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# **A matched comparison of outcomes between percutaneous endoscopic lumbar discectomy and open lumbar microdiscectomy for the treatment of lumbar disc herniation: a two-year retrospective cohort study**

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## **Abstract**

**BACKGROUND CONTEXT:** Although open lumbar microdiscectomy (OLMD) is considered to be the gold standard method for discectomy, recent progress in endoscopic spinal surgery has increased the popularity of percutaneous endoscopic lumbar discectomy (PELD) for this indication. However, one of the main drawbacks of PELD is incomplete decompression, especially at the start of the surgeon's learning curve. The functional outcomes of PELD and OLMD in patients matched for age, hernia level, and hernia location have not previously been compared.

**PURPOSE:** To compare OLMD with PELD in terms of the clinical outcome and the time to recovery.

**STUDY DESIGN:** Retrospective, matched cohort study.

**PATIENT SAMPLE:** Data of all patients who underwent elective spinal surgery between January 2015 and June 2017 were extracted from the local database.

**OUTCOME MEASURES:** Clinical outcomes were assessed using a 0-to-10 visual analogue scale (VAS) for lower back pain (LBP) and leg pain were scored before surgery and at post-operative day 1 and at each follow-up visit (3, 12 and 24 months), the Oswestry Disability Index (ODI: 0% to 100%), the length of hospital stay, time to resumption of work, recurrence of LDH, procedure failures, and complications

**METHODS:** The participants were matched for age, disc level, and location of the herniated disk (central and paracentral vs. far-lateral). The participants' mean  $\pm$  SD age was 47.09  $\pm$  12.55 (range: 28–70). We compared the various clinical outcomes between the two groups to identify which procedure had better immediate and long-term functional outcomes. The differences in mortality and occurrence of postoperative complications were also compared in patients with PELD vs. controls.

**RESULTS:** Fifty-eight patients were enrolled (29 with PELD and 29 with OLMD). Both groups reported significant reductions in LBP and leg pain ( $p < 0.01$ ) postoperatively and an improvement in the ODI at 24 months post-surgery. The intergroup difference in the VAS for LBP at 1-day and 3 months was statistically significant (1.48 vs. 3.5, and 1.62 vs. 2.72, respectively;  $P = 0.01$  and 0.026 respectively) but the intergroup difference in the ODI was not. The mean length of hospital stay and the time to resumption of work were significantly shorter in the PELD group than in the OLMD group (2.55 vs. 3.21 days, and 4.45 vs. 6.62 weeks, respectively;  $P = 0.037$  and 0.01, respectively). There were no significant intergroup differences in terms of complications, recurrence, or procedure failures.

**CONCLUSIONS:** Both PELD and OLMD can provide equivalent, satisfactory outcomes. However, PELD demonstrated several potential advantages, including more rapid recovery and lower LBP early on. Further large-scale, randomized studies with long-term follow-up are now warranted.

**Keywords:** lumbar disc herniation, minimally invasive spinal surgery, endoscopic spinal surgery, lower back pain, Spine robot assisted surgery.

**Abbreviations used in this paper:** PELD: percutaneous endoscopic lumbar discectomy; OLMD: open lumbar microdiscectomy; LDH: lumbar disc herniation; ODI: Oswestry Disability Index. VAS: visual analogue scale

## **INTRODUCTION**

Surgical techniques for lumbar discectomy are continually evolving, with a trend towards less aggressive, less invasive procedures. In the 1970s, Caspar and Yasargil introduced open lumbar microdiscectomy (OLMD) for the treatment of LDH<sup>1</sup>. This less invasive surgery (with a smaller incision size) produced good results and reduced surgical stress on the patient.

Indeed, OLMD has since become the gold standard surgical treatment for symptomatic LDH<sup>2-4</sup>. However, it is now known that OLMD also results in muscle damage, requires partial laminectomy and nerve retraction. This can increase the likelihood of subsequent lumbar instability and clinically symptomatic scarring of the epidural space<sup>5-8</sup>.

In an attempt to improve the outcomes of LDH surgery and to reduce the complication rate, percutaneous endoscopic lumbar discectomy (PELD, with a transforaminal or an interlaminar approach) was introduced in the early 1990s<sup>9,10,11</sup>. Since then, PELD has become increasingly popular. A large number of studies have shown that the outcome for PELD is as good outcome for OLMD.<sup>12-15</sup> Furthermore, PELD appears to result in less soft tissue trauma and better bone preservation. The complications of OLMD, such as postoperative spinal instability

and epidural scarring, occur rarely after PELD<sup>1,8,16,17,18,19</sup>. However, a major disadvantage of PELD is its long learning curve and high frequency of sometimes serious comorbidities.

