ORIGINAL ARTICLE
MINIMALLY INVASIVE SURGERY
http://dx.doi.org/10.1590/S1808-185120222101259450

PAIN INTENSITY AND FUNCTIONAL STATUS 30 DAYS AFTER SURGERY: DIFFERENCE BETWEEN TRANSFORAMINAL AND INTERLAMINAR PERCUTANEOUS ENDOSCOPIC LUMBAR DISCECTOMIES

INTENSIDADE DA DOR E ESTADO DE FUNCIONALIDADE AOS 30 DIAS DE PÓS-OPERATÓRIO: DIFERENÇA ENTRE A DISCECTOMIA ENDOSCÓPICA LOMBAR PERCUTÂNEA TRANSFORAMINAL E INTERLAMINAR

INTENSIDAD DEL DOLOR Y ESTADO FUNCIONAL A LOS 30 DÍAS DEL PROCEDIMIENTO QUIRÚRGICO: DIFERENCIA ENTRE DISCECTOMÍA ENDOSCÓPICA LUMBAR PERCUTÁNEA TRANSFORAMINAL E INTERLAMINAR

CLAUDIO A. G. CASTILHO[1], ROSALINO GUARESCHI JUNIOR[1], OLIVER DAMIANI MEYER[1], SÉRGIO ZYLBERSZTEJN[1], CESAR DALL BELLO[1], NILSON RODINEI RODRIGUES[1], FELIPE LOSS[1], YORITO KISAKI[1]

1. Orthopedic Spinal Surgery Service of the Complexo Hospitalar Santa Casa de Porto Alegre, Porto Alegre, RS, Brazil.

ABSTRACT

Objective: To compare the differences between transforaminal and interlaminar endoscopic approaches in terms of pain intensity and functionality 30 days after the surgical procedure. Methods: A retrospective cohort study, with patients treated by percutaneous interlaminar or transforaminal endoscopic discectomy at the Spine Service of the ISCMPA, in southern Brazil. Data were collected from the patients' electronic medical records by two independent physicians. The clinical outcomes of pain intensity and lumbar functionality were evaluated, respectively, using the visual analogue scale and the Oswestry Disability Index. Results: Thirty-six patients were included in the study, with a mean age of 50.8 ± 15.3 years, 19 (52.8%) of whom were males. As for the clinical outcomes for both transforaminal and interlaminar percutaneous endoscopic approaches, we observed a statistically significant reduction in pain intensity (mean difference of 3.5 points, $p < 0.001$) and a statistically significant improvement in functionality (mean difference of 33.2 points, $p < 0.001$) when we compared the pre- and 30-day postoperative periods, with no significant differences in terms of approaches. The type of technical approach also differed in relation to the patients' age, the location, type, and migration of the herniated disc, and the patient's time in the operating room. Conclusion: There was a similar effect on pain reduction and restoration of lumbar functions, 30 days after percutaneous endoscopic discectomy, in both technical approaches, with no significant differences between them. ***Level of Evidence III; Retrospective comparative study.***

Keywords: Discectomy, Percutaneous; Spine; Low Back Pain.

RESUMO

Objetivo: Comparar as diferenças entre as abordagens endoscópicas transforaminal e interlaminar quanto à intensidade da dor e a funcionalidade 30 dias depois do procedimento cirúrgico. Métodos: Estudo de coorte retrospectivo, com pacientes tratados por discectomia endoscópica percutânea interlaminar ou transforaminal, em acompanhamento no Serviço de Coluna da ISCMPA, sul do Brasil. Os dados foram coletados do prontuário eletrônico dos pacientes por dois médicos independentes. Os desfechos clínicos de intensidade de dor e funcionalidade lombar foram avaliados, respectivamente, pela pontuação da escala visual analógica e do Oswestry Disability Index. Resultados: Trinta e seis pacientes foram incluídos no estudo; a média de idade foi 50,8 ± 15,3 anos, sendo 19 (52,8%), do sexo masculino. Quanto aos desfechos clínicos, observou-se diferença estatisticamente significativa para as abordagens endoscópicas percutânea transforaminal e interlaminar na redução da intensidade da dor (média da diferença 3,5 pontos, $p < 0,001$) e na melhora da funcionalidade (média da diferença 33,2 pontos, $p < 0,001$) quando comparados os momentos pré e em 30 dias pós-operatórios, sem diferença significativa com relação às abordagens. O tipo de abordagem técnica diferiu também com relação à idade dos pacientes, à localização, ao tipo e à migração da hérnia de disco e ao tempo do paciente em sala cirúrgica. Conclusões: Observou-se efeito semelhante na redução da dor e na restauração das funções lombares, 30 dias depois da discectomia endoscópica percutânea, em ambas as abordagens técnicas, sem diferenças significativas entre si. ***Nível de Evidência III; Retrospectivo comparativo****.*

