



The Open Pain Journal

Content list available at: <https://openpainjournal.com>



REVIEW ARTICLE

Failed Back Surgery Syndrome: An Updated Review

Abdelilah Rhoul^{1,*}, Mohammed Gartit¹, Mohammed Noumairi¹, Siham EL. Mir¹ and Ahmed Amine EL Oumri¹

¹Department of Physical Medicine and Rehabilitation, Mohammed VI University Hospital, Faculty of Medicine and Pharmacy, Mohammed Ist University, Oujda, Morocco

Abstract:

Background:

Failed Back Surgery Syndrome (FBSS) is a known condition with severe morbidity. Usually described as pain that either does not improve or worsen after back surgery. Although many possible causes leading back pain to persist after surgery were described, the exact pathology remains not elucidated and the management could be very challenging.

Objectives:

This review aims to discuss different causes of this syndrome besides the different current therapeutic approaches.

Conclusion:

A good assessment of the clinical presentation based on the history of pain and physical examination in addition to the MRI input, help to detect the cause of the persistent pain. The therapeutic options are wide, from pharmacological to interventional methods. Nevertheless, a multidisciplinary approach is frequently needed to treat FBSS patients.

Keywords: Failed back surgery syndrome, Post lumbar surgery syndrome, Persistent spinal pain, Back pain, Back surgery, Chronic pain.

Article History

Received: October 28, 2022

Revised: April 09, 2023

Accepted: May 12, 2023

1. INTRODUCTION

Failed back Surgery Syndrome (FBSS), post lumbar surgery syndrome, or, as suggested, recently persistent spinal pain, are different nominations for the same condition defined by the International Association of Study of Pain as persistent or apparent pain after back surgery with topographic localization [1]. The back or leg pain could start, get worse, or not improve well after surgery [1].

Neuropathic pain is frequently not matched with the dermatome and is characterized by its severity and continuity [2].

The studies have not identified the cause of FBSS, although many factors have been reported to play a part in this syndrome's pathogenesis [3, 4].

This review aims to discuss the different causes and the current management options of FBSS.

* Address correspondence to this author at the Department of Physical Medicine and Rehabilitation, Mohammed VI University Hospital, Faculty of Medicine and Pharmacy, Mohammed Ist University, Oujda, Morocco;
E-mail: abdelilahrhoul@gmail.com

2. ETIOLOGY

The physiopathology of FBSS remains not elucidated, but multiple factors seem to be associated with this condition [4]. These factors are frequently divided into pre, operative, and post-operative ones.

2.1. Pre-operatives Factors

Preoperative factors depend on the patient's condition. Mainly, they are psycho-social conditions: depression, anxiety, hypochondriac patients, and general health issues like obesity [5]. These factors seem to be the most associated with FBSS [5]. Furthermore, the presence of these factors does not exclude organic causes [6].

2.2. Operative Factors

Many surgical factors could lead to FBSS, poor surgical decompressions represent up to 29% of causes leading to this syndrome [7]. Furthermore, misplaced grafts and screws can lead to nerve entrapments and radiculopathy [8].

The wrong level is another surgical factor leading possibly to persistent pain. Notably, operating at the wrong level seems

to be more associated with the use of microscopic techniques due to the limited exposure [9].

2.3. Post-operative Factors

2.3.1. Recurrent Herniation

Up to 15% of patients who have had a discectomy experience recurrent disc herniations, which can occur either at the site of the operation or in the adjacent segment [10]. Recurrence rates for microdiscectomy at the same adjacent level range from 6 to 23% [11, 12].

2.3.2. Epidural Fibrosis

Epidural fibrosis (EP) is a known consequence of lumbar disc surgery, and can still form in minimally invasive interventions either [13]. Different methods have been evaluated to prevent or reduce scar production after back surgery. Karan Rajpal *et al.* conducted a randomized trial of 100 patients with prolapsed intervertebral discs. He concluded that laminectomy placement of autologous fat is more effective in preventing EP [14]. However, the follow-up was short up to 18 months, and no control group was conducted in this trial. Otherwise, suction drainage combined with or without fat grafts or local steroids also seems effective [14].

