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Surgical Outcome of "Neurogenic Claudication and Walking Limitation" due to Degenerative Lumbar Spinal Canal Stenosis

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Abstract

Objectives: This study aimed to evaluate the efficacy of surgical decompression of the lumbar spinal canal, a procedure involving the removal of ligamentum and other degenerated elements causing pressure on the thecal sac, nerve roots, and neurovascular structures. The procedure is considered essential for patients experiencing neurogenic claudication, low back pain, lower limb pain and paresthesia, and decreased walking performance, to effectively decompress the lumbar canal.

Methods: A retrospective analysis was conducted on patients who underwent surgical decompression at Shar hospital between 2018 and 2020. A total of 57 eligible patients were followed up to assess the outcomes related to neurogenic claudication and walking ability after 12–24 months postoperatively.

Results: The postoperative results for neurogenic claudication and walking ability were found to be satisfactory in nearly three-quarters of the cases. The duration of symptoms significantly influenced the results, while factors such as gender, body mass index, smoking history, the number of stenosed levels operated, and the type of stenosis did not show significant impact.

Conclusion: Surgical decompression for degenerative lumbar canal stenosis is a relatively low-risk procedure with a very high rate of postoperative patient satisfaction regarding neurogenic claudication and improved walking distance. These positive outcomes are particularly evident when the procedure is performed promptly, by an experienced surgeon, and with appropriate patient selection.

Keywords: Degenerative stenosis, interlaminar decompression, neurogenic claudication

Introduction

Degenerative stenosis of lumbar spine is a significant cause of functional disability, and one of the most common acquired diseases of the spinal canal, more among aged population.[1,2]

Elderly population are the most prone class of community at risk of developing significant lumbar canal stenosis and undergoing surgical decompression.[3–5]

Spinal stenosis may be classified by either its etiology or location, etiologically the lumbar spinal stenosis (LSS) is classified as acquired (degenerative) or congenital (developmental), In general, lumbar canal stenosis mostly is an acquired degenerative disease leading to a narrow spinal canal, lateral recess, and intervertebral foraminal stenosis.[6–8]

Stenosis of the lumbar spinal canal and pressure on the neurovascular elements can be due to buckled or hypertrophied ligamentum flavum, with or without hypertrophied facet joints.[9–11]

The most common symptoms in cases of lumbar canal stenosis are pain and paresthesia of the lower limbs and back ache, followed by neurogenic claudication, these complains are generally depend on the position and posture of the patients, for example the symptoms worsen by bending backwards (lumbar extension) or weight-bearing, and they relief by bending forwards and non-weight bearing body positions.[12–15]

Neurogenic claudication, is a common presentation of patients with LSS, it is defined as barely localized neurologic origin of a noxious sensation, paresthesia, and cramping of lower limbs, which may be unilateral or bilateral, it occurs with ambulation and gets better by sitting, walking distance could be significantly decreased and limited due to neurogenic claudication.[16–19]

The exact cause of neurogenic claudication is not clear, but vascular cause has been hypothesized (related to pressure on the venules surrounding the nerve roots, leading to engorgement and ischemic nerve impairment).[6,19,20]

While others claimed that mechanical compression as the pathoanatomic process underlying the neurogenic claudication.[21,22]

Findings of reduced epidural pressure measurements and improved walking tolerance in patients with LSS while walking with a flexed lumbar spine support a mechanical mechanism.[22–24]

Neurogenic claudication must be distinguished from vascular claudication, by its being continuous while the patient stopped walking but still standing erectly, and neurogenic claudication can be triggered by prolonged standing alone, and gets better with flexion and siting positions.[25,26]

Neurogenic claudication usually is not triggered by walking uphill and bicycling, while vascular claudication may occur in those situations.[27]

Plain lumbosacral spine X-ray (anterior-posterior and Lateral views) may help little, in suspecting LSS.[28,29]

Computed tomographic (CT) scans may show narrowing of the lumbosacral spinal canal, trefoil shape of the canal, partial or total loss of epidural fat, marked reduction of bony canal dimensions may be showed on CT-scan, more over the degenerative, and destructive changes of the facet joints.[30,31]