Descritores: *Discectomia Percutânea; Coluna Vertebral; Dor Lombar.*

Study conducted at the Complexo Hospitalar Santa Casa de Porto Alegre. Porto Alegre, RS, Brazil.
Correspondence: Cláudio Alan Garcia Castilho. Rua Valdir Antônio Lopes, 199, apto 809 – Bairro Três Figueiras. Porto Alegre, Rio Grande do Sul, Brasil. 90470-245. castilhoclaudio@icloud.com

Received on 12/21/2021 accepted on 02/09/2022
Reviewed by: Dr. Jorge Manuel A. Draper Mineiro

RESUMEN

Objetivos: Comparar las diferencias entre los abordajes endoscópicos transforaminal e interlaminar en cuanto a la intensidad y funcionalidad del dolor a los 30 días del procedimiento quirúrgico. Métodos: Estudio de cohorte retrospectivo, con pacientes tratados por discectomía endoscópica percutánea interlaminar o transforaminal, en acompañamiento en el Servicio de Columna – ISCMPA, sur de Brasil. Los datos fueron recopilados de las historias clínicas electrónicas de los pacientes por dos médicos independientes. Los resultados clínicos de la intensidad del dolor y la funcionalidad lumbar se evaluaron, respectivamente, utilizando la escala visual analógica y el Oswestry Disability Index. Resultados: Se incluyeron en el estudio 36 pacientes, con una edad promedio de 50,8 ± 15,3 años, 19 (52,8%) varones. En cuanto a los resultados clínicos, se observó una diferencia estadísticamente significativa para los enfoques endoscópicos percutáneos transforaminal e interlaminar en la reducción de la intensidad del dolor (diferencia media 3,5 puntos, p <0,001) y en la mejora de la funcionalidad (diferencia media 33,2 puntos, p <0,001) al comparar los períodos preoperatorios y postoperatorios a los 30 días, sin diferencia significativa en cuanto a los enfoques. El tipo de enfoque técnico también difirió con respecto a la edad de los pacientes, la ubicación, el tipo y la migración de la hernia de disco, y el tiempo del paciente en el quirófano. Conclusiones: Hubo un efecto similar en la reducción del dolor y la restauración de las funciones lumbares, 30 días después de la discectomía endoscópica percutánea, en ambos enfoques técnicos, sin diferencias significativas entre ellos. ***Nivel de Evidencia III; Estudio retrospectivo comparativo.***

Descriptores*: Discectomía Percutánea; Columna Vertebral; Dolor de la Región Lumbar.*

INTRODUCTION

The surgical technique has undergone constant changes over the years.[1–7] The surgical options include open discectomy, microdiscectomy, microendoscopic discectomy, and percutaneous endoscopic lumbar discectomy.[8] Currently, microdiscectomy is considered the gold standard procedure for the treatment of lumbar disc herniation.[9,10] However, minimally invasive spinal surgery has been highlighted in recent years.[11,12] There are different approach strategies based on the morphology and the location of the herniated disc.[1,2,13,14] The technical approaches include the transforaminal and interlaminar percutaneous endoscopic discectomies.[3,5,15,16]

The transforaminal endoscopic approach allows the resection of disc herniations located in the foramen or in the lateral recess ventral to the transversal nerve root and is generally applied to spinal segments between L5 and S1,[6,14,17,18] but also allows access to central disc herniations. The interlaminar endoscopic approach is indicated for resections of subarticular disc herniations, particularly in L4/L5 and L5/S1.[19,20] The interlaminar approach is believed to have an advantage over the transforaminal approach in migrated lumbar disc herniations.[21] However, this approach can reach the herniated disc tissue through the spinal canal, which can increase the risk of epidural fibrosis and the formation of scar tissue.[22]

