed back surgery syndrome. *Pain Med* 12:577-606. DOI 10.1111/j.1526-4637.2011.01089.x
75. Skaf G, Bouclaous C, Alaraj A, Chamoun R (2005) Clinical outcome of surgical treatment of failed back surgery syndrome. *Surgical neurology* 64:483-488, discussion 488-489. DOI 10.1016/j.surneu.2005.04.009
76. Hooper PD, Haldeman, S. (2003) Mobilization, manipulation, massage, and exercise for the relief of musculoskeletal pain. In: Wall PD, Melzack, R. (ed) *Handbook of Pain Management*. Churchill Livingstone, Philadelphia, PA. pp. 485-497.
77. Walker S, Cousins MJ (1994) Failed back surgery syndrome. *Australian family physician* 23:2308-2309, 2312-2304
78. Burke SA, Harms-Constas CK, Aden PS (1994) Return to work/work retention outcomes of a functional restoration program. A multi-center, prospective study with a comparison group. *Spine* 19:1880-1885; discussion 1886
79. Jackson CP, Brown MD (1983) Is there a role for exercise in the treatment of patients with low back pain? *Clinical orthopaedics and related research*:39-45
80. Hayden JA, van Tulder MW, Malmivaara A, Koes BW (2005) Exercise therapy for treatment of non-specific low back pain. *The Cochrane database of systematic reviews*:CD000335. DOI 10.1002/14651858.CD000335.pub2
81. Hayden JA, van Tulder MW, Tomlinson G (2005) Systematic review: strategies for using exercise therapy to improve outcomes in chronic low back pain. *Annals of internal medicine* 142:776-785
82. Clare HA, Adams R, Maher CG (2004) A systematic review of efficacy of McKenzie therapy for spinal pain. *The Australian journal of physiotherapy* 50:209-216
83. Liddle SD, Baxter GD, Gracey JH (2004) Exercise and chronic low back pain: what works? *Pain* 107:176-190
84. McNeely ML, Torrance G, Magee DJ (2003) A systematic review of physiotherapy for spondylolysis and spondylolisthesis. *Manual therapy* 8:80-91
85. Machado LA, de Souza M, Ferreira PH, Ferreira ML (2006) The McKenzie method for low back pain: a systematic review of the literature with a meta-analysis approach. *Spine* 31:E254-262. DOI 10.1097/01.brs.0000214884.18502.93
86. Akuthota V, Ferreira A, Moore T, Fredericson M (2008) Core stability exercise principles. *Current sports medicine reports* 7:39-44. DOI 10.1097/01.CSMR.0000308663.13278.69
87. Choi G, Raiturker PP, Kim MJ, Chung DJ, Chae YS, Lee SH (2005) The effect of early isolated lumbar extension exercise program for patients with herniated disc undergoing lumbar discectomy. *Neurosurgery* 57:764-772; discussion 764-772
88. Dolan P, Greenfield K, Nelson RJ, Nelson IW (2000) Can exercise therapy improve the outcome of microdiscectomy? *Spine* 25:1523-1532
89. Brennan GP, Shultz BB, Hood RS, Zahniser JC, Johnson SC, Gerber AH (1994) The effects of aerobic exercise after lumbar microdiscectomy. *Spine* 19:735-739
90. Pridmore S (2002) Psychotherapy in chronic pain. In: *Managing Chronic Pain: A Biopsychosocial Approach* Dunity M, UK.
91. Shealy CN, Mortimer JT, Reswick JB (1967) Electrical inhibition of pain by stimulation of the dorsal columns: preliminary clinical report. *Anesthesia and analgesia* 46:489-491
92. Melzack R, Wall PD (1965) Pain mechanisms: a new theory. *Science* 150:971-979
93. Van Buyten J (2006) Neurostimulation for chronic neuropathic back pain in failed back surgery syndrome. *J Pain Symptom Manage* 31:25-29
94. Stojanovic MP, Abdi S (2002) Spinal cord stimulation. *Pain physician* 5:156-166
95. Wilkinson HA (2005) Injection therapy for enthesopathies causing axial spine pain and the "failed back syndrome": a single blinded, randomized and cross-over study. *Pain physician* 8:167-173

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