Myelography can help to diagnose LSS by showing obstruction to the flow of the contrast in the lumbar spinal canal.[28,29]

Magnetic Resonance Imaging is the most promising imaging modality to confirm anatomic narrowing of the spinal canal and identifying pressure on the neurovascular structures, and there by diagnose the LSS.[31,32]

Patients with severe symptoms usually fail to respond for non-surgical managements, and the progressive degenerative stenosis will cause more compression by time causing intolerable symptoms and failure of conservative therapy up to 60% of the cases.[12,18,33,34]

Surgical decompression is the gold standard for patients with disabling symptoms and signs of lumbar canal stenosis, with correlated radiologically detected "severely compromised lumbar canal", and whom failed to respond to optimal conservative treatment.[5,6]

Different decompression procedures and techniques used, including complete laminectomy, interlaminar decompression, Laminartherectomy, Bilateral decompression through bilateral or unilateral laminotomy, and endoscopic decompression.[5,35–38]

Patients and Methods

This is a retrospective single center study of 57 patients, 13 males and 44 females with lumbar spinal canal stenosis, with age ranging from 34 to 85 years, conducted in Sulaymaniyah university teaching hospital/Shar hospital, Department of neurosurgery, between March. 2018 to March. 2020, after obtaining clearance from the institutional ethical committee.

Patients who were diagnosed as LSS and were surgical candidates, involved in our study, for all patients, preoperatively patient's ID recorded; Age, Gender, occupation, and residency, then patients asked for history of smoking, their Body mass index before operation, their chief complain (Back ache, lower limbs pain or paresthesia, and limited walking distance) and the duration of their symptoms, and any other patients' comorbidities; like Diabetes mellitus, Hypertension, or any other chronic illness, were asked and recorded.

After that Oswestry disability index form filled for all patients, and ranking their disability form 0–20 which is minimal disability to 81–100 which is bed bound and severely disabled.

Neurological examination performed for all patients, with (Motor function of the limbs, Sensory examination, tone of the lower extremities, lower limbs' reflexes and Sphincters' function) all taken into consideration, and the diagnosis were made by plain lumbosacral spine x-ray, CT scan in selected cases (if a boney pathology, like fracture, suspected) and magnetic resonance imaging (MRI).

MRI axial images used to categorize the severity of stenosis according to Schizas classification.

Patient were asked if they tried prior trail of conservative (non-surgical) mode of treatment, like medications, physiotherapy, ESI and tradition non-scientific manipulations (tried by some of the patients as alternative medicine).

The decision for surgical treatment was taken according to one or more of following criteria:

Patients with intractable low back pain and lower limbs radiculopathy.
Neurogenic claudication significantly reducing the patients' quality of life.
Neurological deficits. Failure of different non-surgical therapies.

Interlaminar decompression done for all patients by senior neurosurgeon, after the informed Consent taken from every patient, and any intra-operative event, like incidental iatrogenic dural tear, or nerve root injury were recorded if happened, and whether they repaired intra-operatively or not, to correlate those events with adverse outcomes, CSF leak, infection and not relieving or worsening of pre-operative symptoms and signs.

All patients received perioperative one dose intravenous 3rd generation cephalosporin antibiotic prophylaxis and repeated as required postoperatively, and they discharged the day after surgery, after instructing them for post-operative rehabilitation.

Post operatively, lately after 12–24 months, patients contacted via phone calls, and been asked for their walking performance in terms of (walking period) and their level of satisfaction regarding pre operative neurogenic claudication.

Patients included in our study were those cases with only the diagnoses of acquired lumbar spinal stenosis (due to thickened ligamentum) with or without hypertrophied facet joints, regardless of the number of levels been stenosed, and those who subsequently underwent surgical decompression between 2018 and 2019 in our hospital.