2.3.3. Adjacent Segment Disease (ASD)

ASD is a known long-term complication of spine surgery, described as a degenerative change at the spinal level adjacent to the operated spinal level or levels accompanied by related symptoms such as radiculopathy or instability [15].

Two recent meta-analyses showed that age, obesity, history of hypertension, preoperative adjacent disc degeneration, long-segment fusion, preoperative superior facet violation, high lumbosacral joint angle, pre-and post-operative L1-S1, sagittal vertical axis, post-operative lumbar lordosis, and preoperative pelvic incidence were associated with a significant increase in the incidence of ASD [16, 17].

3. ASSESSMENT AND DIAGNOSIS

FBSS patients should be assessed to discern emergencies or “red flags” such as saddle anesthesia or bowel/bladder incontinence, indicative of cauda equina syndrome; fever, chills, or weight loss indicating infection [18]. Furthermore, the timing of the pain and its localization could be very informative and helpful in the diagnosis tree. Considering this fact, a pain that occurs just right after the surgery is more likely to be related to spinal epidural hematoma especially if neurological signs are present [19].

A sudden recurrence of pain after substantial pain relief initially is the typical picture of recurrence disc herniation, the pain in this case is more likely to occur acutely [20].

Epidural fibrosis is another picture of delayed recurrence pain. Nevertheless, the pain in this condition is more likely gradual. Some physical findings may also help to distinguish epidural fibrosis patients, these later are less likely to have pain with coughing, have less restriction with ambulation, and are less likely to have pain with straight leg raise of less than 30

degrees than those with recurrent disc herniation [21].

Persistent pain after back surgery may be related to a technical error during surgery, a wrong level operation, or was a fragment of herniated disc material missed, or a piece of bone left adjacent to the nerve [9].

3.1. X-Ray

X-rays are useful for detecting vertebral and sacroiliac defects and/or misalignment and are superior to MRIs for the detection of spondylolisthesis [22]. In addition, they can evaluate the surgical site, bone alignment, and degenerative changes [22].

3.2. Magnetic Resonance Imagery (MRI)

MRI is the gold standard to assess neural and soft tissue lesions such as disc herniation or epidural fibrosis in addition to detecting inflammatory or lipomatous osseous alterations [23].

Furthermore, gadolinium-based contrast agent application was shown to be more effective than unenhanced MRI in differentiating disc herniation from epidural fibrosis at 6 months in both inter and intra-observer agreement assessment [24]. Notably, the comparison of gadolinium MRI to unenhanced MRI after 18 months did not increase agreement or confidence [24].

A frequent situation in this context is the presence of metal device implants, which could contra-indicate the realization of MRI sequences. Nevertheless, Metal Artifact Techniques (MAT) showed better soft tissue visualization with linear artifacts dropping significantly [25].

Moreover, CT-Myelography could also help overcome implant artifacts in patients with instrumented devices [26]. In addition, CT scans imaging is more accurate when evaluating bone structures and implant positioning [27].

3.3. Magnetic Resonance Neurography (MRN)

Radicular pain is frequently reported in FBSS patients; therefore, a good assessment of the nerve's structure could be helpful to determine the participation of neuropathy in patient symptoms [28]. Magnetic Resonance Neurography (MRN) could be this alternative since it provides an excellent spatial resolution and easily identifies and characterizes peripheral nerves and surrounding soft tissue [29].

MRN is a technique that enhances selective multiplanar visualization of the peripheral nerve and pathology by encompassing a combination of two-dimensional, three-dimensional, and diffusion imaging pulse sequences [30].

Reports of MRN assessment of the lumbosacral plexus in patients with radiculopathy and FBSS showed that MRN provided more corroborative image findings for symptom correlation compared to other imaging modalities leading to a significant change in diagnosis or therapeutic management [31, 32].

3.4. SPECT/CT Imaging

Another possible diagnostic tool is the combination of

single photon emission computed tomography (SPECT) and CT bone scintigraphy.

A small study of 16 patients assessing the potential usefulness of SPECT/CT in the management of patients with FBSS revealed that SPECT/CT might be an effective tool in elucidating the pain source and consequently helping therapeutic management [33].