Even though total endoscopic discectomy can be performed by interlaminar and transforaminal approaches, it is difficult to determine which one is better in the treatment of lumbar disc herniations. In some cases, sufficient decompression for a herniated disc in L5-S1 could be difficult to achieve via transforaminal access; in these cases, the interlaminar approach is preferred.[23] Ruetten et al.,[24] were the first to perform discectomy and decompression of the intervertebral disc, creating a foramen in the vertebral canal between the upper and lower vertebral discs. Several studies have compared the efficacies of both techniques, but the results continue to be inconsistent.[5,25–27] In addition, the lack of a standard to assist in deciding on an endoscopic approach, especially in relation to disc herniations at the L5-S1 level, remains a problem in surgical practice.

Thus, the objective of the present study was to compare the differences between the transforaminal and interlaminar endoscopic approaches in terms of pain intensity and functionality 30 days after the surgical procedure and, secondly, to evaluate the relationship between the approaches and the sociodemographic and surgical variables.

METHODS

Design

Retrospective cohort study.

Population

Patients diagnosed with disc herniation, who underwent percutaneous endoscopic lumbar discectomy, between January 2019 and October 2020, and follow-up at the Spinal Surgery Service of the Complexo Hospitalar Irmandade Santa Casa de Misericórdia de Porto Alegre (ISCMPA), Brazil, were included.

To establish the diagnosis, the patients routinely undergo an imaging exam (magnetic resonance or computed tomography), which identifies the type of disc herniation, the vertebral segment, and the laterality corresponding to the radicular signs and symptoms. Surgical treatment is considered for patients with radicular pain, signs of radiculopathy, with evidence of nerve root compression, when a minimum of six weeks of conservative treatment (physiotherapy, medication with anti-inflammatory agents and opioids, corticosteroid injections) was not effective.

The exclusion criteria were as follows: 1) upper lumbar disc disease (L2/L3 or higher), 2) previous disc prolapse, 3) previous spinal surgery, 4) spondylolisthesis, 5) moderate/severe spinal stenosis, 6) incomplete clinical data in the electronic data system.

Variables

The sociodemographic variables included sex and age, while the clinical variables included presence of neuropathy, pain intensity, evaluated by administration of the analog visual scale (VAS), and functional status, measured by the Oswestry index (ODI). The ODI score varies from 0 to 100, with the higher scores indicating greater disability related to pain, while the VAS scores range from 0 to 10, where the more intense the pain, the higher the score.

The variables related to the surgical procedure and type of lumbar herniation were as follows: technical approach of the percutaneous endoscopic discectomy (interlaminar or transforaminal), type of disc herniation (central, subarticular, foraminal, and extraforaminal), laterality, migration of the herniation evaluated in the sagittal plane (without migration, cranial migration or caudal migration), surgical segment (L3-L4, L4-L5, L5-S1), and time the patient remained in the operating room.

Surgical techniques

Transforaminal endoscopic lumbar discectomy

This is considered the traditional approach for the total endoscopic lumbar discectomy. First, the patient is placed in the prone position and undergoes local anesthesia and conscious sedation. Then, the distance from the incision in the skin is planned, depending on the patient's body size, the location of the disc herniation, and the foraminal dimensions, being approximately 8 cm in L3/L4, 10 cm in L4/L5, and 12 cm in L5/S1. After confirming the ideal positioning of the puncture needle, a skin incision and dilation of the soft tissues are performed. Keeping the guidewire in place, foraminoplasty is performed using a bone drill to widen the intervertebral foramen. The working cannula is then introduced. Disc forceps are used to remove the disc herniation, and bipolar probes are used to clot bleeding points. The decompression is considered sufficient when all the herniated mass has been removed and the pulsation of the dural sac has been confirmed under endoscopic vision (Figure 1A).

Interlaminar endoscopic lumbar discectomy

This technique is performed under general anesthesia, with the patient in the ventral position. It consists of the introduction of an endoscope through an entry point at the lateral edge of the interlaminar space on the side of the lesion in the anteroposterior view and parallel to the disc space in the lateral view. Then, a dilator is introduced and fitted into the interlaminar space. A cannula is introduced into the epidural space through an opening in the yellow ligament so the margin of the nerve root is reached. After slight retraction of the nerve root, the peridural dissection is performed. Then, the protruding disc pieces are found and removed using disc tweezers (Figure 1B).

