

Comparative Analysis Of Clinical Outcomes: Microdiscectomy Outperforms Standard Discectomy In Lumbar Disc Herniation - Findings From A Single-Centre Study

Noor-ul-ain Irfan¹, Asad Javed², Irfan Afzal Mughal³, Asma Irfan⁴, Niaz Ahmed Khan⁵

1. PGT, SZABMU, 2. Assistant Professor, IMDC 3. Professor, RMI 4. Professor IMDC 5. Registrar, PIMS/SZABMU.

Corresponding author: Dr. Asma Irfan, asma.irfan@imdcollge.edu.pk.

Abstract

Objective: To evaluate the outcomes of both conventional laminectomy and microscopic laminectomy, performed by the same surgeon, using a prospective study design.

Methods: An interventional study was conducted at Akbar Niazi Teaching Hospital ANTH for 2 years. The total Sample Size was 120 by random sampling. Patients were divided into two groups. All required information, including past medical history, was collected through a questionnaire. For clinical diagnosis and assessment, an MRI was done. In Group A, 60 patients underwent surgery by standard laminectomy (SD) and 60 patients were treated by microdiscectomy surgery (MD). The chi-square test was applied to determine statistical findings, and a p-value less than 0.05 was taken as significant.

Results: Analyses of the parameters' mean VAS values of lumbar and leg pain postoperatively, and within one month after surgery, demonstrated statistically significant differences between standard and microdiscectomy ($p < 0.05$). LDH surgical techniques have become more and more sophisticated over the last 40 years, but without a substantial improvement in the functional and clinical results. Appropriate patient selection is a crucial factor for the postoperative outcome. Neurosurgeons should fully master the chosen technique for satisfactory postoperative results.

Conclusion: The study's results show statistically significantly better functional outcomes of the MD technique (VAS lumbar and leg pain), a safe and efficient procedure with minimal blood loss, shorter procedure times, and reduced pain, indicating that MD techniques can yield better results.

Keywords: Laminectomy, Minimally Invasive Surgical Procedures, Radicular Pain, Postoperative Pain, Treatment Outcome, Recurrence, Visual Analogue Scale

Introduction

When conservative treatment for lumbar disc herniation (LDH) does not yield satisfactory results, referral for neurosurgical treatment may be necessary.¹ Typically, a decision for surgery is made within 4-6 weeks. Surgery can often quickly relieve pain symptoms and restore patient functions. The optimal surgical technique for LDH remains a topic of debate.² However, our clinic has found two discectomy methods to be quite effective: standard open discectomy (SD) and microdiscectomy (MD). Various retrospective studies have demonstrated the superiority of one technique over another. Most studies consider microdiscectomy as the gold standard for the surgical treatment of symptomatic disc herniation.³ Our focus has been on examining the clinical aspects and correlations of surgical treatment for LDH as presented in existing literature, of a smaller incision and facilitating a less traumatic procedure.³ Williams published the first clinical results in 1979. He reported a very good outcome after the microsurgical technique.⁴ Several authors have reported a shorter length of stay and quicker return to work in patients treated with microsurgical techniques; however, these advantages have recently been questioned.

Contributions:

N.I, I.A.M, A.I, N.A.K - Conception of study
- Experimentation/Study Conduction
N.I, A.J - Analysis/Interpretation/Discussion
A.J - Manuscript Writing
N.I, I.A.M, A.I, N.A.K - Critical Review

All authors approved the final version to be published & agreed to be accountable for all aspects of the work.

Conflicts of Interest: None

Financial Support: None to report

Potential Competing Interests: None to report

Institutional Review Board Approval

106/MDC/IRB-2023

15-05-2023

Islamabad Medical and Dental College

Review began 10/01/2024

Review ended 10/03/2025

Published 30/06/2025

© Copyright 2025

Irfan et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY-SA 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.



How to cite this article: Irfan N ul ain, Javed MA, Mughal IA, Irfan A, Khan NA. A Comparative Analysis of Clinical Outcomes: Microdiscectomy Outperforms Standard Discectomy in Lumbar Disc Herniation - Findings from a Single-Center Study. JRMCI. 2025 Jun. 30;29(2).