Further high-quality studies should elucidate more on the role of SPECT/CT as a diagnostic tool in FBSS.

Conclusively, a good assessment of the patient and postoperative imaging are the main helpful tools for the physician to address the right diagnosis.

4. MANAGEMENT

Currently, there is no global consensus on managing FBSS; the diagnosis difficulties and the lack of based data represent an obstacle to the clinical effectiveness of each modality. In this chapter, we will regroup the different therapeutic approaches into conservative, mini-invasive, and aggressive ones.

4.1. Conservative and Mini-invasive Methods

4.1.1. Medications

Pharmacological therapies are the cheapest and the first therapeutic option. With a large option from anti-inflammatory steroids to opioids. Nevertheless, gabapentin has been proven to be effective in this population [34].

A recent scorpion review confirmed the beneficial effect of gabapentin in managing FBSS patients, especially when associated with leg pain [35].

4.1.2. Physical Therapies

Few studies have evaluated the effect of exercises and physiotherapy on FBSS, a randomized controlled trial reported pain improvement, especially with isokinetic programs [36].

Another controlled randomized single-blind study showed improvement in spinal pain and disability for patients undergoing immediate exercise programs after a microdiscectomy [37].

4.1.3. Interventional Therapies

Transforaminal corticosteroid injection or facet joint denervation could be considered, especially if another local pathology exists. Furthermore, these procedures could also allow patients to be more cooperative in their physical exercises and reduce medical consumption. Nevertheless, the efficacy of interlaminar or caudal epidural steroid injection is not well established in FBSS [38, 39].

A randomized, double-blind controlled trial evaluated the effectiveness of caudal epidural injections under fluoroscopy in patients with chronic back and lower extremity pain after surgical intervention [40]. The results seem encouraging, with significant improvement in pain relief and functional status. Therefore, the absence of a placebo group was the principal limitation in this trial [40].

4.1.4. Radiofrequency Therapy

A case report of 3 patients with severe back pain after back surgery reported good to reasonable pain relief in 2 patients treated with pulse radiofrequency of dorsal root ganglion at 6 months follow-up [41].

Currently, an ongoing clinical trial assessing the effect of ultrasound-guided caudal epidural pulsed radiofrequency stimulation on chronic pain in patients with FBSS NCT05062993. The results from this study should be more informative to consider this therapeutic option.

4.1.5. Ozone Therapy

Ozone therapy is a medical therapy consisting of a mixture of oxygen and ozone comprising fewer than 5% at its highest concentration. Since 1954, when Wehrli and Steinbart first described it, it has been applied to millions of patients with a variety of illnesses, apparently to their clinical advantage [42].

One pilot study evaluating the efficacy of this therapy in FBSS showed 44.0% of improvement in Oswestry Disability Index (ODI) scores after 6 months 43.7% reduction of lumbar pain, 60.9% reduction in leg pain at the same period, remarkably greater in patients with non-neuropathic predominant pain [43].

Unfortunately, the only randomized double-blinded trial evaluating the effects of Epiduroscopy and ozone therapy in patients with FBSS did not publish any results (NCT01172457).

4.2. Aggressive Methods

4.2.1. Adhesiolysis

A recent systematic analysis of findings of 4 systematic reviews reported level 1 evidence of significant pain relief [44].

Concerning epidural adhesiolysis, studies showed a superior clinical outcome in comparison with epidural steroid injections (up to 1-year follow-up) [45].

4.2.2. Neuromodulation

The International Neuromodulation Society defines neuromodulation as “the alteration of nerve activity through targeted delivery of a stimulus, such as electrical stimulation or chemical agents, to specific neurological sites in the body.” [46].

Several trials have studied the effect of this procedure in FBSS patients demonstrating its safety and favorable long-term outcomes compared with conventional medical management [47, 48].

To increase the success of neuromodulation, patients should be considered earlier in the management of FBSS [49].

Another neuromodulation treatment option is intrathecal drug delivery. Rather than relying on medication taken by mouth, this involves the placement of a catheter that delivers pain medication directly to the affected area, requiring less medication and causing fewer side effects [50].

