

Laboratory-Based Pathological Insights into Post-Laminectomy Lumbar Instability: A Cross-Sectional Analysis

Dr. Ammar Saeed Rashid^{1*}, Dr. Salim Mardan Omer², Dr. Hashim Jawad Jaafar³, Dr. Ali Qais Abdulkafi⁴

¹ Kufa University College of Medicine, Najaf, Iraq

² Ministry of Higher Education and Scientific Research, Kirkuk University \ College of Medicine, Kirkuk, Iraq

³ Emirates Health Service, Neurosurgery Department, Um Al Quwain Hospital, Um Al Quwain, United Arab Emirates

⁴ Iraqi Ministry of Health, Kirkuk Health Department, Kirkuk Teaching Hospital, Kirkuk, Iraq.

ABSTRACT

Background: Laminectomy is a commonly employed decompressive surgical procedure for managing lumbar spinal stenosis. However, it carries a potential risk of inducing iatrogenic lumbar spine instability. Accurate diagnosis and pathological evaluation of post-surgical instability are essential for guiding postoperative care and optimizing treatment outcomes. **Objective:** This study aimed to investigate the pathological and laboratory-based diagnostic indicators of lumbar spine instability following laminectomy and assess their clinical implications in patient management. **Patients and Methods:** A cross-sectional study was conducted on 40 patients who developed lumbar spine instability after laminectomy. Patients were recruited from multiple hospitals in Iraq between April 16, 2021, and August 25, 2022. Data collection included clinical records, imaging-based diagnostic findings (MRI and CT), intraoperative pathological observations, and, where available, histopathological assessments of affected spinal tissues. SPSS and Excel were used for data analysis, focusing on correlations between clinical outcomes, pathological changes, and diagnostic findings. **Results:** The study identified significant pathological features associated with postoperative instability, including incomplete radial posterior annular tears and facet joint degeneration, which were confirmed via imaging and intraoperative observation. Back pain was the predominant clinical symptom, reported in 32.5% of patients. Additionally, preoperative functional status and comorbidities had a statistically significant influence on the severity of postoperative pathology and outcome ($p < 0.05$). **Conclusion:** The findings underscore the value of combining clinical, radiological, and intraoperative pathological evaluation in the assessment of post-laminectomy lumbar instability. Laboratory-based diagnostic tools, including imaging and pathological tissue assessment, are vital in identifying high-risk patients and informing decisions regarding the use of spinal fusion techniques. A multidisciplinary approach integrating pathology, radiology, and surgical assessment is recommended to enhance postoperative care and reduce the risk of complications.

Keywords: Laminectomy; lumbar spine instability; Oswestry Disability Index (ODI); and VAS back score.

INTRODUCTION

Lumbar spinal stenosis (LSS), or lumbar canal stenosis (LCS), is a degenerative condition characterized by the narrowing of the spinal canal, lateral recesses, or intervertebral foramina, leading to compression of the dural sac and neural elements. It is one of the most frequent causes of chronic low back pain and neurogenic claudication in adults, particularly among the elderly population. The pathological changes underlying LSS include intervertebral disc herniation, hypertrophy of the ligamentum flavum, and facet joint arthrosis, all of which contribute to canal narrowing and progressive nerve root compression[1-4]. The diagnosis of LSS relies on a comprehensive evaluation of clinical symptoms—such as lower limb pain, weakness, numbness, and gait disturbances—alongside radiological and pathological confirmation. Magnetic resonance imaging (MRI) remains the gold standard for radiological assessment, providing detailed visualization of the degree and location of stenosis. However, radiological findings must be interpreted in correlation with clinical symptoms and, where applicable, supported by intraoperative or histopathological observations to guide treatment strategies effectively. Surgical intervention is indicated in patients with moderate to severe symptoms who do not respond to conservative therapy. Open decompressive laminectomy has long been considered the definitive surgical procedure, especially for multilevel stenosis. It offers direct decompression of neural elements and has demonstrated favorable outcomes in terms of pain relief and functional recovery. Minimally invasive approaches, such as tubular decompression, have also gained

popularity due to reduced operative trauma, shorter hospital stays, and quicker rehabilitation. Nevertheless, both techniques carry a risk of postoperative complications, including infection, hematoma, and iatrogenic instability. Post-laminectomy instability is a significant concern and can contribute to persistent or recurrent symptoms. The pathological basis for this instability includes disruption of the posterior spinal elements, facet joint degeneration, and insufficient ligamentous support. Understanding these tissue-level changes is essential for predicting surgical outcomes and informing decisions regarding the need for spinal fusion in selected cases[5, 6].