<https://doi.org/10.37939/jrmc.v29i2.2490>

Other authors have reported no difference in long-term results; however, a short-term advantage to microsurgery was found.⁵ There has not been a significant number of prospective studies conducted to compare significantly different techniques.

In the absence of any improvement or deterioration following diverse conservative treatments or in the presence of neurological deficit, surgical treatment is warranted for degenerative lumbar spinal stenosis.⁶ Typically, surgery is performed using a posterior approach for adequate decompression of the stenotic site. If you are considering undergoing spinal surgery, it is important to be aware of the potential risks and complications associated with certain techniques.⁷ One commonly used method, standard laminectomy, may provide adequate decompression but can also result in damage to the posterior structures that support lumbar stability. This damage can lead to postoperative segmental instability, which in turn may require additional fusion surgery.⁸ Another issue with traditional lumbar surgery is the significant trauma it can cause to the paraspinal muscles, even without excessive damage to the facet joints. This trauma can result in chronic lower back pain, reducing your quality of life and causing other complications.⁹ In light of these risks, it is worth considering alternative techniques that may be less invasive and cause fewer complications. Patients should discuss all options with the doctor and the latest advancements in spinal surgery.¹⁰ Remember, taking the time to research and ask questions could ultimately lead to a better outcome and quality of life. Considering undergoing spinal surgery, it is important to be aware of the potential risks and complications associated with certain techniques.¹¹ One commonly used method, standard laminectomy, may provide adequate decompression but can also result in damage to the posterior structures that support lumbar stability. This damage can lead to postoperative segmental instability, which in turn may require additional fusion surgery. Another issue with traditional lumbar surgery is the significant trauma it can cause to the paraspinal muscles, even without excessive damage to the facet joints.¹² This trauma can result in chronic low back pain, reducing quality of life and causing other complications.

In light of these risks, it's worth considering alternative techniques that may be less invasive and cause fewer complications.¹³ It is essential to discuss all available treatment options with your physician and inquire about the latest advancements in spinal surgery that may be most suitable for your specific condition. Taking the time to research and ask informed questions can significantly contribute to better clinical outcomes and an improved quality of life.¹⁴

It is widely believed that standard laminectomy can cause significant damage to the paraspinal muscles, which can ultimately increase spine-related pain. Fortunately, recent studies have shown that microscopic procedures such as microscopic discectomy offer a safer and more effective alternative. With benefits such as reduced spine-related pain, shorter hospital stays, enhanced visualisation of neural elements, and less damage to surrounding tissues, it's no wonder that many patients are now opting for this procedure. However, despite the numerous advantages of microscopic discectomy, no study has yet been done to compare its effectiveness with standard laminectomy in Pakistan. That is why we conducted a comprehensive study to compare the surgical outcomes of these two procedures. Our objective was to evaluate the outcomes of both conventional laminectomy and microscopic laminectomy, performed by the same surgeon, using a prospective study design. By doing so, we aimed to provide patients with valuable information to support informed decision-making regarding their treatment options for spine-related pain.