Incomplete decompression is not uncommon in PELD procedures, and each LDH is assessed morphologically on a case-by-case basis before PELD can be selected.

The present retrospective cohort study is the first to have compared the outcomes of PELD and OLMD in patients matched for age, hernia level, and hernia location.

## **METHODS**

We performed a retrospective, matched-cohort analysis with prospective data collection at Amiens University Hospital (Amiens, France). This study's objectives and procedures were approved by the independent ethics committee (reference: IRB00011687 Collège de neurochirurgie IRB #1: 2019/17).

Between February 2015 and June 2017, a total of 33 cases of LDH treated with PELD (of which 29 were eligible for this study, forming the PELD group) were compared with 29 cases of LDH treated with OLMD over the same period (forming the OLMD group). All patients having undergone PELD were included. For OLMD, 62 matched patients operated on by four other senior neurosurgeons were selected at random. The participants' mean  $\pm$  SD age was  $47.09 \pm 12.55$  (range: 28–70). The groups were matched for age, disc herniation level, and hernia location relative to the facet joint and the spinal canal (central and paracentral vs. far-lateral).

With regard to their professional activity, patients were classified as manual workers (i.e. those handling heavy material) and sedentary workers (i.e. those sitting at a desk in an office and/or performing light physical work only). In total, 58 patients were enrolled.

The following inclusion were applied to both groups: single-level, soft lumbar herniated disc, as confirmed by preoperative computed tomography (CT) and magnetic resonance imaging (MRI); monoradicular symptoms and signs consistent with the imaging findings; failure of conservative treatment for at least 6 weeks; at least two years of follow-up data available.

Patients with cauda equina syndrome or progressive neurological impairment requiring emergency surgery, spinal instability, previous surgery involving the lumbar spine, concomitant somatic or psychological conditions, such as uncontrolled myocardial ischemia, diabetes, spinal tumor, fracture or an infection were excluded.

Clinical and demographic data were prospectively recorded. The patients completed a questionnaire consisting of a 10-point visual analogue scale (VAS) for lower back pain (LBP) and leg pain preoperatively, on post-operative day 1, and at each follow-up visit. The patients also rated their quality of life according to the Oswestry Disability Index (ODI) before surgery and then 24 months thereafter. The follow-up visits were scheduled 3, 12 and 24 months after surgery. All patients followed up in the long term, either at an outpatient clinic or via a telephone assessment. Preoperative MRI and CT datasets were available in all cases.

The length of hospital stay, time to resumption of work, complications, recurrence rate, and procedure failures were also evaluated. We considered that recurrence within 3 months of surgery was a complication. Procedure failures or “incomplete decompression” were defined as cases in which the patient experienced continuous nerve root pain and the presence of residual fragments was confirmed by MRI.

## **Surgical techniques**

All operations were performed by two experienced spine surgeons, who even had cadaver training. Patients decided which surgeon would be in charge of their treatment all by themselves. In this study, both FELD and OLMD were inpatient procedures and were performed under general anaesthesia and endotracheal intubation. The postoperative analgesic regimens were the same in the two groups.

### **PELD**

The patient was placed in the prone position. Fourteen patients underwent PELD with robotic stereotactic assistance using robotic assistance (ROSA® robot from Zimmer Biomet Robotics), and 15 patients underwent PELD with fluoroscopic guidance.

In the robotic subgroup, the guidewire and cannula were positioned using 3D intraoperative planning. The robotic arm was used as an instrument holder to put the cannula and the sheath in place. The surgical sheath was navigated throughout the procedure.

In the fluoroscopic subgroup, we checked the AP and lateral view to determine the entry point (between the tip of the spinous process and the spinolaminar junction). This point was usually located between 10 and 15 cm from the midpoint of a line between the spine and the herniated disc. The needle had to pass through the caudal part of the vertebral foramen. The needle was then removed, leaving the guidewire in place. Next, a 7-8 mm skin incision was made, and a cannulated dilator and surgical sheath with a bevelled opening were inserted. Decompression was performed during constant irrigation. The surgical sheath was removed, and the wound was closed. For the intralaminar approach, the entry point was located at the inferior edge of the superior lamina on the lesion side with an AP view and parallel to the disc space with the lateral view. After a small incision was made in the skin and the fascia, a dilator was introduced and docked under the lower edge of the superior lamina. A working channel was



introduced over the dilator, and the final position was checked on the AP and lateral fluoroscopic images.