Logistics

The radiological exams for diagnosis of the lumbar disc herniation were reviewed by two independent radiologists with at least two years of experience.

Data were collected from the electronic patient medical records by two independent physicians.

Patients who undergo lumbar disc herniation surgery are routinely followed up in both pre- and postoperative consultations at outpatient clinics. During these consultations, the patients are assessed clinically and pain intensity and functionality questionnaires, previously developed by the ISCMPA Surgery Service are administered. These results are recorded in the patients' electronic medical records.

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences program, version 22.0 for Windows (SPSS Inc., Chicago, IL, USA).

The Shapiro-Wilk test was used to evaluate the normality of all the parameters. The continuous variables were described as mean and standard deviation or median and interquartile interval, while the categorical variables were described as absolute and relative frequencies.

The comparative analysis between the transforaminal and interlaminar endoscopic lumbar discectomies was performed according to type and data distribution. For quantitative data with normal distribution, the differences between groups were evaluated using the independent samples t test, and differences between pre- and postoperative data within the groups were evaluated using the paired sample t test. The qualitative data were analyzed using the chi-square, using the Yates' correction or Fisher's exact test if needed.

All the statistical tests used were two-tailed and a level of significance of 5% was established.

Ethics

This study was approved by the Institutional Review Board of the Irmandade Santa Casa de Misericórdia de Porto Alegre (no. 4380117) and complied with all the Declaration of Helsinki norms for studies in humans. The informed consent form was waived as this was a retrospective longitudinal study. All the researchers signed a declaration of confidentiality for both patient and study data.

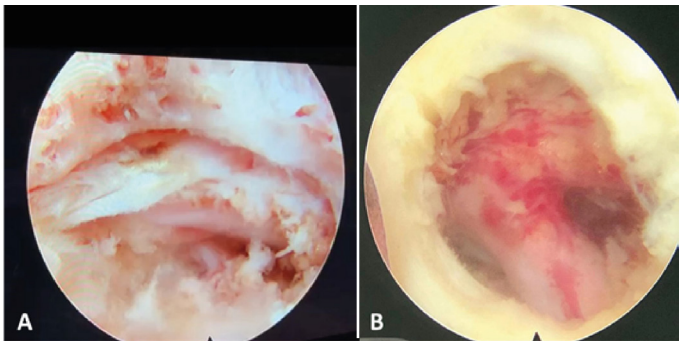

Figure 1. Percutaneous endoscopic lumbar discectomy. A) Transforaminal. B) Interlaminar.

RESULTS

Thirty-six individuals, with a mean age of 50.8 ± 15.3 years, 19 (52.8%) of whom were male, were included in the study. The overall sample characteristics are shown in Table 1.

Table 2 shows the differences between the two percutaneous endoscopic discectomy approaches and the demographic and surgical variables. There was a statistically significant difference in relation to the age of the patients, the locations, and the type and migration of the disc herniation. No significant differences were observed for any of the other variables.

The mean difference in visual analog scale scores reflected a reduction of 3.5 points (CI 95%, 2.5 – 4.6, $p < 0.001$), decreasing from a mean of 7 ± 1.5 points in the preoperative period to 3.5 ± 2.6 points following surgery. The Oswestry index dropped by an average of 33.2 points (CI 95%, 27.2 – 39.3, $p < 0.001$), with mean values of 54.2 ± 21.8 and 20.9 ± 16.5 points in the pre- and postoperative periods, respectively.

Table 3 shows the mean differences in both scales for both transforaminal and interlaminar approaches. Despite the 30-day postoperative clinical improvement for both approaches, no statistically significant difference between the techniques was observed, either in pain intensity ($p = 0.051$ and $p = 0.456$, respectively) or functionality ($p = 0.198$ and $p = 0.844$, respectively).