Despite the growing emphasis on clinical and radiological evaluation, there is a paucity of studies that integrate laboratory-based diagnostic findings, such as histopathological examination of excised tissues and biomarker analysis, into the routine assessment of patients undergoing lumbar spine surgery. Given this context, the present study aims to explore the pathological and diagnostic characteristics associated with lumbar spinal stenosis and its surgical treatment. By examining imaging findings, intraoperative tissue changes, and postoperative outcomes, this research seeks to provide a more integrated understanding of the disease process. Emphasis is placed on the value of correlating clinical, radiological, and pathological data to enhance diagnostic precision, improve patient selection for surgery, and reduce the incidence of postoperative complications such as instability[7, 8]. This approach aligns with current trends in precision

medicine and supports the role of the clinical laboratory in contributing to better outcomes in spinal surgery.

Method and Design of Study

Study Design

This study was concerned with conducting a cross-sectional study to evaluate the outcomes of 40 patients who underwent laminectomy and developed iatrogenic lumbar spine instability. The methodology's findings were assessed and analysed by SPSS program version 22.0 which sought to evaluate the clinical demographics of patients results through databases collected from different hospitals in Iraq from April 16, 2021, to August 25, 2022. Our study was determined clinical features in term of age, sex, comorbidities, and symptoms. To build the methodology, radiological outcomes of patients were diagnosed which both of factors covered by lumbar lordosis and segmental lordosis, with an emphasis on the follow-up period. Furthermore, the study methodology determined within mean and standard deviation (SD) values for two variables through the visual analogue scale (VAS) for back pain and the Oswestry Disability Index (ODI). Our study relied on the use of VAS and ODI to evaluate patient outcomes. VAS is a tool which evaluate the severity pain of a patient that consist of a horizontal line with endpoints labeled "no pain" and "worst pain imaginable," where the patient determines the level of pain. The Oswestry Low Back Pain Disability Scale is the most widely used and recommended scale. This scale seems ideal for patients with low back pain of moderate severity, which is common in rehabilitation consultations. It allows us to identify specific areas of intervention to reduce functional limitations due to low back pain [9-13]. It consists of ten sections, each containing six statements that rate the patient on a scale from 0 to 5. The scores are then added and multiplied by two to obtain a percentile score, with higher scores indicating greater disability. In addition, our

study evaluated postoperative spinal instability by considering the level of operation (single or multiple), postoperative outcomes, and complications [14, 15]. These results are summarized in Figures 3, 4, and 5.

Selection Criteria and Recruitment of Participants

This study determined the selection criteria for patients participating in laminectomy surgery, which included 40 patients. The inclusion criteria included patients aged between 30-70 years, with a body mass index between < 28.5 and > 28.5 , and with comorbidities that included high blood pressure. Diabetes, hypothyroidism, and Parkinson's disease, while exclusion criteria included patients who were less than 30 years old or more than 70 years old, and patients who had previous surgeries or chronic serious diseases.

Data Collection and Analysis

40 patients who underwent laminectomy were recruited, and all clinical and demographic data were collected from different hospitals in Iraq in the period between April 16, 2021, to August 25, 2022. This study conducted an examination of the participating samples based on Our study relied on the use of VAS and ODI to determine the rate of pain and measure the degree of disability in patients.

Statistical Analysis

This study analyzed, designed, and evaluated clinical data and all results associated with patient diagnostic examinations using SPSS version 22.0.

Ethical Considerations

Written consent was obtained from patients residing in Iraq at the hospital from which data were collected, and the general administration cooperated to conduct this study.

Results

Table 1: Clinical Features Characteristics of Patients with Lumbar Spine.