Currently, a randomized double-blind cross-over trial of

continuous intrathecal infusion for assessing patients with chronic non-cancer pain who would benefit from treatment with intrathecal drug delivery system implant NCT03523000.

4.2.3. Reoperation

Re-decompression and fusion in FBSS showed a satisfactory outcome in selected patients and a meticulous surgical technic [51].

Other indications of reoperation are the presence of known red flags, including disabling or progressive neurological deficit, associated with bowel or bladder function impairment, cauda equina syndrome, or established spinal instability requiring reoperation [52].

Percutaneous Endoscopic Lumbar Discectomy (PELD) is a minimally invasive spinal procedure [53]. Several reports showed it was safe and effective for treating disc herniation and lumbar stenosis [54 - 56].

Moreover, a meta-analysis comparing PELD with other surgeries in the treatment of patients with lumbar disc herniation showed similar complications but with a higher recurrence rate [57].

The same results were also observed when comparing PELD with microendoscopic discectomy [58].

An RCT assessing PELD with open microdiscectomy in patients with symptomatic lumbar disc herniation is currently ongoing (NCT02602093). Results from this trial and others will determine the efficacy and costs of this surgical technique.

5. PROGNOSIS AND COMPLICATIONS

With increasing rates of spine surgery, the number of patients with FBSS has increased. Thomson *et al.* compared the demographic characteristics of the PROCESS Trial (ISRCTN 77527324) patients, with published studies of patients who have other chronic pain conditions particularly (osteoarthritis, rheumatoid arthritis, complex regional pain syndrome, and fibromyalgia). The results showed that FBSS patients exhibited lower quality of life scores and higher amounts of pain, unemployment, opioid use, and disability [59].

Additionally, increasing numbers of revision surgeries are associated with a progressively lower chance of successful pain relief [60].

CONCLUSION

The absence of a standardized diagram of the management of post-lumbar surgery syndrome is very challenging for both the patient and health providers. A very good assessment of the clinical presentation based on the history of pain and the physical examination in addition to the MRI input help to spot the cause of FBSS. Nevertheless, a multidisciplinary approach seems to be necessary to treat FBSS patients.

LIST OF ABBREVIATIONS

FBSS = Failed Back Surgery Syndrome

EP = Epidural Fibrosis
ASD = Adjacent Segment Disease

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest financial or otherwise.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