The patient spent an average of 203 ± 40.2 and 182 ± 45.7 minutes in the operating room for the transforaminal and interlaminar approaches, respectively. No peri- or postoperative complications, such as dislocation, dural rupture, nerve root injury, or infections, were observed. In addition, none of the patients used analgesics, such as opioids, during the recovery period. All the patients were discharged soon after anesthetic recovery, with no need for readmission to the hospital.

Table 1. Overall samples characteristics.

Variables	N = 36
Age (years), mean ± SD	50.8 ± 15.3
Sex, n (%)	
Male	19 (52.8)
Comorbidities, n (%)	
Neuropathy	14 (48.3)
Percutaneous endoscopic lumbar discectomy, n (%)	
Interlaminar	21 (58.3)
Transforaminal	15 (41.7)
Location of the lesion, n (%)	
L3 – L4	5 (13.9)
L4 – L5	14 (38.9)
L5 – S1	17 (47.2)
Laterality, n (%)	
Right	15 (41.7)
Left	21 (58.3)
Type of disc herniation, n (%)	
Central	8 (22.2)
Foraminal	10 (27.8)
Subarticular	17 (47.2)
Extraforaminal	1 (2.8)
Migration of disc herniation, n (%)	
Without migration	18 (50)
Cranial migration	13 (36.1)
Caudal migration	5 (13.9)
Time in the operating room (min), mean ± SD	191 ± 44
Visual analog scale, mean ± SD	
Preoperative	7.0 ± 1.5
Postoperative	3.5 ± 2.6
Oswestry disability index, mean ± SD	
Preoperative	54.2 ± 21.8
Postoperative	20.9 ± 16.6

N = sample size; SD = standard deviation; L = lumbar; S = sacral.

Table 2. Differences between transforaminal and interlaminar percutaneous endoscopic discectomies.

	Transforaminal (N = 15)	Interlaminar (N = 21)	p-value
Age (years) mean ± SD	57.2 ± 16.1	46.3 ± 13.4	0.049
Males, n (%)	9 (60)	10 (47.6)	0.347
Location of the lesion, n (%)			< 0.001
L3 – L4	5 (33.3)	0 (0)	
L4 – L5	10 (66.7)	4 (19)	
L5 – S1	0 (0)	17 (81)	
Left laterality, n (%)	7 (46.7)	14 (66.7)	0.196
Type of disc herniation, n (%)			<0.001
Central	0 (0)	8 (38.1)	
Foraminal	10 (66.7)	(0)	
Subarticular	4 (26.7)	13 (61.9)	
Extraforaminal	1 (6.7)	0 (0)	
Migration of disc herniation (%)			0.001
Without migration	13 (86.7)	5 (23.8)	
Cranial migration	0 (0)	5 (23.8)	
Caudal migration	2 (13.3)	11 (52.4)	
Time in the operating room (min), mean ± SD	203 ± 40.2	182 ± 45.7	0.167

N = sample size; SD = standard deviation; L = lumbar; S = sacral.

Table 3. Mean differences between preoperative and 30-day postoperative pain intensity and functional status by percutaneous endoscopic lumbar discectomy technical approach.

	Mean difference	CI 95%	p-value
Interlaminar			
Visual analog scale	4.3	3.2 – 5.3	<0.001
Oswestry disability index	36.8	29.2 – 44.3	<0.001
Transforaminal			
Visual analog scale	2.5	0.2 – 4.8	0.032
Oswestry disability index	28.2	17.7 – 38.7	<0.001

CI = confidence interval.

DISCUSSION

In the present study, we observed a reduction in pain intensity and an improvement in functionality thirty days following surgery, with no statistically significant difference between the two percutaneous endoscopic discectomy approaches. There were differences between the access techniques for the variables of patient age, the herniation location, type, and migration, and the time the patient remained in the operating room.

The significant improvements in pain intensity and functionality for both percutaneous endoscopic approaches have also been reported by other researchers.[5,18-20,28] Although there was no significant difference between the techniques, recent studies suggest adopting the interlaminar technique because it presents results similar to those of the transforaminal approach, but with the advantage of a wider anatomical space, reducing surgical time and, consequently, radiation exposure for the patient and the team.[5,19,29] In addition, this technique has been shown to preserve most of the yellow ligament and reduce adhesion formation in the epidural scar.[30] Another strong point is that it can be easily used by surgeons with experience in microendoscopic discectomy, since they are very similar techniques.