## **OLMD**

The patient was placed in the kneeling prone position. The abdomen was unsupported, so as to reduce intraoperative venous bleeding on the Hall frame. After confirming the target segment using fluoroscopy, a 2.5 cm longitudinal midline skin incision was made. The fascia was dissected (diameter: 5.3 mm) through the incision. Next, an operating sheath was inserted through the dilator. A Caspar retractor was used to obtain a direct view of the operating field, with its beveled opening toward the spinous processes (toward the interlaminar spaces) and with reference to an anatomic marker (the lower border of the upper vertebral lamina). To fully expose the ligamentum flavum, the adhering soft tissues and some of the bony structures from the lamina and the articular process were removed. Next the compressed dural sac and nerve root were exposed and tracked contralaterally in order to locate the herniated disc tissues, which were removed carefully to decompress the nerve root. Following discectomy, any remaining fragments in the intervertebral space were swilled out with saline solution. After removing the hernia, the muscle, subcutaneous and dermal tissues were sutured.

All patients operated for a herniated disc received the same analgesic regimen: intravenous analgesic for the first 24 hours after surgery, followed by analgesia as needed. All patients had a physiotherapy session on postoperative day 1.

## **Statistical analysis**

All statistical analyses were performed using IBM SPSS® Statistics software version 25. Quantitative variables were quoted as the mean  $\pm$  standard deviation (SD) or the median [interquartile range (IQR)]. Intergroup differences were probed using Fisher's exact test, the chi-

squared test, or the Mann–Whitney U-test as appropriate. The threshold for statistical significance was set to  $P < 0.05$ .

## RESULTS

Thirty-three consecutively hospitalized patients underwent PELD for single-level unilateral LDH. Twenty-nine of the 33 patients were suitable for inclusion in the study, and were then matched with 29 patients having undergone OLMD for single-level, unilateral LDH by age, hernia level, and hernia location. There was no age limitation. The patients' demographic, socio-demographic and clinical characteristics are summarized in *Table 1*. There were no significant differences between the PELD and OLMD groups.

### Clinical outcomes

Before surgery, the mean  $\pm$  SD VAS scores for LBP and leg pain were respectively  $6.24 \pm 3.25$  and  $8.28 \pm 1.27$  in the PELD group and  $5.69 \pm 2.9$  and  $7.93 \pm 1.16$  in the OLMD group. There were no significant intergroup differences in these pain VAS scores. Both groups reported a significant postoperative reduction in LBP and leg pain ( $P < 0.001$ ). The mean  $\pm$  SD ODI score had improved significantly in both groups 24 months after surgery ( $23.72 \pm 20.91$ , compared with  $78.34 \pm 19.10$  preoperatively in a pooled analysis ( $P < 0.001$ ). The mean decrease in the ODI score was  $55.58 \pm 23.7$  (Table 2).

The day after surgery, the VAS scores for LBP and leg pain were respectively  $1.48 \pm 1.74$  and  $1.03 \pm 1.99$  in the PELD group and  $3.5 \pm 2.41$  and  $2.25 \pm 2.05$  in the OLMD group. The intergroup differences in the LBP and leg VAS score were significant ( $P = 0.001$  and  $0.06$ , respectively) (Table 3). Three months after surgery, the VAS scores for LBP and leg pain were respectively  $1.62 \pm 1.96$  and  $1.86 \pm 2.37$  in the PELD group and  $2.72 \pm 2.14$  and  $1.57 \pm$

2.23 in the OLMD group ( $P=0.026$  and  $0.80$ , respectively). The intergroup difference in the LBP score was significant. Twelve months after surgery, the VAS scores for LBP and leg pain were respectively  $2.89 \pm 2.74$  and  $2.24 \pm 2.65$  in the PELD group and  $2.46 \pm 2.11$  and  $1.75 \pm 2.47$  in the OLMD group ( $P=0.69$  and  $0.52$ , respectively). The intergroup differences were not significant. Twenty-four months after surgery: The VAS scores for the LBP and leg pain were respectively  $2.54 \pm 2.35$  and  $1.25 \pm 1.43$  in the PELD group and  $2.14 \pm 2.03$  and  $1.33 \pm 2.05$  in the OLMD group. The intergroup differences were not significant ( $P = 0.575$  for the LBP score and  $P = 0.433$  for the leg pain score).