Materials And Methods

An interventional study was conducted at Akbar Niazi Teaching Hospital ANTH for 2 years. The Sample Size was 120 by random sampling, calculated by Epi Calculator with a two-sided significance level (1-alpha): 95, Power (1-beta, % chance of detecting): 80, Ratio of sample size, Unexposed/Exposed: 1. Patients were randomly divided into two groups, both with 60 patients. Written informed consent was taken before any examination. Only the researchers had access to the patients' information, and it was kept confidential. All required information, including past medical history regarding the patient, was collected through a questionnaire. For clinical diagnosis and assessment, an MRI was done. In Group A, 60 patients underwent surgery by standard laminectomy and 60 patients were treated by microdiscectomy surgery. The mean duration of follow-up was 2 years. The same surgeon performed the operations. Prophylactic antibiotic agents were administered preoperatively in all cases. The patients were given general endotracheal anaesthesia and placed on the operating room table with a Hall frame. A spinal needle was inserted into the appropriate spinous process, and a lateral x-ray film was taken to mark the correct level. The patients were randomly divided into 2 groups by selecting an unmarked envelope, the content of which indicated their treatment group. Standard Laminectomy (SD), which is a surgical procedure to remove a portion of the spine called the lamina, is used to decompress the spinal canal. A skin incision was given on the midline along the lumbodorsal fascia, and the paraspinal muscles were detached from the spinous process, and the lamina was retracted. Decompression was done by removing the lamina, spinous process and ligamentum flavum. Microscopic Discectomy (MD) is a technique that uses a microscopic surgical approach via minimally invasive poke-hole incision to remove a portion of the intervertebral disc, a herniated or protruding portion that is compressing the traversing spinal nerve root. Group A: The length of the skin incision was 5 cm. The fascia incision was of the same length as the 1 in the skin. The smallest possible partial laminectomy with removal of a variable amount of the medial facet was made. The ligamentum flavum was removed, and careful hemostasis was ensured by using bipolar diathermy. An operating microscope was not used. In each case, the disc space itself was entered, and all available disc material was removed.

Group B: The length of the skin incision was 2.5 cm. The fascia incision was of the same length as the 1 in the skin. A periosteal elevator was used to dissect clean the lamina, and a Caspar retractor was placed. An operating microscope was brought into play. The ligamentum flavum was removed. There was no or minimal bone excision and removal of the disc material. In each case, the disc space itself was entered, and all available disc material was removed.

A proforma was made enlisting the following investigations, such as operation time, amount of bleeding, duration of hospitalization, amount of analgesic agent used after surgery, pre-and postoperative scores based on judgment criteria for treatment of lumbar spine disorders established by the visual analog scale (VAS; 0–10) to assess the degree of LBP preoperatively as well as at 6, 12, and 24 months postoperatively. The functional outcomes were evaluated at 6, 12, and 24 months postoperatively using the Roland-Morris Low Back Pain and Disability Questionnaire (RMQ).

Patients with degenerative lumbar spinal stenosis requiring surgery due to neurogenic claudication with radiculopathy were included in the study, along with those with one-level central stenosis requiring decompression, with MRI findings consistent with symptoms on preoperative radiological examination. All these patients who agreed to this study

Patients who underwent spinal surgery in the past, in addition to decompression, patients who needed further segmental fusion surgery, who required multiple segments of decompression surgery (≥ 3 levels), those with cervical lesions other than lumbar level with rapidly progressive neurological deficit and those who cannot cooperate in completing the questionnaire due to dementia or stroke or are suffering from Neuromuscular disorder, Spinal malignancy, spinal infection, etc, were excluded from the study.

Statistical analysis of data was performed using SPSS Version 26 software. A p-value <0.05 will be considered significant. The two types of Discectomies and pre-and post-operative parameters are calculated statistically by applying the chi-square test.

Results

Different types of lumbar disc herniation are shown in Table 1, for which we used two main techniques, SD and MD. There are stark differences between standard open discectomy (SD) and microdiscectomy (MD) procedures as shown in Table 2 and Fig.. The results indicate that MD is a more effective and efficient procedure as compared to SD. Age is a significant factor that affects the outcome of the procedure, with significant differences observed in the distribution of conditions across different age groups. At the same time, there seems to be no correlation between sex and education levels among the groups.

The duration of symptoms is another factor that significantly impacts the outcome of the procedure. The data shows that more patients with longer duration of symptoms underwent MD, which suggests that MD is a more suitable procedure for patients with chronic symptoms. Intraoperative blood loss is also a critical factor that determines the success of the procedure. The data indicates that SD is associated with more blood loss, with 37 patients losing greater than 200ml of blood during the procedure, as compared to only 1 patient in MD.

The procedure duration is another critical factor that patients must consider when choosing between SD and MD. The data shows that SD took more time, with more than 90 minutes taken by 11 patients, while only one patient took that long in MD. Additionally, pre- and post-lumbar pain, leg pain, and other factors significantly impact the outcome of the procedure. The data clearly shows that even one year after the procedure, lumbar and leg pain are significantly higher in SD patients as compared to post-MD patients.

