

# EVALUATION OF OUTCOMES IN PATIENTS UNDERGOING ENDOSCOPIC LUMBAR SPINE SURGERY

*AValiação de Resultados em Pacientes Submetidos à Cirurgia Endoscópica da Coluna Lombar*

*Evaluación de Resultados en Pacientes Sometidos a Cirugía Endoscópica de Columna Lombar*

ANAIELLE SCREMIN REISDORFER<sup>1,2</sup> , JOÃO PEDRO FERNANDES SILVA<sup>2</sup> , IGOR EBERT CECIN<sup>2</sup> , ANDRÉ RAFAEL HUBNER<sup>2</sup> , JEAN MARCEL DAMBRÓS<sup>2</sup> ,  
ÁLVARO DIEGO HEREDIA SUAREZ<sup>2</sup> 

1. Universidade Federal da Fronteira Sul (UFFS), Chapecó, SC, Brazil.

2. Instituto de Ortopedia e Traumatologia do Rio Grande do Sul (IOTRS), Passo Fundo, Rio Grande do Sul, Brazil.

## ABSTRACT

**Objective:** To describe the epidemiology, outcomes, complications, and risk factors of lumbar endoscopic discectomies at a tertiary hospital. **Methods:** 138 patients treated for lumbar disc herniation (LDH) between 2021 and 2024 were analyzed regarding outcomes and complications through medical records and statistical analysis. **Results:** Of the 138 patients: 52.89% (n=73) male, 47.10% (n=65) female (mean 44.2 years; BMI 27.9 kg/m<sup>2</sup>). Preoperative pain: 32.6% (n=45) acute, 36.9% (n=51) subacute, and 30.43% (n=42) chronic. Approaches: interlaminar (58%; n=80) and transforaminal (42%; n=58). Comorbidities: hypertension (23.2%), smoking (6.5%), DM (5.8%), and prior lumbar surgery (15.94%). VAS improvement: acute 2.64 (SD 0.712), subacute 1.73 (SD 0.843), and chronic 1.33 (SD 0.798). Average stay: 2 days; surgical time: 80 min (60-90). Complications: acute (2.2%), subacute/acute-on-chronic (4.1%), and chronic (9.5%), p=0.314. Pain recurrence: 13.3%, 30.6%, and 23.8% (p=0.122). Specific complications (n=6): insufficient decompression 3.4% (n=5), dural injury 0.7% (n=1), infection 0.7% (n=1). Symptom return: 23.9% (63.4% low, 15.15% moderate, 21.21% high intensity); recurrent herniation 16.7%; reoperation 10.1%; 105 patients asymptomatic. Prior surgery increased complications (OR 8.16; p=0.013; 18.2% vs. 2.6%). BMI associated with pain recurrence (p=0.024; 29.4 vs. 27.3 kg/m<sup>2</sup>). Transforaminal approach showed higher recurrence (31.0% vs. 12.5%; OR 3.15; p=0.0075) and complications (10.34% vs. 1.25%; OR 9.11; p=0.025). Symptom-free time (n=33): mean 162.7 days (SD 211.1); return in 25% (immediate), 50% (up to 90 days), and 75% (up to 210 days). **Conclusions:** Lumbar endoscopy is safe and effective. Success depends on patient factors, pain profile, and pathology. **Level of evidence IV; Cross-sectional, observational study.**