- [1] Treede RD, Rief W, Barke A, *et al.* Chronic pain as a symptom or a disease: The IASP classification of chronic pain for the international classification of diseases (ICD-11). *Pain* 2019; 160(1): 19-27. [<http://dx.doi.org/10.1097/j.pain.0000000000001384>] [PMID: 30586067]
- [2] Mohi Eldin MM, Abdel Razek NM. Epidural fibrosis after lumbar disc surgery: Prevention and outcome evaluation. *Asian Spine J* 2015; 9(3): 370-85. [<http://dx.doi.org/10.4184/asj.2015.9.3.370>] [PMID: 26097652]
- [3] Sebaaly A, Lahoud MJ, Rizkallah M, Kreichati G, Kharrat K. Etiology, evaluation, and treatment of failed back surgery syndrome. *Asian Spine J* 2018; 12(3): 574-85. [<http://dx.doi.org/10.4184/asj.2018.12.3.574>] [PMID: 29879788]
- [4] Alizadeha R. Pathogenesis, etiology and treatment of failed back surgery syndrome *Neurochirurgie* 2022; 68(4): 426-31. [<http://dx.doi.org/10.1016/j.neuchi.2021.09.005>]
- [5] Carragee EJ, Alamin TF, Miller JL, Carragee JM. Discographic, MRI and psychosocial determinants of low back pain disability and remission: a prospective study in subjects with benign persistent back pain. *Spine J* 2005; 5(1): 24-35. [<http://dx.doi.org/10.1016/j.spinee.2004.05.250>] [PMID: 15653082]
- [6] Voorhies RM, Jiang X, Thomas N. 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. *Spine J* 2007; 7(5): 516-24. [<http://dx.doi.org/10.1016/j.spinee.2006.10.013>] [PMID: 17905313]
- [7] Slipman C. Posterior joints of the lumbar spine as a potential cause of low back pain. *Pain Med* 2004; 5(3): 287-8. [<http://dx.doi.org/10.1111/j.1526-4637.2004.04045.x>] [PMID: 15367307]
- [8] Jutte PC, Castelein RM. Complications of pedicle screws in lumbar and lumbosacral fusions in 105 consecutive primary operations. *Eur Spine J* 2002; 11(6): 594-8. [<http://dx.doi.org/10.1007/s00586-002-0469-8>] [PMID: 12522719]
- [9] Chan C, Peng P. Failed back surgery syndrome. *Pain Med* 2011; 12(4): 577-606. [<http://dx.doi.org/10.1111/j.1526-4637.2011.01089.x>] [PMID: 21463472]
- [10] Carroll SE, Wiesel SW. Neurologic complications and lumbar laminectomy. A standardized approach to the multiply-operated lumbar spine. *Clin Orthop Relat Res* 1992; (284): 14-23. [PMID: 1395283]
- [11] Parker SL, Mendenhall SK, Godil SS, *et al.* Incidence of low back pain after lumbar discectomy for herniated disc and its effect on patient-reported outcomes. *Clin Orthop Relat Res* 2015; 473(6): 1988-99. [<http://dx.doi.org/10.1007/s11999-015-4193-1>] [PMID: 25694267]
- [12] Hong X, Liu L, Bao J, Shi R, Fan Y, Wu X. Characterization and risk factor analysis for reoperation after microendoscopic discectomy. *Orthopedics* 2015; 38(6): e490-6. [<http://dx.doi.org/10.3928/01477447-20150603-57>] [PMID: 26091222]
- [13] Park YK, Kim JH, Chung HS. Outcome analysis of patients after