Therefore, based on this data, it is evident that MD is a significantly better procedure than SD. Patients who want a safe and efficient procedure with minimal blood loss, shorter procedure times, and reduced pain should opt for MD.

Table 1- Classification of herniated nucleus pulposus (Carragee four-part system)

Disc herniation type	Surgical treatment
Type 1- Fragment Fissure	Removal of fragments through a slit like annular defect
Type 2- Fragment defect	Removal of fragments through a massive annular defect
Type 3- Fragment contained	An oblique incision in the annulus is performed to remove subannular fragments.
Type 4-No fragment contained	Extensive annulotomy

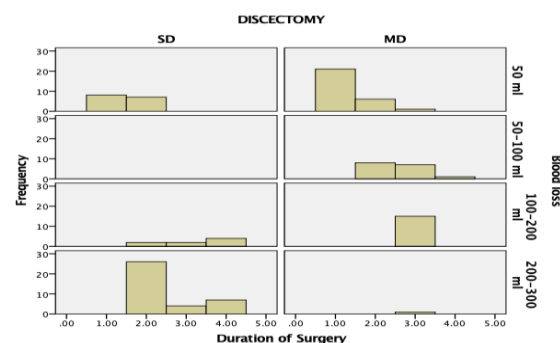


Figure 1: Duration of surgery and Blood loss in patients who underwent standard (SD) and Microdiscectomy (MD).

Table 2: Demographic, pre- and Post-operative parameters in correlation with two types of Discectomies (SD and MD).

S. NO	Parameters	Total n = 120	SD N (%) n = 60	MD N (%) n = 60	P value
Age groups (years)	18- 24	33	10 (30.3)	23 (69.7)	0.00001*
	25-30	41	31 (76)	10 (24)	
	31 - 36	28	13(46.4)	15 (53.6)	
	37 - 42	18	6 (33.3)	12 (66.7)	
Education	Primary	33	19(57.6)	14(42.4)	0.525
	Secondary	19	8(42.1)	11(57.9)	
	College	68	33(48.5)	35(51.5)	
Sex	M	63	28(44.4)	35(55.6)	0.201
	F	57	32(56.1)	25(43.9)	
Duration of symptoms	<6 months	32	23(71.9)	9(28.1)	0.00001*
	6-12 months	21	21(100)	0(0)	
	>12 months	67	16(23.9)	51(76.1)	
Intra-operative blood loss	Up to 50 ml	43	15(34.9)	28(65.1)	0.00001*
	50-100 ml	16	0((0)	16(100)	
	100-200 ml	23	8(34.8)	15(65.2)	
	200-300 ml	38	37(97.4)	1(2.6)	
Procedure duration	30 min	29	8(27.6)	21(72.4)	0.00001*
	50 min	49	35(71.4)	14(28.6)	
	70 min	30	6(20)	24(80)	
	90 min	12	11(91.7)	1(8.3)	
Lumbar pain pre-operative	Yes	98	54(55.1)	44(44.9)	0.018*
	No	22	6(27.3)	16(72.7)	
Lumbar pain Post-operative	Yes	5	5(100)	0(0)	0.02*
	No	115	55(47.8)	60(52.2)	
Leg pain Pre-operative	Yes	120	120(100)	0(0)	constant
	No	0	0(0)	0(0)	
Leg pain Post-operative	Yes	7	7(100)	0(0)	0.006*
	No	113	53(47.4)	60(52.7)	
Lumbar pain 1-month post-operative	Yes	6	6(100)	0(0)	0.012*
	No	114	54(47.4)	60(52.7)	
Leg pain 1-month post-operative	Yes	11	11(100)	0(0)	0.001*
	No	109	49(45)	60(55)	
Lumbar pain 1-year post-operative	Yes	5	5(100)	0(0)	0.02*
	No	115	55(47.8)	60(52.2)	
Leg pain 1-year post-operative	Yes	5	5(100)	0(0)	0.02*
	No	115	55(47.8)	60(52.2)	