On the other hand, discectomy performed using the transforaminal approach endoscopic technique requires greater vigilance against possible vascular and visceral organ injuries.[31] In addition, in cases of disc herniation at the L5-S1 level, the high iliac crest and narrow foramen determine the difficulty of the technique via this approach.[28]

Both techniques present minimal traumatization, faster rehabilitation, and less intraspinal adhesion, as well as easier revision operations.[24,30-33] In addition, a recent study suggests an approach combining both techniques for disc herniations with a high potential for migration as an alternative option for these patients.[29]

All the study patients successfully completed the surgery and the 30-day postoperative period without complications. These include infection, spinal cord injury, cerebrospinal fluid leakage, nerve root damage, and postoperative sensory abnormalities.[13,18]

The present study has several limitations. First, it was a retrospective cohort study with data limited to the protocols routinely used in ISCMPA outpatient consultations. Second, there was no control group, that is, patients treated with open lumbar discectomy or microdiscectomy. Third, only the operating room time was recorded, that is, the time from the moment the patient arrived in the operating room until the moment they were released to the recovery room, and not the surgical time. Finally, the study only evaluated one postoperative moment. However, it is important to emphasize that the main objective of this study was to evaluate the difference in pain intensity and changes in lumbar functionality in relation to the type of surgical approach in the first month following percutaneous endoscopic discectomy.

CONCLUSION

In conclusion, a similar effect was observed in pain reduction and recovery of lumbar function 30 days after percutaneous endoscopic discectomy using both technical approaches, with no significant differences between them. Future studies with larger sample sizes and follow-up times, are still necessary.

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

CONTRIBUTIONS OF THE AUTHORS: Each author made significant individual contributions to this manuscript. CAGC and RGJ: conception of the topic, design of the research project, data collection, statistical analysis, writing, review, and final approval of the work; ODM: data collection, active participation in the discussion of results, review, and final approval of the work; SZ: conception of the topic, writing, and final review; CDB, NRR, FL, and YK: conception of the project, surgeries, discussion of the results, writing, review, and final approval of the work.

REFERENCES

1. Pan M, Li Q, Li S, Mao H, Meng B, Zhou F, et al. Percutaneous Endoscopic Lumbar Discectomy: Indications and Complications. Pain Physician. 2020;23(1):49–56. Available from: http://www.ncbi.nlm.nih.gov/pubmed/32013278
2. Sivakanthan S, Hasan S, Hofstetter C. Full-Endoscopic Lumbar Discectomy. Neurosurg Clin N Am. 2020;31(1):1–7. Available from: https://doi.org/10.1016/j.nec.2019.08.016
3. Song H, Hu W, Liu Z, Hao Y, Zhang X. Percutaneous endoscopic interlaminar discectomy of L5–S1 disc herniation: a comparison between intermittent endoscopy technique and full endoscopy technique. J Orthop Surg Res. 2017;12(1):162. Available from: http://josr-online.biomedcentral.com/articles/10.1186/s13018-017-0662-4
4. Xu G, Zhang C, Zhu K, Bao Z, Zhou P, Li X. Endoscopic removal of nucleus pulposus of intervertebral disc on lumbar intervertebral disc protrusion and the influence on inflammatory factors and immune function. Exp Ther Med. 2019;301–7. Available from: http://www.spandidos-publications.com/10.3892/etm.2019.8223
5. Zhao Y, Fan Y, Yang L, Ni H, Wang C, He S, et al. Percutaneous Endoscopic Lumbar Discectomy (PELD) via a Transforaminal and Interlaminar Combined Approach for Very Highly Migrated Lumbar Disc Herniation (LDH) Between L4/5 and L5/S1 Level. Med Sci Monit. 2020;26:e922777.
6. Ahn Y, Lee SG, Son S, Keum HJ. Transforaminal endoscopic lumbar discectomy versus open lumbar microdiscectomy: A comparative cohort study with a 5-year follow-up. Pain Physician. 2019;22(3):295–304.
7. Benlidayi IC, Başaran S, Seydaoğlu G. Lumbosacral morphology in lumbar disc herniation: a chicken and egg issue. ACTA Orthop Traumatol Turc. 2016;50(3):346–50. Available from: http://www.aott.org.tr/en/lumbosacral-morphology-in-lumbar-disc-herniation-a-chicken--and-egg-issue-133737
8. Wang B. Clinical Outcome of Full-endoscopic Interlaminar Discectomy for Single-level Lumbar Disc Herniation: A Minimum of 5-year Follow-up. Pain Physician. 2017;20(3):E425–30.