Excluded cases were: Patients with other concomitant lumbar canal pathologies (Herniated lumbar disc HLD), patients who underwent simultaneous lumbar discectomies at the same level or in a deferent level of spine, patients with fractured pars inter-articularis, and spondylolisthesis, patients with significant kyphosis and/or scoliosis (who required surgical intervention for correction), patients with congenital stenosis, and stenosis due to neoplastic or inflammatory diseases, and patients with missed or insufficient surgical data, were all excluded in our study.

The collected data analyzed to answer three main questions, the first question was (Surgical outcome of lower limbs radiculopathy due to degenerative lumbar canal stenosis, 12–24 months after decompression) and published as a separate paper in Iraq Medical Journal IMJ.

This paper formed from the second main question (Surgical outcome of "Neurogenic claudication and walking limitation" due to degenerative Lumbar spinal canal stenosis.

The third main question is (quality of life in patients with degenerative lumbar canal stenosis 12–24 months after surgical decompression) that will constitute a different paper.

Results

In this retrospective cohort study, totally 57 patients with degenerative lumbar canal stenosis (due to ligamentum flavum hypertrophy) were included, male (26%) and female (74%), Figure 1, age of the cases were between 34–85 years, mean 57.39 and median 57 and standard deviation 10.96, chief complain of patients were back pain and both lower limbs radiculopathy in (71.9%, $n = 41$) of cases, back pain with only right side lower limb radiculopathy (12.3%, $n = 7$), back pain with only left lower limb radiculopathy (12.3%, $n = 7$), and in (3.5%, $n = 2$) patients the chief complain was only lower limbs radiculopathy without back pain, Most of our cases were non-smokers (82.5%, $n = 47$), chronic smokers (8.5%, $n = 5$ cases), ex-Smokers (8.5%, $n = 5$) cases.

Patients' level of satisfaction and functional outcome in terms of Neurogenic claudication and Walking period were very high after interlaminar decompression, pre-operatively (96.5%, $n = 55$) cases were having neurogenic claudication,

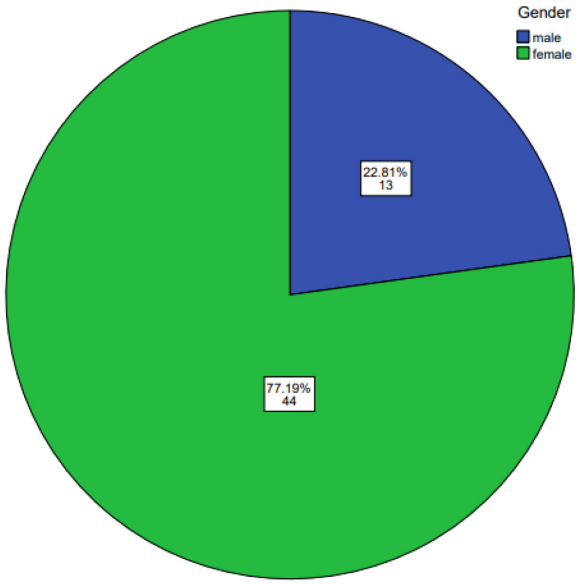

Fig. 1 **Showing male to female ratio of our cases.**

Table 1. **Neurogenic claudication**

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No	2	3.5	3.5	3.5
	Yes	55	96.5	96.5	100.0
	Total	57	100.0	100.0	

Table 2. **Post op neurogenic claudication**

		Frequency	Percent	Valid percent	Cumulative percent
Valid	No post operative neurogenic claudication	40	70.2	70.2	70.2
	Still there is remaining NC but better than pre-op	1	1.8	1.8	71.9
	Yes, there is NC same as pre-op	16	28.1	28.1	100.0
	Total	57	100.0	100.0	

and only (3.5%, n = 2) cases had no neurogenic claudication, Table 1.

But 12–24 months after surgical after surgical decompression, (70.2%, n = 40) cases had absolutely no neurogenic claudication, while (28.1%, n = 16) cases were still complaining of neurogenic claudication even after successful neurovascular decompression but to a lesser intensity than pre-operatively, Table 2.