- ligament-sparing microdiscectomy for lumbar disc herniation. *Neurosurg Focus* 2002; 13(2): 1-4. [http://dx.doi.org/10.3171/foc.2002.13.2.5] [PMID: 15916401]
- [14] Rajpal K, Singh J, Bahadur R. Postoperative epidural fibrosis prevention: Which is better—autologous fat versus gelfoam. *Asian Spine J* 2021. [PMID: 33957745]
- [15] Saavedra-Pozo FM, Deusdara RA, Benzel EC. Adjacent segment disease perspective and review of the literature. *Ochsner J* 2014; 14(1): 78-83. [PMID: 24688337]
- [16] Cannizzaro D, Anania CD, Safa A, *et al.* Lumbar adjacent segment degeneration after spinal fusion surgery. A systematic review and meta-analysis. *J Neurosurg Sci* 2022. Epub ahead of print [http://dx.doi.org/10.23736/S0390-5616.22.05891-X] [PMID: 36345970]
- [17] Wang T, Ding W. Risk factors for adjacent segment degeneration after posterior lumbar fusion surgery in treatment for degenerative lumbar disorders: a meta-analysis. *J Orthop Surg Res* 2020; 15(1): 582. [http://dx.doi.org/10.1186/s13018-020-02032-7] [PMID: 33272288]
- [18] Daniell JR, Osti OL. Failed back surgery syndrome: A review article. *Asian Spine J* 2018; 12(2): 372-9. [http://dx.doi.org/10.4184/asj.2018.12.2.372] [PMID: 29713421]
- [19] Yi S, Yoon DH, Kim KN, Kim SH, Shin HC. Postoperative spinal epidural hematoma: risk factor and clinical outcome. *Yonsei Med J* 2006; 47(3): 326-32. [http://dx.doi.org/10.3349/ymj.2006.47.3.326] [PMID: 16807981]
- [20] Swartz KR, Trost GR. Recurrent lumbar disc herniation. *Neurosurg Focus* 2003; 15(3): 1-4. [http://dx.doi.org/10.3171/foc.2003.15.3.10] [PMID: 15347228]
- [21] Jönsson B, Strömqvist B. Clinical characteristics of recurrent sciatica after lumbar discectomy. *Spine* 1996; 21(4): 500-5. [http://dx.doi.org/10.1097/00007632-199602150-00017] [PMID: 8658255]
- [22] Kizilkilic O, Yalcin O, Sen O, Aydin MV, Yildirim T, Hurcan C. The role of standing flexion-extension radiographs for spondylolisthesis following single level disk surgery. *Neuro Res* 2007; 29(6): 540-3. [http://dx.doi.org/10.1179/016164107X164166] [PMID: 17535575]
- [23] Van Goethem J, Parizel P, Jinkins J. Review Article: MRI of the postoperative lumbar spine. *Neuroradiology* 2002; 44(9): 723-39. [http://dx.doi.org/10.1007/s00234-002-0790-2] [PMID: 12221444]
- [24] Passavanti Z, Leschka S, Wildermuth S, Forster T, Dietrich TJ. Differentiating epidural fibrosis from disc herniation on contrast-enhanced and unenhanced MRI in the postoperative lumbar spine. *Skeletal Radiol* 2020; 49(11): 1819-27. [http://dx.doi.org/10.1007/s00256-020-03488-8] [PMID: 32524168]
- [25] Kotsenas AL, Michalak GJ, DeLone DR, *et al.* CT metal artifact reduction in the spine: can an iterative reconstruction technique improve visualization? *AJNR Am J Neuroradiol* 2015; 36(11): 2184-90. [http://dx.doi.org/10.3174/ajnr.A4416] [PMID: 25599844]
- [26] Patel DM, Weinberg BD, Hoch MJ. CT myelography: Clinical indications and imaging findings. *Radiographics* 2020; 40(2): 470-84. [http://dx.doi.org/10.1148/rg.2020190135] [PMID: 32058837]
- [27] Ghodasara N, Yi PH, Clark K, Fishman EK, Farshad M, Fritz J. Postoperative spinal CT: What the radiologist needs to know. *Radiographics* 2019; 39(6): 1840-61. [http://dx.doi.org/10.1148/rg.2019190050] [PMID: 31589573]
- [28] Witkam RL, Buckens CF, van Goethem JWM, Vissers KCP, Henssen DJHA. The current role and future directions of imaging in failed back surgery syndrome patients: an educational review. *Insights Imaging* 2022; 13(1): 117. [http://dx.doi.org/10.1186/s13244-022-01246-z] [PMID: 35838802]
- [29] Dessouky R, Xi Y, Scott KM, *et al.* Magnetic resonance neurography in chronic lumbosacral and pelvic pain: diagnostic and management impact-institutional audit. *World Neurosurg* 2018; 114: e77-e113. [http://dx.doi.org/10.1016/j.wneu.2018.02.072] [PMID: 29846365]
- [30] Chhabra A, Madhuranthakam AJ, Andreisek G. Magnetic resonance neurography: current perspectives and literature review. *Eur Radiol* 2018; 28(2): 698-707. [http://dx.doi.org/10.1007/s00330-017-4976-8] [PMID: 28710579]
- [31] Dessouky R, Khaleel M, Khalifa DN, Tantawy HI, Chhabra A. Magnetic resonance neurography of the lumbosacral plexus in failed back surgery syndrome. *Spine* 2018; 43(12): 839-47. [http://dx.doi.org/10.1097/BRS.0000000000002460] [PMID: 29846365]
- [32] Kim SG, Jung JY. Role of MR Neurography for evaluation of the lumbosacral plexus: A scoping review. *J Korean Soc Radiol* 2022; 83(6): 1273-85. [http://dx.doi.org/10.3348/jksr.2022.0001] [PMID: 36545407]