**Keywords:** Intervertebral Disc Displacement; Radiculopathy; Low Back Pain; Spinal Diseases; Endoscopy.

## RESUMO

**Objetivo:** Descrever epidemiologia, desfechos, complicações e fatores de risco em discectomias endoscópicas lombares em hospital terciário. **Métodos:** Analisaram-se 138 pacientes entre 2021 e 2024 por hérnia de disco lombar (HDL), desfechos e complicações através de prontuários e análise estatística. **Resultados:** 138 pacientes: 52,89% (n=73) masculino, 47,10% (n=65) feminino (média 44,2 anos; IMC 27,9 kg/m<sup>2</sup>). Dor pré-operatória: 32,6% (n=45) aguda, 36,9% (n=51) subaguda e 30,43% (n=42) crônica. Vias: interlaminar (58%; n=80) e transforaminal (42%; n=58). Comorbidades: HAS (23,2%), tabagismo (6,5%), DM (5,8%) e cirurgia lombar prévia (15,94%). Melhora na EVA: aguda 2,64 (DP 0,712), subaguda 1,73 (DP 0,843) e crônica 1,33 (DP 0,798). Internação média de 2 dias; tempo cirúrgico de 80 min (60-90). Complicações: agudo (2,2%), subagudo/agudização de dor crônica (4,1%) e crônica (9,5%), p=0,314. Recidiva da dor: 13,3%, 30,6% e 23,8% (p=0,122). Complicações (n=6): descompressão insuficiente 3,4% (n=5), lesão dural 0,7% (n=1), infecção 0,7% (n=1). Retorno dos sintomas: 23,9% (63,4% baixa, 15,15% moderada, 21,21% alta intensidade); nova hérnia 16,7%; nova cirurgia 10,1%; 105 pacientes assintomáticos. Cirurgia prévia elevou complicações (OR 8,16; p=0,013; 18,2% vs. 2,6%). IMC associou-se à recidiva da dor (p=0,024; 29,4 vs. 27,3 kg/m<sup>2</sup>). Via transforaminal: maior recidiva (31,0% vs. 12,5%; OR 3,15; p=0,0075) e complicações (10,34% vs. 1,25%; OR 9,11; p=0,025). Tempo livre de sintomas (n=33): média 162,7 dias (DP 211,1); retorno em 25% (imediate), 50% (até 90 dias) e 75% (até 210 dias). **Conclusões:** A endoscopia lombar é segura e eficaz para hérnias. O sucesso depende do paciente, dor e patologia abordada. **Nível de evidência IV; Estudo transversal, observacional.**

**Descritores:** Deslocamento do disco intervertebral; Radiculopatia; Dor Lombar; Doenças da Coluna Vertebral; Endoscopia.

## RESUMEN

**Objetivo:** Describir la epidemiología, resultados, complicaciones y factores de riesgo en discectomías endoscópicas lombares en hospital terciario. **Métodos:** Fueron analizados 138 pacientes entre 2021 y 2024 por hernia de disco lumbar (HDL), evaluando resultados y complicaciones mediante historias clínicas y análisis estadístico. **Resultados:** 138 pacientes: 52,89% (n=73) masculino, 47,10% (n=65)

Study conducted by the Hospital São Vicente de Passo Fundo, RS, Brazil.

Correspondence: João Pedro Fernandes Silva. 369, Rua Santa Catarina, Passo Fundo, RS, Brazil. 41830-610. drjportopedia@gmail.com



femenino (media 44,2 años; IMC 27,9 kg/m<sup>2</sup>). Dolor preoperatorio: 32,6% (n=45) agudo, 36,9% (n=51) subagudo y 30,43% (n=42) crónico. Vías: interlaminar (58%; n=80) y transforaminal (42%; n=58). Comorbilidades: HTA (23,2%), tabaquismo (6,5%), DM (5,8%) y cirugía lumbar previa (15,94%). Mejora en la EVA: agudo 2,64 (DE 0,712), subagudo 1,73 (DE 0,843) y crónico 1,33 (DE 0,798). Estancia media de 2 días; tiempo quirúrgico de 80 min (60-90). Complicaciones: agudo (2,2%), subagudo/agudización de dolor crónico (4,1%) y crónico (9,5%), p=0,314. Recidiva del dolor: 13,3%, 30,6% y 23,8% (p=0,122). Complicaciones (n=6): descompresión insuficiente 3,4% (n=5), lesión dural 0,7% (n=1), infección 0,7% (n=1). Retorno de síntomas: 23,9% (63,4% baja, 15,15% moderada, 21,21% alta intensidad); nueva hernia 16,7%; nueva cirugía 10,1%; 105 pacientes asintomáticos. Cirugía previa elevó complicaciones (OR 8,16; p=0,013; 18,2% vs 2,6%). El IMC asoció a recidiva del dolor (p=0,024; 29,4 vs. 27,3 kg/m<sup>2</sup>). Vía transforaminal: mayor recidiva (31,0% vs. 12,5%; OR 3,15; p=0,0075) y complicaciones (10,34% vs. 1,25%; OR 9,11; p=0,025). Tiempo libre de síntomas (n=33): media 162,7 días (DE 211,1); retorno 25% (inmediato), 50% (hasta 90 días) y 75% (hasta 210 días). Conclusiones: La endoscopia lumbar es segura y eficaz para hernias. El éxito depende del paciente, dolor y patología abordada. **Nivel de evidencia IV; Estudio transversal, observacional.**