Available from: https://painphysicianjournal.com/current/pdf?article=NDMxNw%3D%3D&journal=104
9. Kreiner DS, Hwang SW, Easa JE, Resnick DK, Baisden JL, Bess S, et al. An evidence-based clinical guideline for the diagnosis and treatment of lumbar disc herniation with radiculopathy. Spine Journal. 2014;14(1):180-91.
10. Riesenburger RI, David CA. Lumbar microdiscectomy and microendoscopic discectomy. Minim Invasive Ther Allied Technol. 2006;15(5):267–70. Available from: http://www.tandfonline.com/doi/full/10.1080/13645700600958432
11. Schoenfeld AJ, Weiner BK. Treatment of lumbar disc herniation: Evidence-based practice. Int J Gen Med. 2010;3:209–14.
12. Rasouli MR, Rahimi-Movaghar V, Shokraneh F, Moradi-Lakeh M, Chou R. Minimally invasive discectomy versus microdiscectomy/open discectomy for symptomatic lumbar disc herniation. Cochrane Database Syst Rev. 2014;(9):CD010328. Available from: http://doi.wiley.com/10.1002/14651858.CD010328.pub2
13. Kim M, Lee S, Kim H-S, Park S, Shim S-Y, Lim D-J. A Comparison of Percutaneous Endoscopic Lumbar Discectomy and Open Lumbar Microdiscectomy for Lumbar Disc Herniation in the Korean: A Meta-Analysis. Biomed Res Int. 2018;2018:9073460. Available from: https://www.hindawi.com/journals/bmri/2018/9073460/
14. Kapetanakis S, Chaniotakis C, Angoules AG. Full Endoscopic Discectomy Using Transforaminal Endoscopic Spine System Technique: A Mini Review of Complications. Open Orthop J. 2019;13(1):76–83. Available from: https://openorthopaedicsjournal.com/VOLUME/13/PAGE/76/
15. Yoon SM, Ahn S-S, Kim KH, Kim YD, Cho JH, Kim D-H. Comparative Study of the Outcomes of Percutaneous Endoscopic Lumbar Discectomy and Microscopic Lumbar Discectomy Using the Tubular Retractor System Based on the VAS, ODI, and SF-36. Korean J Spine. 2012;9(3):215-22. Available from: http://e-kjs.org/journal/view.php?doi=10.14245/kjs.2012.9.3.215
16. Sinkemani A, Hong X, Gao Z-X, Zhuang S-Y, Jiang Z-L, Zhang S-D, et al. Outcomes of Microendoscopic Discectomy and Percutaneous Transforaminal Endoscopic Discectomy for the Treatment of Lumbar Disc Herniation: A Comparative Retrospective Study. Asian Spine J. 2015;9(6):833. Available from: http://asianspinejournal.org/journal/view.php?doi=10.4184/asj.2015.9.6.833
17. Chen P, Hu Y, Li Z. Percutaneous endoscopic transforaminal discectomy precedes interlaminar discectomy in the efficacy and safety for lumbar disc herniation. Biosci Rep. 2019;39(2):1–11. Available from: https://portlandpress.com/bioscirep/article/doi/10.1042/BSR20181866/110894/Percutaneous-endoscopic-transforaminal-discectomy
18. Ahn Y, Lee U, Kim W-K, Keum HJ. Five-year outcomes and predictive factors of transforaminal full-endoscopic lumbar discectomy. Medicine (Baltimore). 2018;97(48):e13454. Available from: http://journals.lww.com/00005792-201811300-00086
19. Du J, Tang X, Jing X, Li N, Wang Y, Zhang X. Outcomes of percutaneous endoscopic lumbar discectomy via a translaminar approach, especially for soft, highly down-migrated lumbar disc herniation. Int Orthop. 2016;40(6):1247–52. Available from: http://dx.doi.org/10.1007/s00264-016-3177-4
20. Hua W, Tu J, Li S, Wu X, Zhang Y, Gao Y, et al. Full-endoscopic discectomy via the interlaminar approach for disc herniation at L4-L5 and L5-S1. Medicine (Baltimore). 2018;97(17):e0585. Available from: http://journals.lww.com/00005792-201804270-00085