At 3 months, 12 months and last follow-up (24 months after surgery), the intergroup differences in the ODI were not significantly different ( $P = 0.30$ ,  $0.56$ , and  $0.22$  respectively) (Table 2). The mean  $\pm$ SD length of hospital stay was significantly shorter in the PELD group ( $2.55 \pm 1.78$  days) than in the OLMD group ( $3.21 \pm 1.26$  days;  $p < 0.037$ ).

The mean time to resumption of work was significantly shorter in the PELD group ( $4.45 \pm 3.1$  weeks) than in the OLMD group ( $6.62 \pm 2.4$  weeks;  $p = 0.01$ ).

Complications occurred in three patients in the PELD group (10.3%) and two patients in the OLMD group (6.9%); the intergroup difference was not statistically significant. The overall complication rate in this study was 8.6%. In the PELD Group, two patients complained of transient dysaesthesia after the operation; both recovered fully after conservative treatment. One patient complained of unilateral paresis of the quadriceps, which gradually improved after 8 weeks of rehabilitation. In the OLMD group, one patient sustained a dural tear, which was immediately and successfully repaired. The second patient had a recurrent herniation with discogenic LBP in the two months following surgery. Conservative management did not

provide relief, and so lumbar fusion was performed. There were no major complications (including surgical site infections) in either group.

Incomplete decompression was observed in three patients in the PELD group (10.3%). Two patients chose re-operation (using the OLMD technique) and the third chose conservative treatment. All three cases occurred early in our series and may have been related to the learning process. No procedure failures were observed in the OLMD group. The intergroup difference in the failure rate was not significant ( $p = 0.237$ ). Between the postoperative follow-up visits at month 3 and month 24, herniation recurred in four patients (6.9%, two in each group). The mean time interval between initial surgery and recurrence was  $14.3 \pm 9.7$  months.

## **DISCUSSION**

Minimally invasive spinal procedures have become increasingly popular with both spine surgeons and their patients undergoing surgery for LDH. However, the procedure still appears to be relatively complicated for many surgeons<sup>20-23</sup>.

In the present study, the leg pain VAS scores in both groups decreased significantly 24 months after surgery (vs. baseline); the magnitude of the reduction was in line with the literature data.<sup>16,18,24,25</sup> The reductions in the ODI were also similar to those reported previously for the PELD and OLMD techniques.<sup>27, 28</sup>

The OLMD procedure is associated with good results and is minimally invasive; however, it sometimes results in muscle damage, partial laminectomy, and nerve retraction. The patients

prone to developing lumbar instability, intraspinal adhesions, and scarring of the epidural space typically have residual LBP in the presence of Modic changes or the onset of other complications<sup>5,11,13</sup>. In contrast to OLMD, PELD has the advantage of not sectioning the lamina and so causes very little damage to the paravertebral muscles and ligaments. In line with the concept of minimally invasive surgery, PELD keeps disc tissue intact and avoids the invasion of intradiscal tissue<sup>18,28</sup>. However, excessive retraction or manipulation of neural structures in a narrow space can cause paresis.<sup>29</sup>

In our study population, the OLMD and PELD subgroups did not differ significantly with regard to Modic changes before surgery. Many surgeons have performed PELD with satisfactory results<sup>30,31</sup>. In view of PELD's advantages in terms of safety, efficacy and minimal invasiveness, this technique is being adopted by a growing number of spine care centers. The incision is significantly smaller with PELD ( $\leq 7$  mm), and it causes less damage to soft tissue and bony structures.

The failure rate for "incomplete decompression" after PELD ranges from 4% to 20%<sup>16,24</sup>, resulting in the need for subsequent open surgery. Schaffer and Kambin<sup>32</sup> analyzed 10 reoperations among 100 patients having undergone PELD. The most common causes for subsequent surgery were lateral recess stenosis, sequestered herniation, and improper placement of the surgical instruments. Lee et al.'s radiological analysis of 55 PELD failures showed that the procedure is more likely to fail in cases of a large central hernia or high-grade extruded disc.<sup>33</sup> Kim et al. and Xie et al. considered that surgical failures mainly occurred early in the learning curve; this could perhaps be solved by a case-by-case morphological analysis of the disc and its location, together with more cautious handling.<sup>16,34</sup> We observed a surgical failure rate of 10.3% in the PELD group; this is similar to the literature values and

remains acceptable - especially in a novice surgical team.<sup>14,24,35,40</sup> Even though failure to decompress adequately was relatively frequent in the PELD group, our study was not powered to evaluate this risk. Furthermore, this risk may have been affected by the learning curve.