**Descriptores:** Desplazamiento del Disco Intervertebral; Radiculopatía; Dolor de la Región Lumbar; Enfermedades de la Columna Vertebral; Endoscopia.

## INTRODUCTION

Lumbar disc herniation is a common pathology in the daily practice of orthopedics and has social, functional, and financial impacts on patients and society<sup>1</sup>. Despite the possibilities of conservative treatment with good responses in many cases, around 1-3% of patients with lumbar disc herniation progress to surgical treatment, which relies on three basic forms: conventional open surgery, minimally invasive surgery, and endoscopic surgery<sup>2</sup>. In this context, endoscopic discectomy has been gaining traction as a treatment for lumbar disc herniation, emphasizing the technique's lower invasiveness, less alteration of lumbar anatomy, lower complication rates, lower reoperation rates, early recovery, and its non-inferiority compared to open discectomy<sup>3-7</sup> making it a safe and effective option for treatment<sup>5</sup>.

The endoscopic procedure allows for a direct and magnified view of the lumbar anatomy, further improved by reduced bleeding due to continuous irrigation, in addition to enabling access to various compartments of the lumbar anatomy without the need for excessive manipulation and retraction of the dural sac and nerve roots<sup>6-9</sup>.

Still regarding the technical aspect of the endoscopic procedure, there are two well-established access routes: transforaminal and interlaminar<sup>8-10</sup>. The transforaminal route is the most commonly used (around 55%), followed by the interlaminar route (around 31%) in international case studies<sup>8</sup>. In our study, we aim to identify the prevalence of its use and outline the outcomes associated with each one.

Among the relevant outcomes to be studied after endoscopic surgery, the following are highlighted: pain-free time after the procedure, pre- and post-operative sensitivity, and complications - recurrence of hernia, need for surgical reintervention, surgical site infection, and dural injury<sup>4</sup>.

It is also important to investigate the recurrence of symptoms after endoscopic discectomy. In the literature, the recurrence of symptoms has led to a reoperation rate of 8% in patients undergoing endoscopic discectomy within 2 years and 10% within 4 years<sup>11-12</sup>.

Considering the complications and recurrence of symptoms, it is evident that there is a need to outline risk factors associated with the recurrence of lumbar disc herniation after endoscopic surgery. However, there are few studies investigating the risk factors associated with symptom recurrence in patients specifically undergoing endoscopic surgery, rather than in open and minimally invasive techniques, so we aim to investigate these associations.

## METHODS

A survey was conducted on cases of endoscopic lumbar spine surgery performed at Hospital São Vicente de Paulo - Passo Fundo - RS from 2021 to 2024 by a single surgeon. A total of 152 patients undergoing endoscopic lumbar surgery for various pathologies were identified. Patients who underwent surgery for lumbar stenosis were excluded due to insufficient sample size.

Patients who had postoperative follow-up of less than ninety days, patients without records of preoperative physical examination, and patients without records of postoperative outcomes were also excluded from the sample.

Based on the data contained in medical records and the studied variables (Sex; Age range; Body Mass Index - BMI; Preoperative pain profile - Acute / Subacute / Chronic; Surgical access route - Transforaminal / Interlaminar; Comorbidities - Systemic Arterial Hypertension, Smoking, Type 2 Diabetes Mellitus, and Previous Lumbar Spine Surgery; Complications - Dural Injury, Infection, Cerebrospinal Fluid Fistula, and Hematoma; Recurrences - Pain / Herniated Disc; Visual Analog Scale for Pain - VAS), the main objective was to test three pre-specified hypotheses related to clinical outcomes and complication rates of this surgical procedure, which corroborate with the published literature. *Hypothesis 1:* Patients with symptom duration (acute or subacute) have better clinical outcomes; *Hypothesis 2:* Endoscopic surgery has a low complication rate; *Hypothesis 3:* Body mass index, diabetes mellitus, arterial hypertension, previous lumbar spine surgery, and smoking are associated with worse clinical outcomes.