Parameters	No. Patients (40)	Percentage (%)
Age		
(Mean $\pm$ SD) Years	50 $\pm$ 20	-----
Sex		
Males	28	70%
Females	12	30%
Related Comorbidities		
Hypertension	22	55%
Diabetes	10	25%
Hypothyroidism	6	15%
Parkinsonism	2	5%
Bmi		
< 28.5	14	35%
> 28.5	26	65%
Symptoms		
Back Pain	13	32.5%
Weakness	12	30%
A Feeling of Locking in Between a Physical Activity	9	22.5%
Coughing	6	15%
Education Level		
Primary	18	45%
Secondary	8	20%
University	14	35%
Income Level		
Low	22	55%
Middle	11	27.5%
High	7	17.5%

To follow up of clinical outcomes, this study enrolled that back pain is considered as the most common factor who patients suffered with 32.5 % of cases. The rate of males was 70% as high percentage to compare with females with 30%. Also, our result found that 65% of patients have a BMI high, which get > 28.5 . Which most studies, that BMI factor was consider on of the basics factors who effect on the spinal instability. Most common comorbidities prevalence was hypertension with 55% of total patients and diabetes with 25%.

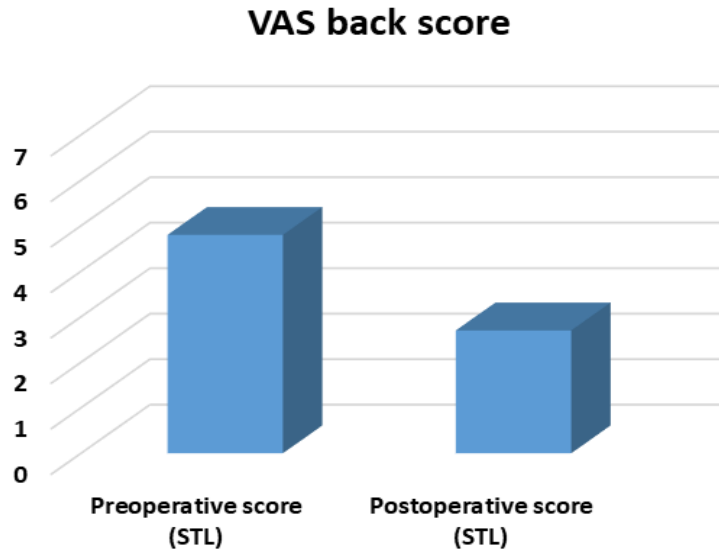


Figure 1: Clinical Status Assessment of Patients Based on VAS Back Score.

According to the VAS score, our results showed that the percentage of STL preoperative got 4.8 out of 7 while postoperative STL have 2.7 of 7, which it can be notify that laminectomy operative improved of spinal instability.

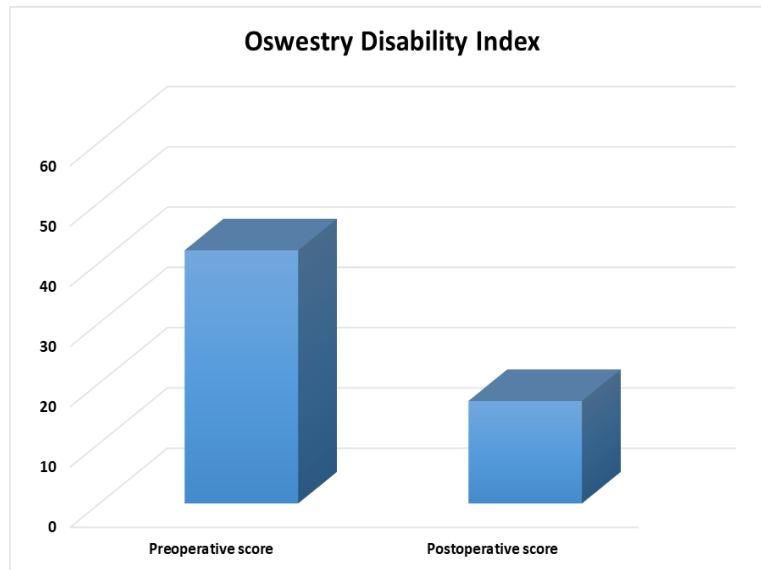


Figure 2: Clinical Status Assessment of Patients Based on Oswestry Disability Index (ODI).

In comparison to previous studies, our study evaluated the ODI of patients before and after surgery with spinal instability. Our findings indicated that the pre-operative ODI among patients was 42%, which clinically reduced to 17% in the postoperative period.

Table 2: Identify the Radiologic Outcome of Patients According to Lumbar lordosis and Segmental Lordosis.