Dural tears and nerve injury have been reported as major complications in many clinical studies lumbar decompressive surgery. The incidence of these complications depends on the type and complexity of the spinal procedure. In a recent meta-analysis, Bydon et al. reported that the incidence of a dural tear was greater for OLMD (2.4%) than for PELD (1%)<sup>36</sup>. We encountered this complication in one patient in the OLMD group.

Transient dysesthesia is one of most frequent complications after PELD. Choi et al. reported that the working cannula may compress the exiting root during surgery, and that postoperative dysesthesia should be prevented by keeping the cannula away from the upper nerve root<sup>37</sup> In our study, this happened in two patients from PELD group. Overall, our post-operative complication rate was similar to the values published in the literature<sup>12</sup>.

In the literature, the recurrence rate ranges from 5% to 15%.<sup>38,39</sup> The rate in our cohort (6.9%) fell within this range, and was similar in the OLMD and PELD groups.

In spinal surgery, robotic assistance may be of value for smoothing the workflow (due to greater rapidity, accuracy, and frameless registration), facilitating the planning and implementation of a trajectory in the same surgical session, and therefore avoiding potential technical complications.<sup>40,41</sup> We believe that robotic assistance during PELD could increase the success rate and reduce comorbidity especially early in the learning curve.

As also found in earlier studies,<sup>14,16,19,24,27</sup> we noted that the mean length of hospital stay and time to resumption of work were shorter in the PELD group than in the OLM group.

However, the mean lengths of hospital stay in our PELD and OLM groups were longer than those reported in the literature.<sup>16,27</sup> This may have occurred because all procedures were performed under general anaesthesia, and our criteria for patient discharge are based on symptom relief, a physiotherapy assessment, and patient education.

In summary, the results of our matched cohort study demonstrated that PELD was superior to OLMD in terms of better immediate clinical outcomes, quicker recovery, a shorter length of hospital stay, and more rapid return to work. The learning process and proper patient selection are essential for successful PELD procedures.

The present study had several limitations. Firstly, this was a retrospective matched cohort study with a small sample size (29 patients in each of the two groups) and a short follow-up period (2 years). This made it impossible to compare the two approaches long-term outcomes. Further follow-up studies could remedy this shortcoming. However, our matching for several factors (age, disc level and hernia site) is likely to have reduced confounding bias.

Nevertheless, a full assessment of PELD and OLMD's effectiveness will require prospective, randomized non-inferiority or superiority studies.

## **CONCLUSIONS**

Both PELD and OLMD can achieve equivalent, satisfactory outcomes. However, PELD demonstrated several potential advantages, including more rapid recovery, and early reductions in LBP. We believe that PELD can be safely used on well-selected cases, despite a

high frequency of incomplete decompression, especially at the start of the learning curve, and that surgical experience has an impact on the outcomes.

## REFERENCES

1. Caspar W. A New Surgical Procedure for Lumbar Disc Herniation Causing Less Tissue Damage Through a Microsurgical Approach. In: Wüllenweber R, Brock M, Hamer J, Klinger M, Spoerri O, eds. *Lumbar Disc Adult Hydrocephalus*. Advances in Neurosurgery. Springer Berlin Heidelberg; 1977:74-80.
2. Apostolides PJ, Jacobowitz R, Sonntag VK. Lumbar discectomy microdiscectomy: “the gold standard.” *Clin Neurosurg*. 1996;43:228-238.
3. Casal-Moro R, Castro-Menéndez M, Hernández-Blanco M, Bravo-Ricoy JA, Jorge-Barreiro FJ. Long-term outcome after microendoscopic discectomy for lumbar disk herniation: a prospective clinical study with a 5-year follow-up. *Neurosurgery*. 2011;68(6):1568-1575; discussion 1575. doi:10.1227/NEU.0b013e31820cd16a
4. Perez-Cruet MJ, Foley KT, Isaacs RE, et al. Microendoscopic lumbar discectomy: technical note. *Neurosurgery*. 2002;51(5 Suppl):S129-136.
5. Annertz M, Jönsson B, Strömqvist B, Holtås S. No relationship between epidural fibrosis and sciatica in the lumbar postdiscectomy syndrome. A study with contrast-enhanced magnetic resonance imaging in symptomatic and asymptomatic patients. *Spine*. 1995;20(4):449-453.
6. Fritsch EW, Heisel J, Rupp S. The failed back surgery syndrome: reasons, intraoperative findings, and long-term results: a report of 182 operative treatments. *Spine*. 1996;21(5):626-633.