## Statistical Analysis

The analysis utilized robust statistical methods, which are widely employed in the treatment of this type of data, including Fisher's exact tests (ref 4 and 7) for categorical variables, Kruskal-Wallis test (ref 1 and 7) for multiple group comparisons, bootstrap for confidence intervals, and multiple imputation for handling missing data. All analyses were corrected for multiple comparisons using the Benjamini-Hochberg method to control the false discovery rate. The analyses were conducted using Posit Software, PBC (formerly RStudio, PBC) version 2025.09.1 2009-2025 (Free Software Foundation, Inc., Boston, USA) with R packages version 4.5.1 2025 (The R Foundation for Statistical Computing, Vienna, Austria).

## Surgical Procedure

Transforaminal route: after using fluoroscopy to determine the entry point of the endoscopic working cannula, the lateral aspect of the foramen is enlarged through foraminoplasty, with outside-in decompression under direct visualization. In this way, the herniated disc is removed, and the emerging and traversing roots are directly released<sup>13,14</sup>.

Interlaminar route: the surgical access is performed with the patient in a prone position, using fluoroscopy. The skin incision is made as close as possible to the craniocaudal midpoint of the interlaminar window. The working cannula is positioned at the lateral edge of the interlaminar window, exposing the yellow ligament, making its opening; lateral bone resection is performed as needed, preserving joint integrity. Afterward, the root is mobilized, with rotation of the working cannula and proceeding to discectomy<sup>14</sup>. Figure 1 includes a clinical case that illustrates the indication for the interlaminar route.

## Ethical aspects

The study was submitted and approved by the research ethics committee of Hospital São Vicente de Paulo - Passo Fundo - RS with the proper authorization for exemption from the application of the informed consent form (CAAE: 88456425.3.0000.5564, opinion number: 7.746.309).

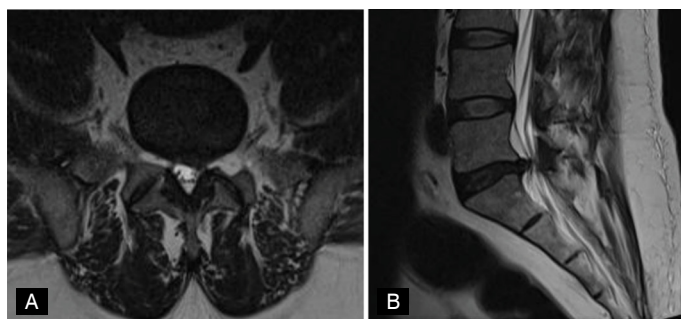


**Figure 1.** Male patient, 44 years old, previously healthy, presented with acute left-sided low back pain with sciatica associated with paresis in the L5 and S1 myotomes. Endoscopic lumbar spine surgery via interlaminar approach was indicated. He experienced complete improvement of pain and paresis in the postoperative period. (A) Magnetic Resonance Imaging of the lumbosacral spine weighted in T2, axial cut, showing central lumbar disc herniation/lateral recess on the left. (B) Magnetic Resonance Imaging of the lumbosacral spine weighted in T2, sagittal cut, showing lumbar disc herniation L5-S1.

## RESULTS

The initial sample included 152 patients, of whom 07 did not have minimum data in their records for analysis and were excluded from the study. In addition, there were 07 patients who underwent endoscopic decompression of isolated lumbar stenosis, who were also excluded from the study. The final sample included 138 patients, with 52.89% being male patients ( $n=73$ ) and 47.10% female patients ( $n=65$ ), with an average age of 44.2 years. The average body mass index was 27.9 kg/m<sup>2</sup> (overweight). Regarding the preoperative pain profile, 32.6% of patients presented an acute triggering episode of pain ( $n=45$ ), 36.9% subacute pain ( $n=51$ ), and 30.43% chronic pain ( $n=42$ ). The predominant access route was interlaminar in 58% of cases ( $n=80$ ), with the transforaminal route chosen in 42% ( $n=58$ ). No patient was approached through both accesses in the same procedure.