Discussion

Lumbar disc herniation (LDH) can be a debilitating condition that can greatly affect one's quality of life.¹⁵ If conservative treatment is not effective, surgical intervention may be necessary. When it comes to surgical techniques for LDH, there are various options available, including standard open discectomy, microdiscectomy, and minimally invasive procedures. However, it is important to base the decision on clinical and radiological findings, and further analysis may be required to make the best treatment decision.¹⁶ Although microdiscectomy is often considered the preferred method for LDH surgery, some neurosurgeons still opt for standard open discectomy. While there may be differing opinions on which technique is best, we have found that standard open discectomy can be quite effective.¹⁷

Numerous studies have reported better outcomes with microdiscectomy, such as shorter hospital stays, less bleeding, faster recovery, and quicker return to work. However, other studies have found no significant differences between the two techniques in terms of postoperative pain and outcomes.¹⁸ In our study, we observed a significant difference in postoperative pain scores up to one month after surgery.

One advantage of standard open discectomy is that it typically takes less time to perform than microdiscectomy because a microscope is not needed. Our findings are consistent with studies that have reported shorter operation times when using the

standard open discectomy technique.¹⁹ The goal of LDH surgery is to achieve the best clinical and functional outcome, which is closely tied to the absence of a herniation. Our recurrence rate after surgery was within the range reported in the literature, which underscores the importance of a careful and thorough approach to surgical intervention.²⁰

While microdiscectomy and minimally invasive surgical techniques are becoming increasingly popular for initial operations, some reports suggest that recurrent LDH may be more common when hidden fragments are removed, which can occur with standard open discectomy. Therefore, it is important to carefully consider the pros and cons of each technique and choose the one that is best suited for each patient.²¹

The study conducted shows that the MD group, consisting of 60 patients, is large enough to conclude. Unlike previous reports, the study demonstrates that functional results for SD and MD are not different.²² The benefits of MD are evident in its ability to provide residents and younger doctors with a better insight into neuroanatomy and relevant pathology. On the other hand, SD lacks this advantage. Moreover, patients often perceive MD as superior to SD, due to the psychological effect of minimally invasive techniques.²³

Similarly, a single-blind randomised controlled trial was done in a tertiary hospital with 122 adult patients. They were divided into three groups of microdiscectomy at 6 weeks, 3 months, and 6 months from symptom onset.²⁴ This study aimed to evaluate the impact of the duration of preoperative symptoms on the outcomes of microdiscectomy in patients with symptomatic lumbar disc herniation. The study concluded just like ours that the duration of preoperative symptoms significantly impacted postoperative outcomes following lumbar microdiscectomy. Shorter durations of symptoms correlated with better postoperative clinical and functional outcomes, emphasising the importance of early intervention in achieving improved results for patients with lumbar disc herniation undergoing microdiscectomy.²⁵

Another prospective comparative cohort study done in 2022 examined 309 consecutive patients undergoing lumbar microdiscectomy for lumbar disc herniation (LDH). Follow-up was conducted at 6 weeks, 3 months, 6 months, and 1 year. Just like our study, their study also concluded that preoperative back pain, functional scores, and patient satisfaction following lumbar microdiscectomy are much better than open discectomy.¹⁷

Conclusions

Although LDH surgical techniques have become more sophisticated over the years, there has been no significant improvement in functional and clinical results. Thus, appropriate patient selection plays a crucial role in achieving satisfactory postoperative outcomes. It is essential for neurosurgeons to fully master the chosen technique. The study's results show statistically significantly better functional outcomes of the MD technique (VAS lumbar and leg pain), a safe and efficient procedure with minimal blood loss, shorter procedure times, and reduced pain, indicating that MD techniques can yield better results.

Lower back pain is progressively becoming prevalent in the Pakistani population, but the topic is yet to be researched on a broader basis. This is the first research-based study conducted to depict the benefits of standard laminectomy and microscopic discectomy for the treatment of lower back pain.

The aim of conducting this study is to see the efficacy of Microscopic discectomy for the treatment of lower back pain. There are no noticeable side effects to this intervention recorded to date.