7. Schoeggl A, Maier H, Saringer W, Reddy M, Matula C. Outcome after chronic sciatica as the only reason for lumbar microdiscectomy. *J Spinal Disord Tech.* 2002;15(5):415-419.
8. Schick U, Döhnert J, Richter A, König A, Vitzthum HE. Microendoscopic lumbar discectomy versus open surgery: an intraoperative EMG study. *Eur Spine J.* 2002;11(1):20-26. doi:10.1007/s005860100315
9. Kambin P, Casey K, O'Brien E, Zhou L. Transforaminal arthroscopic decompression of lateral recess stenosis. *Journal of Neurosurgery.* 1996;84(3):462-467. doi:10.3171/jns.1996.84.3.0462
10. Brayda-Bruno M, Cinnella P. Posterior endoscopic discectomy (and other procedures). *Eur Spine J.* 2000;9 Suppl 1:S24-29. doi:10.1007/pl00010018
11. Destandau J. A special device for endoscopic surgery of lumbar disc herniation. *Neurol Res.* 1999;21(1):39-42.
12. Chen Z, Zhang L, Dong J, et al. Percutaneous transforaminal endoscopic discectomy compared with microendoscopic discectomy for lumbar disc herniation: 1-year results of an ongoing randomized controlled trial. *Journal of Neurosurgery: Spine.* 2018;28(3):300-310. doi:10.3171/2017.7.SPINE161434
13. Meyer G, DA Rocha ID, Cristante AF, et al. Percutaneous Endoscopic Lumbar Discectomy Versus Microdiscectomy for the Treatment of Lumbar Disc Herniation: Pain, Disability, and Complication Rate-A Randomized Clinical Trial. *Int J Spine Surg.* 2020;14(1):72-78. doi:10.14444/7010
14. Qin R, Liu B, Hao J, et al. Percutaneous Endoscopic Lumbar Discectomy Versus Posterior Open Lumbar Microdiscectomy for the Treatment of Symptomatic Lumbar Disc Herniation: A Systemic Review and Meta-Analysis. *World Neurosurg.* 2018;120:352-362. doi:10.1016/j.wneu.2018.08.236

15. Ruan W, Feng F, Liu Z, Xie J, Cai L, Ping A. Comparison of percutaneous endoscopic lumbar discectomy versus open lumbar microdiscectomy for lumbar disc herniation: A meta-analysis. *International Journal of Surgery*. 2016;31:86-92.  
doi:10.1016/j.ijisu.2016.05.061
16. Kim M-J, Lee S-H, Jung E-S, et al. Targeted percutaneous transforaminal endoscopic discectomy in 295 patients: comparison with results of microscopic discectomy. *Surgical Neurology*. 2007;68(6):623-631. doi:10.1016/j.surneu.2006.12.051
17. Gempt J, Jonek M, Ringel F, Preuß A, Wolf P, Ryang Y. Long-term follow-up of standard microdiscectomy versus minimal access surgery for lumbar disc herniations. *Acta Neurochirurgica*. 2013;155(12):2333-2338. doi:10.1007/s00701-013-1901-z
18. 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):521-530.  
doi:10.3171/spi.2007.6.6.2
19. 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.  
doi:10.1002/14651858.CD010328.pub2
20. Choi G, Lee S-H, Bhanot A, Raiturker PP, Chae YS. Percutaneous endoscopic discectomy for extraforaminal lumbar disc herniations: extraforaminal targeted fragmentectomy technique using working channel endoscope. *Spine*. 2007;32(2):E93-99.  
doi:10.1097/01.brs.0000252093.31632.54
21. Jang J-S, An S-H, Lee S-H. Transforaminal percutaneous endoscopic discectomy in the treatment of foraminal and extraforaminal lumbar disc herniations. *J Spinal Disord Tech*. 2006;19(5):338-343. doi:10.1097/01.bsd.0000204500.14719.2e

22. Lee S-H, Chung S-E, Ahn Y, Kim T-H, Park J-Y, Shin S-W. Comparative radiologic evaluation of percutaneous endoscopic lumbar discectomy and open microdiscectomy: a matched cohort analysis. *Mt Sinai J Med.* 2006;73(5):795-801.
23. Sasani M, Ozer AF, Oktenoglu T, Canbulat N, Sarioglu AC. Percutaneous endoscopic discectomy for far lateral lumbar disc herniations: prospective study and outcome of 66 patients. *Minim Invasive Neurosurg.* 2007;50(2):91-97. doi:10.1055/s-2007-984383
24. Mayer HM, Brock M. Percutaneous endoscopic discectomy: surgical technique and preliminary results compared to microsurgical discectomy. *Journal of Neurosurgery.* 1993;78(2):216-225. doi:10.3171/jns.1993.78.2.0216
25. Lee DY, Ahn Y, Lee S-H. Percutaneous endoscopic lumbar discectomy for adolescent lumbar disc herniation: surgical outcomes in 46 consecutive patients. *Mt Sinai J Med.* 2006;73(6):864-870.
26. Sinkemani A, Hong X, Gao Z-X, 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):833-840. doi:10.4184/asj.2015.9.6.833
27. 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.* 2008;33(9):931-939. doi:10.1097/BRS.0b013e31816c8af7
28. Birkenmaier C, Komp M, Leu HF, Wegener B, Ruetten S. The current state of endoscopic disc surgery: review of controlled studies comparing full-endoscopic procedures for disc herniations to standard procedures. *Pain Physician.* 2013;16(4):335-344.