Regarding the prevalence of comorbidities, the most prevalent was systemic arterial hypertension (SAH) at 23.2%, followed by smoking (6.5%) and diabetes mellitus (5.8%). 15.94% of patients had a previous lumbar spine surgery (lumbar arthrodesis, open decompression, and/or endoscopic decompression).

The analysis of the VAS (visual analog scale) pre and post-surgery showed an improvement of 2.64 points (SD 0.712) in patients with acute pain, 1.73 points (SD 0.843) in patients with subacute/chronic pain exacerbation, and 1.33 points (SD 0.798) in patients with chronic pain (Figure 2).

The average length of stay was 2 days, including the day of surgery and discharge the following day, and the surgical time averaged 80 minutes (ranging from 60 to 90 minutes).

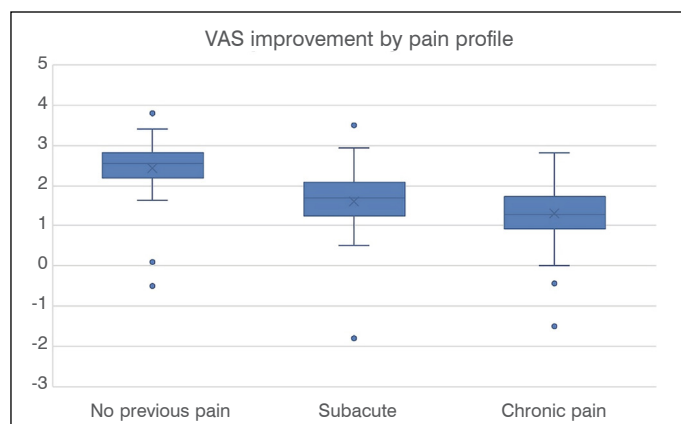


**Figure 2.** Graph showing the improvement of the visual analog scale (VAS), by Pain Profile.

Patients with acute onset of pain experienced 2.2% complications, while the subacute/chronic pain exacerbation presented 4.1%, and patients with chronic pain had 9.5%, without reaching statistically significant difference ( $p=0.314$ ). Regarding pain recurrence for patients with acute, subacute, and chronic pain conditions, 13.3%, 30.6%, and 23.8% respectively experienced symptom return, with a non-significant difference but a clear trend ( $p=0.122$ ).

Among the complications studied, between the two groups, 5 patients (3.4%) presented insufficient decompression, 1 patient presented dural injury (0.7%), and 1 patient presented infection (0.7%). No patient developed hematoma or cerebrospinal fluid fistula in the postoperative period (Figure 3). A total of 6 patients experienced complications, as 1 patient developed dural injury and infection.

We included the chart with complications and symptom recurrence, new HDL, and the need for further surgery. 24% of patients undergoing endoscopic lumbar discectomy reported some degree of symptom return (63.4% low-intensity pain, 21.21% high-intensity pain, and 15.15% moderate-intensity pain, according to VAS), but only 16.7% presented new lumbar hernia and 10.1% required further surgery. In total, 105 patients remained pain-free at the end of the follow-up.

Regarding sensitivity, 77 patients presented paresthesia in the corresponding dermatome before surgery, and after, 17 patients maintained symptoms in this aspect, with 5 maintaining the same degree of symptoms, 2 patients worsening, 6 presenting partial improvement, and 4 developing dysesthesia. Additionally, 4 patients who previously had no sensitivity alteration developed changes, with 2 having paresthesia and 2 having dysesthesia. Both the access route and the pre-surgical pain status do not appear to have statistically significant correlation with these data ( $p > 0.05$ ), likely due to the sample size.

Four comorbidities were analyzed as possible risk factors for complications, but only previous spinal surgery showed statistically significant difference, with an Odds Ratio of 8.16 (95% CI: 1.27 - 60.45;  $p = 0.013$ ). Patients without previous surgery presented 2.6% complications, while 18.2% of patients with previous surgery presented complications.

On the other hand, for pain recurrence, BMI showed statistically significant difference ( $p = 0.024$ ). Patients without pain return had an average BMI of 27.3 kg/m<sup>2</sup>, while patients with pain recurrence had an average BMI of 29.4 kg/m<sup>2</sup>.