21. Chiu C-C, Chuang T-Y, Chang K-H, Wu C-H, Lin P-W, Hsu W-Y. The probability of spontaneous regression of lumbar herniated disc: a systematic review. Clin Rehabil. 2015;29(2):184–95. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25009200
22. Aydın Y, Ziyal IM, Duman H, Türkmen CS, Başak M, Şahin Y. Clinical and radiological results of lumbar microdiskectomy technique with preserving of ligamentum flavum comparing to the standard microdiskectomy technique. Surg Neurol. 2002;57(1):5–13. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0090301901006772
23. Mo X, Shen J, Jiang W, Zhang X, Zhou N, Wang Y, et al. Percutaneous Endoscopic Lumbar Diskectomy for Axillar Herniation at L5-S1 via the Transforaminal Approach Versus the Interlaminar Approach: A Prospective Clinical Trial. World Neurosurg. 2019;125:e508–14. Available from: https://linkinghub.elsevier.com/retrieve/pii/S187887501930213X
24. Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: A prospective, randomized, controlled study. Spine (Phila Pa 1976). 2008;20;33(9):931-9.
25. Choi K-C, Lee J-H, Kim J-S, Sabal LA, Lee S, Kim H, et al. Unsuccessful Percutaneous Endoscopic Lumbar Discectomy. Neurosurg. 2015;76(4):372–81. Available from: https://academic.oup.com/neurosurgery/article/76/4/372/2452227
26. Hua W, Zhang Y, Wu X, Gao Y, Li S, Wang K, et al. Outcomes of discectomy by using full-endoscopic visualization technique via the interlaminar and transforaminal approaches in the treatment of L5-S1 disc herniation. Medicine (Baltimore). 2018;97(48):e13456. Available from: http://journals.lww.com/00005792-201811300-00087
27. Yörükoğlu AG, Göker B, Tahta A, Akçakaya MO, Aydoseli A, Sabancı PA, et al. Fully endoscopic interlaminar and transforaminal lumbar discectomy: Analysis of 47 complications encountered in a series of 835 patients. Neurocirugia (Astur). 2017;28(5):235–41. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1130147317300556
28. Nie H, Zeng J, Song Y, Chen G, Wang X, Li Z, et al. Percutaneous Endoscopic Lumbar Discectomy for L5–S1 Disc Herniation Via an Interlaminar Approach Versus a Transforaminal Approach. Spine. 2016;41(Suppl 19):B30–7. doi:10.1097/brs.0000000000001810
29. Zhou Z, Ni H, Zaho W, Gu G, Chen J, Zhu Y, et al. Meta-analysis of the operative treatment of lumbar disc herniation via transforaminal percutaneous endoscopic discectomy versus interlaminar percutaneous endoscopic discectomy in randomized trials. Orthopaedic Surgery 2021;13:979–988.
30. Li ZZ, Hou SX, Shang WL, Song KR, Zhao HI. The strategy and early clinical outcome of full-endoscopic l5/s1 discectomy through interlaminar approach. Clin Neurol Neurosurg. 2015;133:40–5.
31. Sencer A, Yorukoglu AG, Akcakaya MO, Aras Y, Aydoseli A, Boyali O, et al. Fully endoscopic interlaminar and transforaminal lumbar discectomy: short-term clinical results of 163 surgically treated patients. World Neurosurg. 2014;82(5):884–90.
32. Ruetten S, Komp M, Merk H, Godolias G. Recurrent lumbar disc herniation after conventional discectomy: a prospective, randomized study comparing full-endoscopic interlaminar and transforaminal versus microsurgical revision. J Spinal Disord Tech. 2009;22(2):122–9.
33. Ruetten S, Komp M, Merk H, Godolias G. Use of newly developed instruments and endoscopes: full-endoscopic resection of lumbar disc herniations via the interlaminar and lateral transforaminal approach. J Neurosurg Spine. 2007;6(6):521–30.