- [33] Huang BR, Peng BR, Pan LK, *et al.* Potential usefulness of single photon emission computed tomography/computed tomography in management of patients with failed back surgery syndrome. *J Med Imaging Health Inform* 2019; 9(7): 1386-92. [http://dx.doi.org/10.4103/JODP.JODP_10_20] [PMID: 31386922]
- [34] Khosravi MB, Azemati S, Sahmeddini MA. Gabapentin versus naproxen in the management of failed back surgery syndrome; a randomized controlled trial. *Acta Anaesthesiol Belg* 2014; 65(1): 31-7. [PMID: 24988825]
- [35] Salaria AK, Kumar V, Dagar A, Aggarwal S, Kumar P, Dhath SS. Efficacy of gabapentin in the management of failed back surgery syndrome: A scoping review of literature. *J Orthopaed Dis Traumatol* 2020; 3(2): 75-8. [http://dx.doi.org/10.4103/JODP.JODP_10_20] [PMID: 33272288]
- [36] Karahan AY, Sahin N, Baskent A. Comparison of effectiveness of different exercise programs in treatment of failed back surgery syndrome: a randomized controlled trial. *J Back Musculoskelet Rehabil* 2017; 30(1): 109-20. [http://dx.doi.org/10.3233/BMR-160722] [PMID: 28713421]
- [37] Ozkara GO, Ozgen M, Ozkara E, Armagan O, Arslantasi A, Atasoy MA. Effectiveness of physical therapy and rehabilitation programs starting immediately after lumbar disc surgery. *Turk Neurosurg* 2015; 25(3): 372-9. [http://dx.doi.org/10.5137/1019-5149.JTN.8440-13.0] [PMID: 26037176]
- [38] Devulder J. Transforaminal nerve root sleeve injection with corticosteroids, hyaluronidase, and local anesthetic in the failed back surgery syndrome. *J Spinal Disord* 1998; 11(2): 151-4. [http://dx.doi.org/10.1097/00002517-199804000-00011] [PMID: 9588473]
- [39] Manchikanti L, Singh V, Cash KA, Pampati V, Datta S. Preliminary results of a randomized, equivalence trial of fluoroscopic caudal epidural injections in managing chronic low back pain: Part 3—Post surgery syndrome. *Pain Physician* 2008; 6(11): 817-31. [http://dx.doi.org/10.36076/ppj.2008/11/817] [PMID: 19057628]
- [40] Manchikanti L, Singh V. Management of pain of post lumbar surgery syndrome: One-year results of a randomized, double-blind, active controlled trial of fluoroscopic caudal epidural injections. *Pain Physician* 2010; 13: 509-21. [http://dx.doi.org/10.36076/ppj.2010.13.509] [PMID: 20599844]
- [41] Hussain AM, Afshan G. Use of pulsed radiofrequency in failed back surgery syndrome. *J Coll Physicians Surg Pak* 2007; 17(6): 353-5. [PMID: 17623586]
- [42] Atroschi F, Ed. *Pharmacology and nutritional intervention in the treatment of disease*. IntechOpen 2014. [http://dx.doi.org/10.5772/57023] [PMID: 24259984]
- [43] Magalhães FN, Soares SC, Torres JM, *et al.* Effects of ozone applied by spinal endoscopy in patients with chronic pain related to failed back surgery syndrome: a pilot study. *Neuropsychiatr Dis Treat* 2013; 9: 1759-66. [http://dx.doi.org/10.36076/ppj/2019.22.307] [PMID: 31337160]
- [44] Manchikanti L, Soin A, Boswell MV, Kaye AD, Sanapati M, Hirsch JA. Effectiveness of percutaneous adhesiolysis in post lumbar surgery syndrome: A systematic analysis of findings of systematic reviews. *Pain Physician* 2019; 22(4): 307-22. [http://dx.doi.org/10.36076/ppj/2019.22.307] [PMID: 31337160]
- [45] Manchikanti L, Singh V, Cash KA, Pampati V. Assessment of effectiveness of percutaneous adhesiolysis and caudal epidural injections in managing post lumbar surgery syndrome: 2-year follow-up of a randomized, controlled trial. *J Pain Res* 2012; 5: 597-608. [http://dx.doi.org/10.2147/JPR.S38999] [PMID: 23293536]
- [46] Neuromodulation, or neuromodulatory effect 2018. <https://www.neuromodulation.com/neuromodulation-defined>
- [47] Kumar K, Taylor RS, Jacques L, *et al.* Spinal cord stimulation versus conventional medical management for neuropathic pain: a multicentre randomised controlled trial in patients with failed back surgery syndrome. *Pain* 2007; 132(1): 179-88. [http://dx.doi.org/10.1016/j.pain.2007.07.028] [PMID: 17845835]
- [48] Kumar K, Taylor RS, Jacques L, *et al.* The effects of spinal cord stimulation in neuropathic pain are sustained. *Neurosurgery* 2008; 63(4): 762-70. [http://dx.doi.org/10.1227/01.NEU.0000325731.46702.D9] [PMID: 17845835]
- [49] Kumar K, Hunter G, Demeria D. Spinal cord stimulation in treatment of chronic benign pain: challenges in treatment planning and present status, a 22-year experience. *Neurosurgery* 2006; 58(3): 481-96. [http://dx.doi.org/10.1227/01.NEU.0000192162.99567.96] [PMID: 16807981]