Comparing the access routes, the recurrence rate (of hernia or symptoms) was 12.5% in the interlaminar route versus 31.0% in the transforaminal route, with an odds ratio of 3.15 (95% CI: 1.33-7.4;  $p = 0.0075$ ), while the complication rate was 1.25% and 10.34% respectively, with an odds ratio of 9.11 ( $p = 0.025$ ).

Of the complications, the interlaminar route presented only 1 case of insufficient decompression, while the transforaminal route presented 4 cases of insufficient decompression, 1 case of dural injury, and 1 case of infection.

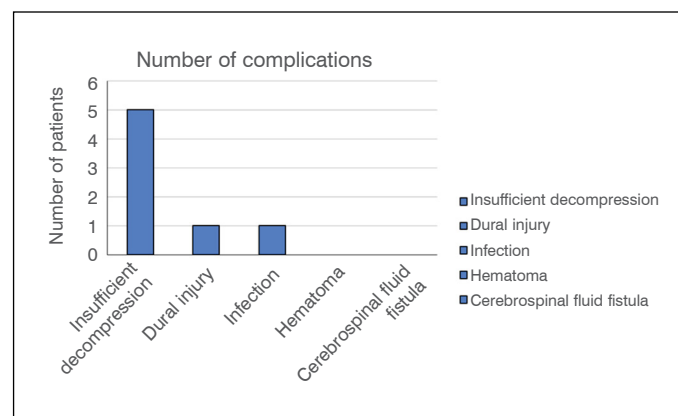


**Figure 2.** Graph highlighting the number of patients affected by surgical complications.

The symptom-free time was on average 162.7 days (SD: 211.1) for the 33 patients who experienced a return of pain, of which, 25% had an immediate return of pain, 50% had a return within 90 days, and 75% had a return within 210 days.

## DISCUSSION

The analysis of pain improvement measured by the VAS showed highly significant results, remaining statistically significant after correction for multiple tests (adjusted  $p = 0.00000368$ ). Patients with an acute episode of pain showed better clinical outcomes compared to the other two groups. Regarding complications and recurrences, there was no statistical evidence among these groups, although there is a possible trend of worse outcomes in patients with chronic pain.

In the literature, the recurrence of symptoms in patients undergoing endoscopic discectomy, requiring new surgery, was 8% in 2 years and 10% in 4 years<sup>11,12</sup>. Our results regarding the need for reoperation after endoscopic discectomy align with these data (10.1%).

Concerning dural injury, this is the most prevalent complication for the studied technique, ranging around 3% to 4.5%<sup>4,11</sup>. In our sample, endoscopic discectomy presented a 0.7% rate of dural injury, lower than the rate reported in the literature. It is safe to conclude that lumbar endoscopic discectomy presents a good safety profile, as illustrated in the literature<sup>13-16</sup>.

When comparing access routes, the transforaminal route presented a 3.15 times greater chance of recurrence (of the hernia or symptoms) compared to the interlaminar route, achieving a statistically significant difference ( $p < 0.01$ ). However, since the confidence interval is wide (1.33 to 7.47), the precision of the exact risk can be refined in the presence of a larger sample.

Additionally, the transforaminal route in our study presented a 9.11 times greater chance of complications ( $p < 0.05$ ). It is important to emphasize that the low number of complications in the interlaminar route increases the confidence interval, so this data should be viewed with caution. One might consider that the greater experience of the surgeon with the interlaminar route is responsible for this difference.

These data conflict with those from the researched literature, in which Jitpakdee K, et al<sup>13</sup> found no statistical difference in complications between the two routes and reported an overall complication rate of 11%. Still, the literature seems to favor the greater dural injury in the interlaminar route than in the transforaminal route, as in Lewandowski et al.<sup>14</sup> and Chen J et al.<sup>15</sup>, which was also not proven in our study, despite the low number of complications to ensure a definitive conclusion.