References

1. Ammerman J, Watters WC, Inzana JA, Carragee G, Groff MW. Closing the treatment gap for lumbar disc herniation patients with large annular defects: a systematic review of techniques and outcomes in this high-risk population. *Cureus*. 2019 May 7;11(5). <https://doi.org/10.7759/cureus.4613>
2. Di Cello A, Borelli M, Marra ML, Franzon M, D'Alessandro P, Di Carlo C, Venturella R, Zullo F. A more accurate method to interpret lactate dehydrogenase (LDH) isoenzymes' results in patients with uterine masses. *European Journal of Obstetrics & Gynaecology and Reproductive Biology*. 2019 May 1;236:143-7. <https://doi.org/10.1016/j.ejogrb.2019.03.017>
3. Muthu S, Ramakrishnan E, Chellamuthu G. Is endoscopic discectomy the next gold standard in the management of lumbar disc disease? Systematic review and superiority analysis. *Global spine journal*. 2021 Sep;11(7):1104-20. <https://doi.org/10.1177/2192568220948814>
4. Molteni G, Nocini R, Ghirelli M, Molinari G, Fior A, Veneri A, Nocini PF, Marchioni D. Free flap head and neck microsurgery with VITOM® 3D: Surgical outcomes and surgeon's perspective. *Auris Nasus Larynx*. 2021 Jun 1;48(3):464-70. <https://doi.org/10.1016/j.anl.2020.09.010>
5. Pinto D, Marques A, Pereira JF, Palma PJ, Santos JM. Long-term prognosis of endodontic microsurgery—a systematic review and meta-analysis. *Medicina*. 2020 Sep 3;56(9):447. <https://doi.org/10.3390/medicina56090447>
6. Deer T, Sayed D, Michels J, Josephson Y, Li S, Calodney AK. A review of lumbar spinal stenosis with intermittent neurogenic claudication: disease and diagnosis. *Pain medicine*. 2019 Dec 1;20(Supplement_2):S32-44. <https://doi.org/10.1093/pm/pnz161>
7. Angelini E, Baranto A, Brisby H, Wijk H. Healthcare practitioners' experiences of postoperative pain management in lumbar spine surgery care—a qualitative study. *Journal of clinical nursing*. 2020 May;29(9-10):1662-72. <https://doi.org/10.1111/jocn.15230>
8. Ebrahimkhani M, Arjmand N, Shirazi-Adl A. Biomechanical effects of lumbar fusion surgery on adjacent segments using musculoskeletal models of the intact, degenerated and fused spine. *Scientific reports*. 2021 Sep 9;11(1):17892. <https://doi.org/10.1038/s41598-021-97288-2>