- 16528188]
- [50] Galica RJ, Hayek SM, Veizi E, *et al.* Intrathecal trialing of continuous infusion combination therapy with hydromorphone and bupivacaine in failed back surgery patients. *Neuromodulation* 2018; 21(7): 648-54. [http://dx.doi.org/10.1111/ner.12737] [PMID: 29206315]
- [51] Biondi J, Greenberg BJ. Redecompression and fusion in failed back syndrome patients. *J Spinal Disord* 1990; 3(4): 362-9. [PMID: 2151992]
- [52] Hussain A, Erdek M. Interventional pain management for failed back surgery syndrome. *Pain Pract* 2014; 14(1): 64-78. [http://dx.doi.org/10.1111/papr.12035] [PMID: 23374545]
- [53] Pan M, Li Q, Li S, *et al.* Percutaneous endoscopic lumbar discectomy: Indications and complications. *Pain Physician* 2020; 23(1): 49-56. [PMID: 32013278]
- [54] Shen SC, Chen HC, Tsou HK, *et al.* Percutaneous endoscopic lumbar discectomy for L5-S1 disc herniation based on image analysis and clinical findings: A retrospective review of 345 cases. *Medicine (Baltimore)* 2023; 102(5)e32832 [http://dx.doi.org/10.1097/MD.00000000000032832] [PMID: 36749265]
- [55] Liang J, Lian L, Liang S, *et al.* Efficacy and complications of unilateral biportal endoscopic spinal surgery for lumbar spinal stenosis: a meta-analysis and systematic review. *World Neurosurg* 2022; 159: e91-e102. [http://dx.doi.org/10.1016/j.wneu.2021.12.005] [PMID: 34890849]
- [56] Hwa Eum J, Hwa Heo D, Son SK, Park CK. Percutaneous biportal endoscopic decompression for lumbar spinal stenosis: a technical note and preliminary clinical results. *J Neurosurg Spine* 2016; 24(4): 602-7. [http://dx.doi.org/10.3171/2015.7.SPINE15304] [PMID: 26722954]
- [57] Bai X, Lian Y, Wang J, *et al.* Percutaneous endoscopic lumbar discectomy compared with other surgeries for lumbar disc herniation. *Medicine (Baltimore)* 2021; 100(9)e24747 [http://dx.doi.org/10.1097/MD.00000000000024747] [PMID: 33655938]
- [58] Shi R, Wang F, Hong X, *et al.* Comparison of percutaneous endoscopic lumbar discectomy versus microendoscopic discectomy for the treatment of lumbar disc herniation: a meta-analysis. *Int Orthop* 2019; 43(4): 923-37. [http://dx.doi.org/10.1007/s00264-018-4253-8] [PMID: 30547214]
- [59] Thomson S, Jacques L. Demographic characteristics of patients with severe neuropathic pain secondary to failed back surgery syndrome. *Pain Pract* 2009; 9(3): 206-15. [http://dx.doi.org/10.1111/j.1533-2500.2009.00276.x] [PMID: 19281499]
- [60] Nachemson AL. Evaluation of results in lumbar spine surgery. *Acta Orthop Scand* 1993; 64(sup251): 130-3. [http://dx.doi.org/10.3109/17453679309160143] [PMID: 8451971]