Variables	No. patients
Preoperative, Lumbar Lordosis (LL)	47.64 ± 8.86
Postoperative, Lumbar Lordosis (LL)	54 ± 9.32
LL Difference	2.43 ± 6.82
Preoperative, Segmental Lordosis (SL)	15.26 ± 5.65
Postoperative, Segmental Lordosis (SL)	17.51 ± 3.65
SL Difference	2.25 ± 2.25

Our study determined radiologic outcome which factors included both lumbar lordosis and segmental lordosis. During preoperative findings, we enrolled radiologic outcome in term of lumbar lordosis was 47.64 ± 8.86 and segmental lordosis was 15.26 ± 5.65 . Postoperative outcomes, we found lumbar lordosis was 54 ± 9.32 and segmental lordosis was 17.51 ± 3.65 .

Table 3: Clinical Outcomes in Follow-up of Patients.

Parameters	No. Years
Mean Follow-Up	5.47 Years
Minimum	4.2 Years
Maximum	9.87 Years

Our results were defined clinical outcomes which are mean follow-up was 5.47 years, minimum was 4.2 years, and maximum was 9.87 years.

Table 4: Describe Outcomes of the Scale of Visual Analog Through Pre-Operative and Post-Operative

Variables	Mean	SD
VAS Back Pain Pre-Operative	3.77	2.35
VAS Back Pain Immediate Post-Operative	3.45	0.443
The Scale of Visual Analog of Back Pain Post Two Years	2.55	1.65
ODI Pre-Operative	36.364	7.76
ODI Immediate Post-Operative	8.96	1.86
ODI Post Two Years	12.81	11.46

According to pain and disability outcomes, we enrolled pre and post-operative outcomes where we found that back pain pre-operative was 3.77 ± 2.35 , back pain immediate post-operative was 3.45 ± 0.443 , and back pain post two years was 2.55 ± 1.65 . According to disability outcomes, we got ODI Pre-operative was 36.364 ± 7.76 , ODI immediate post-operative was 8.96 ± 1.86 , and ODI post two years was 12.81 ± 11.46 .

POSTOPERATIVE INSTABILITY

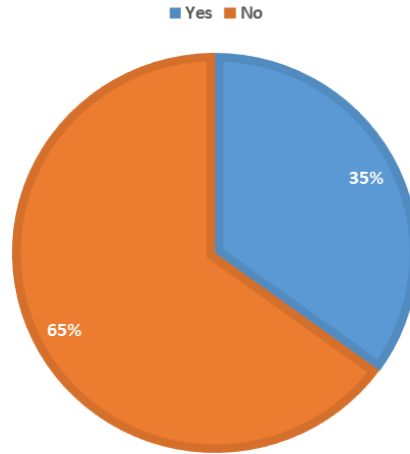


Figure 3: Associated Outcomes between Operated Levels and Instability After Post-Operative.

In contrast, our clinical outcome clarified the number of patients enrolled and assessed for postoperative spinal instability. It revealed that only 35% of patients suffered from spinal instability, while the rest did not.

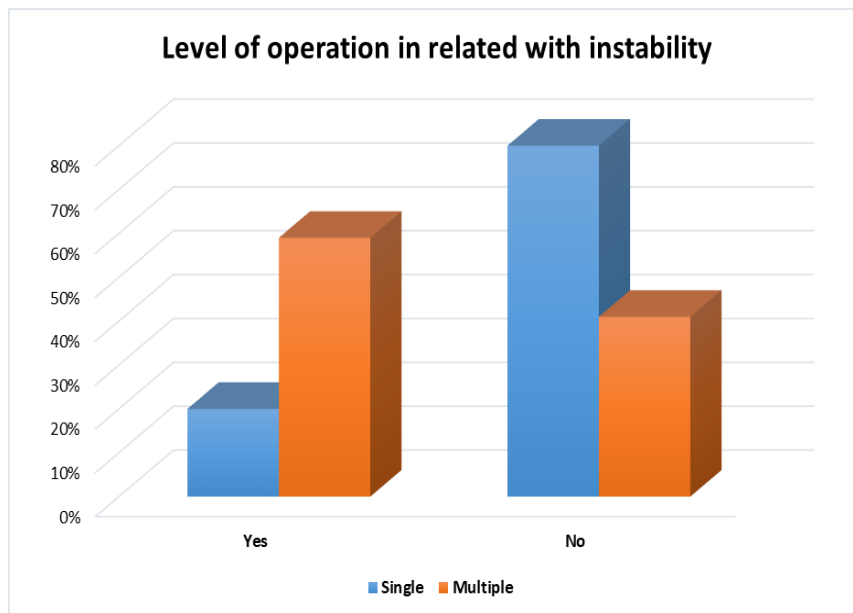


Figure 4: Detect the Level of Operation in Relation to Instability.