Regarding the infection rate, only one case (0.7%) was observed in our sample. These findings are in line with the results of the multicenter retrospective analysis by Sen et al.<sup>17</sup>, which evaluated 553 cases of endoscopic spine surgery and did not identify any episodes of surgical site infection throughout the series. Thus, the results of the present study corroborate the previous evidence of low infection rates associated with endoscopic spine techniques.

Our data also differ in the recurrence rate of symptoms, which was not significant in the studies by Jitpakdee K and Chen J et al.<sup>13,15</sup>.

Among the comorbidities analyzed as possible risk factors for complications, only previous spine surgery showed a statistically significant difference, with an Odds Ratio of 8.16 (95% CI: 1.27 - 60.45;  $p = 0.013$ ). On the other hand, for pain recurrence, BMI proved to be relevant ( $p = 0.024$ ). In the studies researched, risk factors for complications and symptom recurrence for discectomy were found: advanced age, greater change in Modic, BMI, type 2 diabetes, smoking, and sagittal range of motion<sup>18</sup>, while others found an association only with smoking, disc protrusion, and diabetes<sup>19</sup>.

## CONCLUSIONS

Endoscopic lumbar spine surgery through its different access routes is established as a safe, effective procedure with a low complication rate for the treatment of lumbar disc herniation. The most favorable clinical and surgical outcomes are closely linked to the patient's profile and their pain characteristics, as well as the type of pathology that will be addressed by the procedure.

## CONFLICT OF INTEREST

All authors declare no potential conflict of interest related to this article.

## CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. RAS: Conceptualization, data curation, methodology, resources; Writing - Original Draft SJP: Conceptualization, data curation, methodology, resources, Writing - Original Draft. CIE: Methodology, Supervision, Validation, Writing - Review and Editing. HAR: Visualization, Supervision, Writing - Review and Editing. DJM: Data curation, Supervision, Writing - Review and Editing. SADH: Visualization, Supervision, Writing - Review and Editing.

## DATA AVAILABILITY DECLARATION

The underlying contents of the research text are contained in the manuscript

## REFERENCES

1. Dagenais S, Caro J, Haldeman S. A systematic review of low back pain cost of illness studies in the United States and internationally. *Spine J*. 2008;8(1):8-20. doi: 10.1016/j.spinee.2007.10.005.
2. Tosteson AN, Tosteson TD, Lurie JD, Abdu W, Herkowitz H, Andersson G, et al. Comparative effectiveness evidence from the spine patient outcomes research trial: surgical versus nonoperative care for spinal stenosis, degenerative spondylolisthesis, and intervertebral disc herniation. *Spine (Phila Pa 1976)*. 2011;36(24):2061-8. doi: 10.1097/BRS.0b013e318235457b.
3. Shriver MF, Rubinstein SM, Peul WC, Depauw PR, Vleggeert-Lankamp CL, Seiger A, et al. Full endoscopic versus open discectomy for sciatica: randomised controlled non-inferiority trial. *BMJ*. 2022;376:e065846. doi: 10.1136/bmj-2021-065846.
4. Gadradj PS, Rubinstein SM, Tye EY, Rosenbaum BP, Kshettry VR, Benzel EC, et al. Lumbar microdiscectomy complication rates: a systematic review and meta-analysis. *Neurosurg Focus*. 2015;39(4):E6. doi: 10.3171/2015.7.FOCUS15281.
5. Zhang B, Kong Q, Yan Y, Feng P. Degenerative central lumbar spinal stenosis: is endoscopic decompression through bilateral transforaminal approach sufficient? *BMC Musculoskelet Disord*. 2020;21(1):714. doi: 10.1186/s12891-020-03722-3.
6. Wu F, Kong W, Liao W, Ao J, Ye S, Du Q, et al. Percutaneous Total Endoscopic Resection of Partial Articular Processes for Treatment of Lateral Crypt Stenosis and Lumbar Spinal Stenosis: Technical Report and Efficacy Analysis. *Biomed Res Int*. 2018;2018:9130182. doi: 10.1155/2018/9130182.
7. Kim HS, Raorane HD, Wu PH, Heo DH, Sharma SB, Jang IT. Incidental Durotomy During Endoscopic Stenosis Lumbar Decompression: Incidence, Classification, and Proposed Management Strategies. *World Neurosurg*. 2020;139:e13-e22. doi: 10.1016/j.wneu.2020.01.242.
8. Dowling A, Lewandowski KU, da Silva FHP, Parra JAA, Portillo DM, Giménez YCP. Patient selection protocols for endoscopic transforaminal, interlaminar, and translaminar decompression of lumbar spinal stenosis. *J Spine Surg*. 2020;6(Suppl 1):S120-32. doi: 10.21037/jss.2019.11.07.
9. Chen KT, Choi KC, Song MS, Jabri H, Lokanath YK, Kim JS. Hybrid Interlaminar Endoscopic Lumbar Decompression in Disc Herniation Combined With Spinal Stenosis. *Oper Neurosurg (Hagerstown)*. 2021;20(3):E168-74. doi: 10.1093/ons/opaa360.
10. Bui AT, Trinh GM, Wu MH, Hoang TT, Hu MH, Pao JL. Indications for and Outcomes of Three Unilateral Biptoral Endoscopic Approaches for the Decompression of Degenerative Lumbar Spinal Stenosis: A Systematic Review. *Diagnostics (Basel)*. 2023;13(6):1092. doi: 10.3390/diagnostics13061092.
11. Weinstein JN, Tosteson TD, Lurie JD, Tosteson A, Blood E, Herkowitz H, et al. Surgical versus nonoperative treatment for lumbar spinal stenosis four-year results of the Spine Patient Outcomes Research Trial. *Spine (Phila Pa 1976)*. 2010;35(14):1329-38. doi: 10.1097/BRS.0b013e3181e0f04d.