29. McLaren AC, Bailey SI. Cauda equina syndrome: a complication of lumbar discectomy. *Clin Orthop Relat Res.* 1986;(204):143-149.
30. Kim CH, Chung CK, Woo JW. Surgical Outcome of Percutaneous Endoscopic Interlaminar Lumbar Discectomy for Highly Migrated Disk Herniation. *Clin Spine Surg.* 2016;29(5):E259-266. doi:10.1097/BSD.0b013e31827649ea
31. Choi KC, Kim J-S, Park C-K. Percutaneous Endoscopic Lumbar Discectomy as an Alternative to Open Lumbar Microdiscectomy for Large Lumbar Disc Herniation. *Pain Physician.* 2016;19(2):E291-300.
32. Schaffer JL, Kambin P. Percutaneous posterolateral lumbar discectomy and decompression with a 6.9-millimeter cannula. Analysis of operative failures and complications. *J Bone Joint Surg Am.* 1991;73(6):822-831.
33. Lee S-H, Uk Kang B, Ahn Y, et al. Operative Failure of Percutaneous Endoscopic Lumbar Discectomy: A Radiologic Analysis of 55 Cases. *Spine.* 2006;31(10):E285. doi:10.1097/01.brs.0000216446.13205.7a
34. Xie T-H, Zeng J-C, Li Z-H, et al. Complications of Lumbar Disc Herniation Following Full-endoscopic Interlaminar Lumbar Discectomy: A Large, Single-Center, Retrospective Study. *Pain Physician.* 2017;20(3):E379-E387.
35. Wang H, Zhou Y, Li C, Liu J, Xiang L. Risk factors for failure of single-level percutaneous endoscopic lumbar discectomy. *Journal of Neurosurgery: Spine.* 2015;23(3):320-325. doi:10.3171/2014.10.SPINE1442
36. Alvi MA, Kerezoudis P, Wahood W, Goyal A, Bydon M. Operative Approaches for Lumbar Disc Herniation: A Systematic Review and Multiple Treatment Meta-Analysis of Conventional and Minimally Invasive Surgeries. *World Neurosurg.* 2018;114:391-407.e2. doi:10.1016/j.wneu.2018.02.156

37. Choi I, Ahn J-O, So W-S, Lee S, Choi I-J, Kim H. Exiting root injury in transforaminal endoscopic discectomy: preoperative image considerations for safety. *Eur Spine J.* 2013;22(11):2481-2487. doi:10.1007/s00586-013-2849-7
38. Swartz KR, Trost GR. Recurrent lumbar disc herniation. *Neurosurgical Focus.* 2003;15(3):1-4. doi:10.3171/foc.2003.15.3.10
39. Leven D, Passias PG, Errico TJ, et al. Risk Factors for Reoperation in Patients Treated Surgically for Intervertebral Disc Herniation: A Subanalysis of Eight-Year SPORT Data. *J Bone Joint Surg Am.* 2015;97(16):1316-1325. doi:10.2106/JBJS.N.01287
40. Chenin L, Peltier J, Lefranc M. Minimally invasive transforaminal lumbar interbody fusion with the ROSA(TM) Spine robot and intraoperative flat-panel CT guidance. *Acta Neurochir (Wien).* 2016;158(6):1125-1128. doi:10.1007/s00701-016-2799-z
41. Chenin L, Capel C, Fichten A, Peltier J, Lefranc M. Evaluation of Screw Placement Accuracy in Circumferential Lumbar Arthrodesis Using Robotic Assistance and Intraoperative Flat-Panel Computed Tomography. *World Neurosurg.* 2017;105:86-94. doi:10.1016/j.wneu.2017.05.118

## Figures legends

a. Table 1. The general characteristics of the patients, by study group.