Table 5: The Final Clinical Outcomes.

Outcomes	NO. of Patients, 40
Clinical Deterioration N (%)	19 (47.5%)
Improvement in Walking Distance	13 (32.5%) – 4-8 Times
Partial Recovery	8 (20%)

In these final clinical outcomes, our results enrolled the rate of improvement percentage where the walking distance of patients was improving in 4-8 times, but the partial recovery has got 8 (20%).

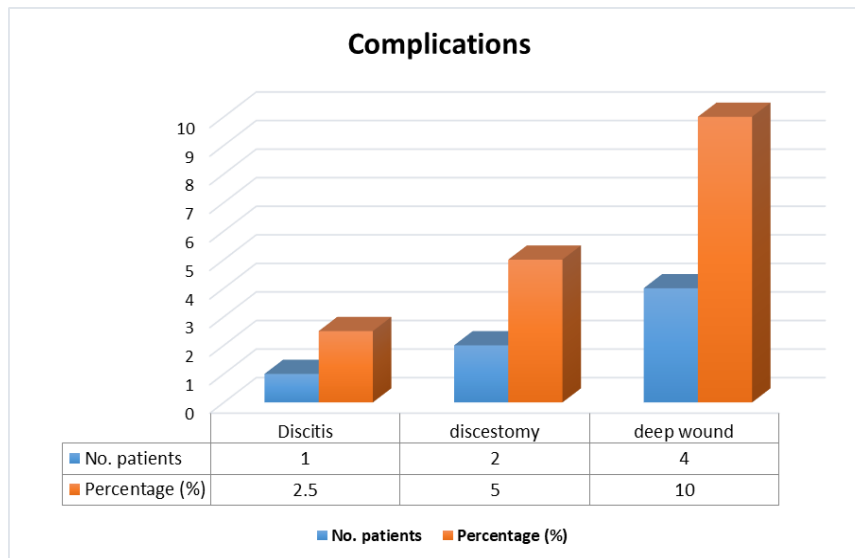


FIGURE 5: Post-Operative Complications.

Our study was figured out to assess the complications where it found deep wounds was the highest impact on patients after surgery, where it enrolled 10 % of cases.

Discussion

Our study discussed iatrogenic lumbar spine instability after laminectomy. This study has demonstrated that preoperative function in lumbar spine instability patients is affected by comorbidities. It has been found that comorbidities are linked to symptoms associated with low back pain and neurogenic claudication but not radicular pain. Therefore, comorbidities may impact the variation of patients' outcomes. This discovery should be provided as part of the preoperative information for patients. Additionally, the role of comorbidities on postoperative outcomes needs to be explored. Our results noticed that back pain could enroll the highest score of cases with 13 (32.5%) because of incomplete radial posterior tears. Previous research has indicated that lumbar spine instability can result from multiple factors [16]. According to Morgan [17], a leading contributor to back pain is primary instability of the lumbar vertebrae, which is caused by incomplete radial posterior tears or anterior concentric fissures. According to previous studies, Moon Ray found that iatrogenic lumbar spine instability after laminectomy can be caused by several factor which found that large laminectomy and extensive facetectomy for lumbar stenosis in patients who do not have obvious pre-existing instability can result in iatrogenic instability. As low bone mineral content and density, small intervertebral discs, and absence of osteophytes could predict the possible development of post-operative instability following lumbar laminectomy [18]. In another study, Negative results were found, as it was concluded in a study that laminectomy for lumbar stenosis leads to the presence of iatrogenic spondylolisthesis. Furthermore, several factors may influence the evaluation of the risk of spondylolisthesis following surgery. These factors include the degree of decompression of the facet joints, the number of levels that have been decompressed, and the height of the disc space prior to the operation [19]. Iatrogenic lumbar instability is a common complication after laminectomy, according to the papers. According to [20], 5.5% of patients experienced radiographic instability after surgery. This was more prevalent in individuals who already had spondylolisthesis (12.6%) and those who underwent open laminectomy (12%). Another study by Hafez [21] reported that 18% of patients experienced postoperative instability after laminectomy,