12. Weinstein JN, Lurie JD, Tosteson TD, Tosteson AN, Blood EA, Abdu WA, et al. Surgical versus nonoperative treatment for lumbar disc herniation: four-year results for the Spine Patient Outcomes Research Trial (SPORT). *Spine (Phila Pa 1976)*. 2008;33(25):2789-800. doi: 10.1097/BRS.0b013e3181818ed8f4.
13. Jitpakdee K, Liu Y, Kotheeranurak V, Kim JS. Transforaminal Versus Interlaminar Endoscopic Lumbar Discectomy for Lumbar Disc Herniation: A Systematic Review and Meta-Analysis. *Global Spine J*. 2023;13(2):575-87. doi: 10.1177/21925682221120530.
14. Lewandrowski KU, Hellinger S, De Carvalho PST, Ramos MRF, Sanchez JAS, Xifeng Zhang, et al. Dural tears during lumbar spinal endoscopy: Surgeon skill, training, incidence, risk factors, and management. *Int J Spine Surg*. 2021;15(2):280-94. doi: 10.14444/8038.
15. Chen J, Jing X, Li C, Jiang Y, Cheng S, Ma J. Percutaneous Endoscopic Lumbar Discectomy for L5/S1 Lumbar Disc Herniation Using a Transforaminal Approach Versus an Interlaminar Approach: A Systematic Review and Meta-Analysis. *World Neurosurg*. 2018;116:412-420. e2. doi: 10.1016/j.wneu.2018.05.075.
16. Wagner R, Haefner M. Indications and Contraindications of Full-Endoscopic Interlaminar Lumbar Decompression. *World Neurosurg*. 2021;145:657-62. doi: 10.1016/j.wneu.2020.08.042.
17. Sen RD, White-Dzuro G, Ruzevick J, Kim CW, Witt JP, Telfeian AE, et al. Intra- and Perioperative Complications Associated with Endoscopic Spine Surgery: A Multi-Institutional Study. *World Neurosurg*. 2018;120:e1054-60. doi: 10.1016/j.wneu.2018.09.009.
18. Jiang L, Xie X, He R, Da J. Analysis of risk factors for post-operative recurrence after percutaneous endoscopic lumbar discectomy in patients with lumbar disc herniation: a meta-analysis. *J Orthop Surg Res*. 2023;18(1):935. doi: 10.1186/s13018-023-04378-0.
19. Huang W, Han Z, Liu J, Yu L, Yu X. Risk Factors for Recurrent Lumbar Disc Herniation: A Systematic Review and Meta-Analysis. *Medicine (Baltimore)*. 2016;95(2):e2378. doi: 10.1097/MD.0000000000002378.