On the other side, for walking period, (64.9%, n = 37 cases) were having sever limitation of walking ability, and they were able to walk <5 minutes, (29.8%, n = 7) patients were able to continue walking between 6–30 minutes and only (5.3%, n = 3) cases were having no limited walking period, Table 3.

But a dramatic improvement seen in walking period of patients after lumbar canal decompression, to become unlimited in (78.9%, n = 45) cases, and (19.3%, n = 11) cases became able to walk between (5–30 minutes), while only (1.8%, n = 1) case was still unable to walk more than 5 minutes, 12–24 months after the inter-laminar decompression, Table 4.

Predictors of Outcome

Patients who were included in our study were asked pre-operatively for their: Body mass index, smoking history, Duration of their symptoms, trial of conservative treatment before operation, and whether they had Systemic co-morbidities (like Diabetes mellitus, Hypertension, Hyperlipidemia and Ischemic heart disease), they were also assessed radiologically for the number of levels been stenosed (single level or multiple?) and then qualitative MRI classification of the stenosed level/levels (Schizas classification) taken into consideration, all of the above parameters measured and documented pre-operatively to evaluate their influence on the functional outcome of the patients.

Pre-operatively prolonged symptoms adversely affected the outcome in terms of remaining neurogenic claudication and post operatively low performance of walking, those with shorter history of symptoms pre-operatively had better results, Tables 5 and 6.

On the other hand; systemic comorbidities, number of stenosed levels (single versus multiple level), Type of stenosis according Schizas' classification (Type C versus Type D), History of smoking and Body mass index, none of the found to have significant influence on the outcome, since the results of normal body weight index and over weighted patients statistically revealed no significant difference.

Table 3. **Walking period before the operation**

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Less than 5 min	37	64.9	64.9	64.9
	6–30 min	17	29.8	29.8	94.7
	Unlimited	3	5.3	5.3	100.0
	Total	57	100.0	100.0	

Table 4. **Post op walking period**

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Less than 5 min	1	1.8	1.8	1.8
	5–30 min	11	19.3	19.3	21.1
	Unlimited	45	78.9	78.9	100.0
	Total	57	100.0	100.0	

Table 5. **Influence of pre-operative symptom duration on post-operative neurogenic claudication**

		Post op neurogenic claudication			
		No post operative neurogenic claudication	Still there is remaining NC but better than pre-op	Yes, there is NC same as pre-op	Total
Duration of symptoms	Less than 3 months	6	0	2	8
	3 months–12 months	1	0	3	4
	More than 1 year	33	1	11	45
Total		40	1	16	57

Table 6. **Relationship between pre-operative symptom duration and post-operative walking performance**

		Post op walking period			
		Less than 5 min	5–30 min	Unlimited	Total
Duration of symptoms	Less than 3 months	0	2	6	8
	3 months–12 months	0	1	3	4
	More than 1 year	1	8	36	45
Total		1	11	45	57

Discussion

The study revealed a clear female predominance among cases underwent surgical intervention over male gender, but there was no difference between the two genders in the functional outcome and level of satisfaction in terms of post operative walking distance, OD score, neurogenic claudication, lower limbs radiculopathy, numbness and paresthesia, Elisabeth Thornes et al., in their prospective Cohort Study revealed the same outcomes and claimed no gender influences on the outcome.[39] and Shay Shabat et al., also stated in their study that gender differences had no influence on patients' satisfaction rates in lumbar spinal stenosis surgery.[40]

Most of our cases were nonsmokers 82.5%, and 8.5% were chronic smokers, while 8.5% were Ex-Smokers, however our study didn't reveal any significant correlation between smoking and post operative functional outcome, there was no different between smokers, non-smokers, and ex-smokers in terms post-operative radiculopathy and paresthesia of the lower limbs, neurogenic claudication, post operative walking period and post operative quality of life (measured by OD Score), and this result was almost the same as the outcomes of the two studies conducted by Shaun Previn Appaduray et al., and the other by Martin N. Stienen et al., they found that no relation between smoking and good or unfavorable outcomes.[41,42]