	SURGICAL PROCEDURE		
	PELD	OLMD	P value
Number of patients	29	29	1

Age (years)*		<i>mean ± SD</i>	47.21 ± 12.55	46.97 ± 12.55	0.942
			SD 47.09 ± 12.55. ( 28-70 years)		
Gender§		M / F	19 / 10	15 / 14	0.424
Smoking§		Y / N	10 / 19	14 / 15	0.289
retirement		Y / N	4 / 29	3 / 29	0.67
Occupation	Manual workers (heavy labour)		10 / 25	13 / 26 (45.1%)	0.48
	Sedentary workers (sitting at a desk)		15 / 25	13 / 26 (54.9%)	
Depression §		Y / N	5 / 24	1 / 28	0.194
Fibromyalgia §		Y / N	0 / 29	1 / 28	1
Side§		R / G	14 / 15	17 / 12	0.599
Time off work before surgery * (weeks)			3.89 ± 3.843	3 ± 3.414	0.384
Symptom duration* (weeks)			10.27 ± 7.41	7.76 ± 6.40	0.212
Preoperative radiological signs of discopathy (Modic changes)§			12 / 17	13 / 16	1
Infiltration in the preoperative period §		Y / N	22 / 7	18 / 11	0.395

Hernia location		PELD		OLMD	Percentage
		ROBOT	NON-ROBOT		
central and paracentral				15	51.7%
		2	13		
far-lateral		8	6	14	48.3%
Disc herniation level	L2-L3	1	0	1	3%
	L3-L4	4	1	5	17.2%
	L4-L5	1	18	19	65.5%
	L5-S1	4	0	4	13.8%
Preoperative <i>mean ± SD</i>	LBP	6.24 ± 3.2		5.7 ± 3	0.43
	Overall LBP	5.97 ± 3.1			
	LEG	8.3 ± 1.3		8 ± 1.2	0.32
	Overall LEG	8.1 ± 1.2			
Preoperative ODI <i>mean ± SD</i>		79 ± 67		21 ± 47	0.92

Data are quoted as the mean ± SD. ODI: Oswestry Disability Index

\* In a t-test for independent samples

§ Fisher's exact test

PELD: percutaneous endoscopic lumbar discectomy; OLMD: open lumbar microdiscectomy.

- Table2 : outcome

VAS		Pre-op	Post-op (day 1)	P value
Overall	Lower back pain	5.97 ± 3	2.48 ± 2.3	< 0.001
	Leg pain	8.10 ± 1.22	1.67 ± 2.10	< 0.001

VAS: visual analogue scale; ODI: Oswestry Disability Index

ODI		Pre-op	Post-op (month 24)	
Overall		78.34 ± 19.10	23.72 ± 20.91	< 0.001

- Table3: Clinical outcomes

Variables		PELD	OLMD	P Value
VAS	LBP (D1)	1.48 ± 1.74	3.5 ± 2.41	<b>0.01</b>



	Leg pain (D1)	1.03 ± 1.99	2.25 ± 2.05	<b>0.06</b>
	LBP (3 M)	1.62 ± 1.96	2.72 ± 2.14	<b>0.026</b>
	Leg pain (3 M)	1.86 ± 2.37	1.57 ± 2.23	0.80
	LBP (12 M)	2.89 ± 2.74	2.46 ± 2.11	0.69
	leg pain (12 M)	2.24 ± 2.65	1.75 ± 2.47	0.52
	LBP (24 M)	2.54 ± 2.35	2.14 ± 2.03	0.55
	leg pain (24 M)	1.25 ± 1.43	1.33 ± 2.05	0.51
Length of hospital stay (days)		2.55 ± 1.785	3.21 ± 1.264	<b>0.037</b>
ODI (%)	3 Months	21.8 ± 19.5	23.9 ± 20.5	0.30
	12 Months	21.1 ± 16.3	23.5 ± 16.5	0.56
	24 Months	21.4 ± 15.3	24.1 ± 19.5	0.22
Time to resumption of work (weeks)		4.45 ± 3.1	6.62 ± 2.4	<b>0.01</b>
Peri and post-operative complications rate (%)		3 cases (10.3%)	2 cases (6.9%)	>0.05
Incomplete decompression, Chi <sup>2</sup>		3 cases (10.3%)	0 cases (0%)	0.237
Recurrent hernia		4 cases (13.8%)	3 cases (10.3%)	>0.05

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PELD: percutaneous endoscopic lumbar discectomy; OLMD: open lumbar microdiscectomy;

VAS: visual analogue scale; ODI: Oswestry Disability Index