and the number of operated levels and degree of mesial facetectomy were identified as variables that can impact postoperative stability as well as it found that static instability was observed in 50% of patients during follow-up after lamino-arthrectomy, and an increase in pre-existing slip was often noted but was considered to be moderate and did not affect the functional outcome. The success level of a lumbar laminectomy to alleviate for leg pain from spinal stenosis is generally favorable, where literature review refers to 85% to 90% of patients with lumbar central spinal stenosis experience postoperative relief of leg pain after open laminectomy surgery. Up to 75% of patients achieve satisfactory results for a decade after surgery [22]. Despite generally positive outcomes, 10% to 15% may require further intervention owing to postoperative complications. Stenosis of the lumbar spine can cause various symptoms. However, open laminectomy may be useful only in a few carefully selected patients [23]. The outcome of an open lumbar laminectomy depends largely on the patient involved. In well-selected cases, the response to surgery and the overall results are often good, with approximately 85% to 90% of patients experiencing a decrease in symptoms. It has also been found in previous studies that there is a possibility of Stenosis of the central spine. There is a constriction in the spinal canal, which leads to pressure in the spinal cord. An open laminectomy is usually only seen after 8 to 12 weeks of non-surgical treatments for lumbar spinal stenosis pain, and non-surgical treatments may include physiotherapy, available painkillers, or epidural steroid injections [24]. The papers provide information on the long-term outcomes of iatrogenic instability of the lumbar spine after laminectomy [25]. Patients who underwent a more thorough surgical technique, such as total laminectomy with bilateral facetectomy and transpedicular fixation, experienced a higher degree of postoperative para-spinal muscle atrophy [26]. It is discussed the lateral lumbar interbody fusion technique, which has shown promising results in patients with various lumbar spine pathologies. Many imaging findings, including degenerative changes, are clinically irrelevant and that effective clinical management can improve outcomes and reduce unnecessary healthcare costs [27]. Finally, the authors' experience with the use of pedicular instrumentation as a complement to posterior lumbar spine arthrodesis, highlighting the

potential complications and risk factors associated with this technique [28, 29].

Conclusion

Lumbar canal stenosis (LCS) represents a significant cause of disability among the adult and aging population, with its multifactorial etiology rooted in degenerative changes that lead to narrowing of the spinal canal and compression of neural elements. While surgical decompression—particularly laminectomy—remains the cornerstone of treatment in cases where conservative management fails, the risk of postoperative complications, such as iatrogenic instability and persistent symptoms, highlights the necessity of a more comprehensive diagnostic and management framework. This study underscores the critical importance of integrating clinical evaluation, advanced imaging modalities, and laboratory-based pathological assessment in the preoperative and postoperative management of LCS. Radiological tools such as MRI and CT scanning are invaluable in determining the extent and severity of stenosis, but their predictive value is significantly enhanced when correlated with intraoperative and histopathological observations. In particular, the identification of tissue-level changes—such as ligamentum flavum hypertrophy, facet joint degeneration, and disc pathology—provides insight into the structural compromise of the lumbar spine and helps forecast

potential instability following decompression. Our findings further emphasize that surgical planning should not be solely technique-driven, but rather tailored to the individual pathology of each patient, as revealed through multidisciplinary diagnostic inputs. The inclusion of laboratory pathology—whether through tissue sampling, inflammatory marker analysis, or histological grading—can significantly refine the decision-making process, particularly when determining the need for concurrent spinal fusion to prevent postoperative complications. From a laboratory medicine perspective, this study highlights the emerging role of the clinical pathology laboratory in supporting surgical disciplines through diagnostic confirmation, risk stratification, and postoperative monitoring. As healthcare moves toward precision and personalized approaches, the collaborative interface between clinicians, radiologists, and pathologists becomes increasingly central to improving patient outcomes in spinal disorders.

In conclusion, enhancing diagnostic rigor through the integration of radiological and pathological data is essential for optimizing the management of lumbar canal stenosis. A structured approach that incorporates clinical-laboratory correlation not only aids in preventing surgical failure but also fosters a more holistic understanding of spinal degeneration, supporting better long-term functional outcomes for patients undergoing lumbar spine surgery.