In general, we detected a high level of satisfaction post-operatively in terms of neurogenic claudication and Walking period among our cases, those two symptoms achieved the most significant improvement after interlaminar decompression, walking period to become unlimited in 78.9%, and neurogenic claudication resolved totally post operatively in 70.2% of cases, these results were almost the same as the findings of the two studies: of them by C. M. Prasad et al., and the other by: Yukawa et al., who found a high level of satisfaction for neurogenic claudication and walking period post operatively in lumbar spinal canal decompression.[43,44]

Shorter duration of symptoms pre-operatively, associated with better outcomes post-operatively in our study, this was also noted by Leslie C. L. Ng et al., who found prolonged duration of symptoms is associated with a less favourable outcome in their study.[45]

Conclusion

Interlaminar decompression is a relatively safe and effective surgical technique for release of stenosed lumbar spinal canal, and to liberate the neurovascular contents of the canal, patient with significant impingement of lumbar canal due to thickened ligamentum flavum can be offered surgical intervention with expected good results, which can significantly improve patients' quality of life by boosting post operative walking period, resolving neurogenic claudication, reducing ODI and satisfying a great proportion of cases in terms of eliminating or reducing lower limbs radiculopathy, numbness and paresthesia post operatively.

The functional outcome; in terms of post operative walking distance and elimination of neurogenic claudication are influenced by: duration of symptoms before operation, while the results are not affected by age, gender, history of smoking, trial of conservative treatment prior to surgery, and body mass index before operation.

References

1. Dilip K. Sengupta, MD; Harry N. Herkowitz, MD. Lumbar spinal stenosis Treatment strategies and indications for surgery. Orthop Clin N Am 34 (2003) 281–295.
2. Judith A. Turner, Mary Ersek Mn., Larry Herron, et al. Surgery for lumbar spinal stenosis, attempted meta-analysis of the literature. Spine. Volume 17. Number 1. 1992, 1–8.
3. Leonid Kalichman, Robert Cole, David H. Kim, et al. Spinal stenosis prevalence and association with symptoms: the Framingham Study. The Spine Journal 9 (2009) 545–550.
4. Ai-Min Wu, Fei Zou, Yong Cao, et al. Lumbar spinal stenosis: an update on the epidemiology, diagnosis and treatment. AME Medical Journal, (2) 2017, p. 63.