9. Zahra N, Sheha EA, Elsayed H. Low back pain, disability and quality of life among health care workers. *IJPRPM*. 2020 Apr 1;9(2):34-44. <https://doi.org/10.1002/1348-9585.12378>
10. Hines K, Mouchtouris N, Knightly JJ, Harrop J. A brief history of quality improvement in health care and spinal surgery. *Global Spine Journal*. 2020 Jan;10(1_suppl):5S-9S. <https://doi.org/10.1111/jocn.15230>
11. Angelini E, Baranto A, Brisby H, Wijk H. Healthcare practitioners' experiences of postoperative pain management in lumbar spine surgery care—a qualitative study. *Journal of clinical nursing*. 2020 May;29(9-10):1662-72. <https://doi.org/10.1111/jocn.15230>
12. Frost BA, Camarero-Espinosa S, Foster EJ. Materials for the spine: anatomy, problems, and solutions. *Materials*. 2019 Jan 14;12(2):253. <https://doi.org/10.3390/ma12020253>
13. Rawal N. Epidural analgesia for postoperative pain: improving outcomes or adding risks?. *Best Practice & Research Clinical Anaesthesiology*. 2021 May 1;35(1):53-65. Rawal N. Epidural analgesia for postoperative pain: improving outcomes or adding risks?. *Best Practice & Research Clinical Anaesthesiology*. 2021 May 1;35(1):53-65. <https://doi.org/10.1016/j.bpa.2020.12.001>
14. Aprilia A, Aminatun D. INVESTIGATING MEMORY LOSS: HOW DEPRESSION AFFECTS STUDENTS' MEMORY ENDURANCE. *Journal of English Language Teaching and Learning*. 2022 Jul 1;3(1):1-1. <https://doi.org/10.33365/jeltl.v3i1.1719>
15. Kose G, Tastan S, Temiz NC, Sari M, Izci Y. The effect of low back pain on daily activities and sleep quality in patients with lumbar disc herniation: a pilot study. *Journal of Neuroscience Nursing*. 2019 Aug 1;51(4):184-9. <https://doi.org/10.1097/jnn.0000000000000446>
16. Fuhrman JD, Gorre N, Hu Q, Li H, El Naqa I, Giger ML. A review of explainable and interpretable AI with applications in COVID-19 imaging. *Medical Physics*. 2022 Jan;49(1):1-4. <https://doi.org/10.1002/mp.15359>
17. Yadav RI, Long L, Yanming C. Comparison of the effectiveness and outcome of microendoscopic and open discectomy in patients suffering from lumbar disc herniation. *Medicine*. 2019 Dec;98(50). <https://doi.org/10.1097/md.00000000000016627>
18. Yang MM, Hartley RL, Leung AA, Ronsley PE, Jetté N, Casha S, Riva-Cambrin J. Preoperative predictors of poor acute postoperative pain control: a systematic review and meta-analysis. *BMJ open*. 2019 Apr 1;9(4):e025091. <https://doi.org/10.1136/bmjopen-2018-025091>
19. Bombieri FF, Shafafy R, Elsayed S. Complications associated with lumbar discectomy surgical techniques: a systematic review. *Journal of Spine Surgery*. 2022 Sep;8(3):377. <https://doi.org/10.21037/jss-21-59>
20. Almeida JP, Tabasinejad R, Kalyvas A, Takami H, Mohan N, O'Halloran PJ, Sanchez MM, Velasquez C, Zadeh G, Gentili F. The importance of long term follow up after endoscopic pituitary surgery: durability of results and tumor recurrence. *Neurology India*. 2020 Jun 1;68(7):92. <https://doi.org/10.4103/0028-3886.287675>
21. Chowdhury MZ, Turin TC. Variable selection strategies and their importance in clinical prediction modelling. *Family medicine and community health*. 2020;8(1). <https://doi.org/10.1136/fmch-2019-000262>
22. Morales-Arráez D, Ventura-Cots M, Altamirano J, Abalde JG, Cruz-Lemini M, Thursz MR, Atkinson SR, Sarin SK, Kim W, Chavez-Araujo R, Higuera-de La Tijera MF. The MELD score is superior to the Maddrey discriminant function score to predict short-term mortality in alcohol-associated hepatitis: a global study. *Official journal of the American College of Gastroenterology| ACG*. 2022 Feb 1;117(2):301-10. <https://doi.org/10.14309/ajg.0000000000001596>
23. Piarulli A, Chiariello GA, Bruno P, Cammertoni F, Rabini A, Pavone N, Pasquini A, Ferraro F, Mazza A, Nesta M, Francesco M. Psychological effects of skin incision size in minimally invasive valve surgery patients. *Innovations*. 2020 Nov;15(6):532-40. <https://doi.org/10.1177/1556984520956980>
24. Hamawandi SA, Sulaiman II, Abdulhameed AM. Effect of duration of symptoms on the clinical and functional outcomes of lumbar microdiscectomy: a randomized controlled trial. *Orthopaedic Surgery*. 2022 Jan;14(1):157-68. <https://doi.org/10.1111/os.13114>
25. Kasir R, Zakko P, Hasan S, Aleem I, Park D, Nerenz D, Abdulhak M, Perez-Cruz M, Schwalb J, Saleh ES, Easton R. The Duration of Symptoms Influences Outcomes After Lumbar Microdiscectomies: A Michigan Spine Surgery Improvement Collaborative. *Global spine journal*. 2023 Nov 2;21925682231210469. <https://doi.org/10.1177/21925682231210469>