References

- [1] R. A. Deyo, S. K. Mirza, and B. I. Martin, "Back pain prevalence and visit rates: estimates from US national surveys, 2002," *Spine*, vol. 31, no. 23, pp. 2724-2727, 2006.
- [2] R. A. Deyo, S. K. Mirza, B. I. Martin, W. Kreuter, D. C. Goodman, and J. G. Jarvik, "Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults," *Jama*, vol. 303, no. 13, pp. 1259-1265, 2010.
- [3] F. Costa *et al.*, "Degenerative lumbar spinal stenosis: analysis of results in a series of 374 patients treated with unilateral laminotomy for bilateral microdecompression," *Journal of Neurosurgery: Spine*, vol. 7, no. 6, pp. 579-586, 2007.
- [4] D. S. Rosen *et al.*, "Minimally invasive lumbar spinal decompression in the elderly: outcomes of 50 patients aged 75 years and older," *Neurosurgery*, vol. 60, no. 3, pp. 503-510, 2007.
- [5] V. Popov and D. G. Anderson, "Minimal invasive decompression for lumbar spinal stenosis," *Advances in Orthopedics*, vol. 2012, no. 1, p. 645321, 2012.
- [6] C.-W. Lee, K.-J. Yoon, and J.-H. Jun, "Percutaneous endoscopic laminotomy with flavectomy by uniportal, unilateral approach for the lumbar canal or lateral recess stenosis," *World neurosurgery*, vol. 113, pp. e129-e137, 2018.
- [7] A. Takada *et al.*, "Long-term follow-up of intensive chemotherapy followed by reduced-dose and reduced-field irradiation for intracranial germ cell tumor," *Journal of Neurosurgery: Pediatrics*, vol. 23, no. 3, pp. 317-324, 2018.
- [8] D. Bzinkowski, T. Ryba, Z. Siemiatkowski, and M. Rucki, "Real-time monitoring of the rubber belt tension in an industrial conveyor," *Reports in Mechanical Engineering*, vol. 3, no. 1, pp. 1-10, 2022.
- [9] M. Demirayak *et al.*, "Clinical and radiological results of microsurgical posterior lumbar interbody fusion and decompression without posterior instrumentation for lateral recess stenosis," *Asian Spine Journal*, vol. 9, no. 5, p. 713, 2015.
- [10] M. Uehara *et al.*, "Comparison of spinous process-splitting laminectomy versus conventional laminectomy for lumbar spinal stenosis," *Asian Spine Journal*, vol. 8, no. 6, p. 768, 2014.
- [11] S. Dohzono, H. Toyoda, A. Matsumura, H. Terai, A. Suzuki, and H. Nakamura, "Clinical and radiological outcomes after microscopic bilateral decompression via a unilateral approach for degenerative lumbar disease: minimum 5-year follow-up," *Asian Spine Journal*, vol. 11, no. 2, p. 285, 2017.
- [12] R. J. Mobbs, J. Li, P. Sivabalan, D. Raley, and P. J. Rao, "Outcomes after decompressive laminectomy for lumbar spinal stenosis: comparison between minimally invasive unilateral laminectomy for bilateral decompression and open laminectomy," *Journal of Neurosurgery: Spine*, vol. 21, no. 2, pp. 179-186, 2014.
- [13] M. W. Fox, B. M. Onofrio, and A. D. Hanssen, "Clinical outcomes and radiological instability following decompressive lumbar laminectomy for degenerative spinal stenosis: a comparison of patients undergoing concomitant arthrodesis versus decompression alone," *Journal of neurosurgery*, vol. 85, no. 5, pp. 793-802, 1996.
- [14] Z. Ghogawala *et al.*, "Prospective outcomes evaluation after decompression with or without instrumented fusion for lumbar stenosis and degenerative Grade I spondylolisthesis," *Journal of Neurosurgery: Spine*, vol. 1, no. 3, pp. 267-272, 2004.
- [15] M. Komp *et al.*, "Bilateral spinal decompression of lumbar central stenosis with the full-endoscopic interlaminar versus microsurgical laminotomy technique: a prospective, randomized, controlled study," *Pain physician*, vol. 18, no. 1, p. 61, 2015.
- [16] E. Ferrero, G. Lonjon, B. Bouyer, M. Sabourin, M. Ould-Slimane, and P. Guigui, "Influence of comorbidities on patients reported outcomes in degenerative lumbar spinal stenosis," *Orthopaedics & Traumatology: Surgery & Research*, vol. 104, no. 7, pp. 1031-1036, 2018.
- [17] F. P. Morgan and T. King, "Primary instability of lumbar vertebrae as a common cause of low back pain," *The Journal of Bone & Joint Surgery British Volume*, vol. 39, no. 1, pp. 6-22, 1957.
- [18] U. Charles, A. Anthony, N. Evaristus, A. Obinna, O. Cyril, and S. Morayo, "Pattern and Outcome of Surgery for Degenerative Disease of the Lumbar Spine using the Visual Analogue Score (VAS) and Oswestry Disability Index (ODI) at a Tertiary Hospital," *Clin Surg*, vol. 5, pp. 1-6, 2020.
- [19] C. Schizas *et al.*, "Qualitative grading of severity of lumbar spinal stenosis based on the morphology of the dural sac on magnetic resonance images," *Spine*, vol. 35, no. 21, pp. 1919-1924, 2010.
- [20] C. Thomé *et al.*, "Outcome after less-invasive decompression of lumbar spinal stenosis: a randomized comparison of unilateral laminotomy, bilateral laminotomy, and laminectomy," *Journal of Neurosurgery: Spine*, vol. 3, no. 2, pp. 129-141, 2005.