5. Robert Gunzburg, Marek Szpalski. The conservative surgical treatment of lumbar spinal stenosis in the elderly. Eur Spine J (2003) 12 (Suppl. 2): S176–S180.
6. Jeffrey N. Katz, and Mitchel B. Harris. Lumbar Spinal Stenosis. N Engl J Med 2008; 358:818–25.
7. Avraam Ploumis, Ensor E. Transfledt, Francis Denis. Review Article Degenerative lumbar scoliosis associated with spinal stenosis. The Spine Journal 7 (2007) 428–436.
8. Christy C. Tomkins-Lanea, Michele C. Battiéb, Richard Hu, et al. Pathoanatomical characteristics of clinical lumbar spinal stenosis. Journal of Back and Musculoskeletal Rehabilitation 27 (2014) 223–229.
9. Tom Amundsen, Henrik Weber, Finn Lilleas, et al. Lumbar spinal stenosis: clinical and radiological features. Spine. Volume 20. Number 10. pp. 1178–1186. 1995.
10. Janan Abbas, Kamal Hamoud, Youssef M. Masharawi, et al. Ligamentum Flavum Thickness in Normal and Stenotic Lumbar Spines. Spine Volume 35, Number 12, pp. 1225–1230, 2010.
11. Naime Altinkaya, Tulin Yildirim, Senay Demir, et al. Factors Associated with the Thickness of the Ligamentum Flavum: is Ligamentum Flavum Thickening due to Hypertrophy or Buckling?. Spine Volume 36, Number 16, pp. E1093–E1097, 2011.
12. Jeffrey N. Katz, Stephen J. Lipson, Gregory W. Brick, et al. Clinical correlates of patient satisfaction after laminectomy for degenerative lumbar spinal stenosis. Spine. Volume 20. Number 10. pp. 1155–1160. 1995.
13. L Penning MD. Functional pathology of lumbar spinal stenosis; Review paper. Clinical Biomechanics 1992; 7: 3–17.
14. L. Penning, J. T. Wilmink. Poster-dependent bilateral compression of L4 or L5 nerve roots in facet hypertrophy; a dynamic CT-myelography study. Spine. Volume 12. Number 5. 1987.
15. Ehud Arbit, and Susan Pannullo. Lumbar Stenosis a Clinical Review. Clinical Orthopaedics and Related Research. Number 384, pp. 137–143, 2001.
16. Evelien I. T. de Schepper, Gijsbert M. Overdevest, Pradeep Suri, et al. Diagnosis of Lumbar Spinal Stenosis an Updated Systematic Review of the Accuracy of Diagnostic Tests. Spine Volume 38, Number 8, pp. E469–E481, 2013.
17. J. N. Blau, Valentine Logue. The natural history of intermittent claudication of the cauda equina. A long-term follow-up study. Brain (1978), 101, 211–222.
18. Rajendra Nath, Sanjay Middha, Anil Kumar, et al. Functional outcome of surgical management of degenerative lumbar canal stenosis. Indian Journal of Orthopaedics, May 2012, Vol. 46, Issue 3, 285–290.
19. Jeffrey N. Katz, Marianne Dalgas, Gerold Stucki, et al. Degenerative Lumbar Spinal Stenosis. Diagnostic Value of the History and Physical Examination. ARTHRITIS & RHEUMATISM Vol. 38, No. 9, September 1995, pp. 1236–1241.
20. Kjell Olmarker, Bjorn Rydevik, Sten Holm, et al. Effects of Experimental Graded Compression on Blood Flow in Spinal Nerve Roots. A Vital Microscopic Study on the Porcine Cauda Equina. Journal of Orthopaedic Research 7:817–823 Raven Press, Ltd., New York, 1989.
21. Ehud Arbit, and Susan Pannullo. Lumbar Stenosis: a Clinical Review. Clinical Orthopaedics and Related Research. Number 384, pp. 137–143, 2001.
22. Keisuke Takahashi, Kenji Kagechika, Tetsuya Takino, et al. Changes in epidural pressure during walking in patients with lumbar spinal stenosis. Spine Volume 20, Number 24, pp. 2746–2749, 1995.
23. Gx. Dong, R. W. Porter. Walking and cycling tests in neurogenic and intermittent claudication. Spine. Volume 14. Number 9. 1989, 965–969.
24. Shigeru Kobayashi. Pathophysiology, diagnosis and treatment of intermittent claudication in patients with lumbar canal stenosis. World J Orthop. 2014 April 18; 5(2): 134–145.
25. Stephen Hall, John D. Bartleson, Burton M. Onofrio, et al. Lumbar Spinal Stenosis Clinical Features, Diagnostic Procedures, and Results of Surgical Treatment in 68 Patients. Annals of Internal Medicine. 1985; 103:271–275.
26. P. Gopinathan. Lumbar spinal canal stenosis-special features. Journal of Orthopaedics 12 (2015) 123–125.
27. Peter Cowley, BA Oxon. Neuroimaging of Spinal Canal Stenosis. Magn Reson Imaging Clin N Am 24 (2016) 523–539.
28. Hazim M. El-Nagdi, Amer A. Tantawy, Ihab M. Said. Diagnostic value of plain radiography and myelography in lumbar canal stenosis. Benha M.J. Volume 10. Number 2. May. 1993, 109–120.
29. Scott D. Boden, and Sam W. Wiesel. Lumbar Spine Imaging: Role in Clinical Decision Making. Journal of Am. Acad. Orthop. Surg 1996; 4:238–248.
30. Nils S. R. Schonstrom, Nicole-Francoise Bolender, Dan M. Spengler. The pathomorphology of spinal stenosis as seen on CT scans of the lumbar spine. Spine. Volume 10. Number 9. 1985, 806–11.
31. J. Roulleau and J. Guillaume (Toulouse). Plain X-Ray Diagnosis of Developmental Narrow Lumbar Canal. A. Wackenheim et al., The Narrow Lumbar Canal. Springer-Verlag Berlin Heidelberg 1980, pp. 11–21.
32. Constantin Schizas, Nicolas Theumann, Alexandre Burn, et al. Qualitative Grading of Severity of Lumbar Spinal Stenosis Based on the Morphology of the Dural Sac on Magnetic Resonance Images. SPINE Volume 35, Number 21, pp. 1919–1924, 2010.
33. James N. Weinstein, Tor D. Tosteson, Jon D. Lurie, et al. Surgical Versus Nonoperative Treatment for Lumbar Spinal Stenosis Four-Year Results of the Spine Patient Outcomes Research Trial. SPINE Volume 35, Number 14, pp. 1329–1338, 2010.
34. Steven J. Atlas, Robert B. Keller, Yen A. Wu, et al. Long-Term Outcomes of Surgical and Nonsurgical Management of Lumbar Spinal Stenosis: 8 to 10 Year Results from the Maine Lumbar Spine Study. SPINE Volume 30, Number 8, pp. 936–943, 2005.
35. Poletti, Charles E. Central Lumbar Stenosis Caused by Ligamentum Flavum: Unilateral Laminotomy for Bilateral Ligamentectomy: Preliminary Report of Two Cases. Neurosurgery 37; 343–347, 1995.
36. Nancy E. Epstein. Decompression in the surgical management of degenerative spondylolisthesis: Advantages of conservative approach in 290 patients. Journal of Spinal Disorders, Volume 11. Number 2. PP. 116–122, 1998.
37. Manucher J. Javid, Eldad J. Hadar. Long-term follow-up review of patients who underwent laminectomy for lumbar stenosis: a prospective study. Journal of Neurosurg. Volume 89. July, 1998, 1–7.
38. Shunji Tsutsui, Ryohei Kagotani, Hiroshi Yamada, et al. Can decompression surgery relieve low back pain in patients with lumbar spinal stenosis combined with degenerative lumbar scoliosis? Eur Spine J. 2013;22(9): 2010–2014.
39. Elisabeth Thornes, Nikolaos Ikonomou, and Margreth Grotle. Prognosis of Surgical Treatment for Degenerative Lumbar Spinal Stenosis: A Prospective Cohort Study of Clinical Outcomes and Health-Related Quality of Life Across Gender and Age Groups. Open Orthop J. 2011; 5: 372–378.
40. Shay Shabat, Yoram Folman, Zeev Arinzon, et al. Gender differences as an influence on patients' satisfaction rates in spinal surgery of elderly patients. Eur Spine J (2005) 14: 1027–1032.
41. Martin N. Stienena, Holger Joswiga, Nicolas R. Smoll, et al. Short- and long-term effects of smoking on pain and health-related quality of life after non-instrumented lumbar spine surgery. Clinical Neurology and Neurosurgery 142 (2016) 87–92.
42. Shaun Previn Appadurai, Patrick Lo. Effects of diabetes and smoking on lumbar spinal surgery outcomes. Journal of Clinical Neuroscience 20 (2013) 1713–1717.
43. B. C. M. Prasad, VV Ramesh Chandra, B Vijayalakshmi Devi, et al. Clinical, radiological, and functional evaluation of surgical treatment in degenerative lumbar canal stenosis. Neurol India 2016; 64:677-683.
44. Yukawa, Yasutsugu MD, Lawrence G. MD et al. A Comprehensive Study of Patients with Surgically Treated Lumbar Spinal Stenosis with Neurogenic Claudication. The Journal of Bone & Joint Surgery: November 2002 - Volume 84 - Issue 11 - p 1954–1959.
45. Leslie C. L. Ng, Suhayl Tafazal, and Philip Sell. The effect of duration of symptoms on standard outcome measures in the surgical treatment of spinal stenosis. Eur Spine J (2007) 16: 199–206.