- [21] A. A. Hafez, A. H. Ashry, A. Elsayed, A. El Tayeb, and M. B. A. S. ElShenawy, "Incidence of iatrogenic lumbar spinal instability after laminectomy, discectomy or facetectomy," *Open Access Macedonian Journal of Medical Sciences*, vol. 9, no. B, pp. 588-592, 2021.
- [22] M. Alimi, C. P. Hofstetter, S. Y. Pyo, D. Paulo, and R. Härtl, "Minimally invasive laminectomy for lumbar spinal stenosis in patients with and without preoperative spondylolisthesis: clinical outcome and reoperation rates," *Journal of Neurosurgery: Spine*, vol. 22, no. 4, pp. 339-352, 2015.
- [23] S. Ruetten, M. Komp, H. Merk, and G. Godolias, "Surgical treatment for lumbar lateral recess stenosis with the full-endoscopic interlaminar approach versus conventional microsurgical technique: a prospective, randomized, controlled study," *Journal of Neurosurgery: Spine*, vol. 10, no. 5, pp. 476-485, 2009.
- [24] S.-M. Park *et al.*, "Biportal endoscopic versus microscopic lumbar decompressive laminectomy in patients with spinal stenosis: a randomized controlled trial," *The Spine Journal*, vol. 20, no. 2, pp. 156-165, 2020.
- [25] T. Kang, S. Y. Park, C. H. Kang, S. H. Lee, J. H. Park, and S. W. Suh, "Is biportal technique/endoscopic spinal surgery satisfactory for lumbar spinal stenosis patients?: a prospective randomized comparative study," *Medicine*, vol. 98, no. 18, p. e15451, 2019.
- [26] P. K. Singh, "Data with Intuitionistic Plithogenic attributes and its analysis," *Full Length Article*, vol. 7, no. 2, pp. 08-8-17, 2023, doi: 10.54216/GJMSA.070201.
- [27] D. H. Heo, D. C. Lee, and C. K. Park, "Comparative analysis of three types of minimally invasive decompressive surgery for lumbar central stenosis: biportal endoscopy, uniportal endoscopy, and microsurgery," *Neurosurgical focus*, vol. 46, no. 5, p. E9, 2019.
- [28] J. Hatakka, K. Pernaa, J. Rantakokko, I. Laaksonen, and M. Saltychev, "Effect of lumbar laminectomy on spinal sagittal alignment: a systematic review," *European Spine Journal*, vol. 30, pp. 2413-2426, 2021.
- [29] K. Fujii, N. Kawamura, M. Ikegami, G. Niitsuma, and J. Kunogi, "Radiological improvements in global sagittal alignment after lumbar decompression without fusion," *Spine*, vol. 40, no. 10, pp. 703-709, 2015.



This is an open-access article distributed under the terms of the Creative Commons Attribution License.