IMMEDIATE AND LONG-TERM RESULTS OF PERCUTANEOUS FULL-ENDOSCOPIC AND MICROSURGICAL LUMBAR DISCECTOMY: PROSPECTIVE COHORT STUDY

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Objective. To analyze immediate and long-term results of percutaneous endoscopic and microsurgical discectomy.
Material and Methods. A prospective cohort study in two groups of patients was conducted in 2015–2018. The observation period was 6–42 months. Group 1 included 110 patients who underwent percutaneous endoscopic lumbar discectomy, and Group 2 – 331 patients who underwent microdiscectomy. Efficiency was assessed using NRS-11, ODI, SF-36, and MacNab questionnaires.
Results. The operating time, bed day number, and disability period were shorter in Group 1 ($p < 0.001$). The average effective dose of radiation exposure to the patient was 4.4 mSv in transforaminal endoscopy, and 0.8 mSv in interlaminar and microsurgical discectomy. There were no significant intergroup differences in frequency and types of complications and reoperations. The portion of symptomatic hernia recurrence in Group 1 was 10 %, in Group 2 – 4.8 %. Significant differences in neurological outcomes and quality of life were not revealed. Good and excellent outcomes according to MacNab criteria were noted in 78.2 % and 84.9 %, in Groups 1 and 2, respectively.
Conclusion. The percutaneous endoscopic discectomy allows reducing hospital stay length and disability period, while having clinical efficacy equal to that of other disectomy methods. A statistically insignificant increase in the risk of hernia recurrence after percutaneous endoscopic discectomy was noted.
Key Words: full-endoscopic discectomy, microdiscectomy, disc herniation, discogenic radiculopathy, lumbar discectomy.
Please cite this paper as: *Kravtsov MN, Mirzametov SD, Malakhovskiy VN, Alekseyeva NP, Gaidar BV, Svistov DV. Immediate and long-term results of percutaneous full-endoscopic and microsurgical lumbar discectomy: prospective cohort study. Hir. Pozvonoc. 2019;16(2):27–34. In Russian.*
DOI: http://dx.doi.org/10.14531/ss2019.2.27-34.

Introduction of minimally invasive techniques, one of which is percutaneous endoscopy, has become a priority in surgical treatment of degenerative spine diseases at the beginning of the XXI century. This surgical procedure was developed by famous surgeons Hijikata and Kambin, who performed needle nucleotomy of lumbar discs through a posterolateral approach as early as the 1970s [1, 2]. Later, in the 1980s, Schreiber and Suezawa, independently each other, performed indirect decompression of the neural structures by means of endoscopic nucleotomy through a modified arthroscope [3, 4].

At the turn of the XXth and XXIst centuries, the introduction of multichannel endoscopes and special tools for bone resection enabled transforaminal and interlaminar endoscopic approaches to the spinal canal structures for direct decompression of the neural structures, like in microsurgery using a microscope. This stage of transformation of arthroscopic spinal surgery into neuroendoscopic surgery is associated with studies by Ruetten, Schubert, Hoogland, Yeung, Iprenburg, and many other researchers [5–8].

Today, percutaneous endoscopy is not inferior to standard microdiscectomy in terms of surgical accessibility of herniated discs [9, 10]. Despite popularity of the technique, it is still unclear whether percutaneous endoscopic lumbar discectomy (PELD) will become a new standard for surgical treatment of discogenic lumboischialgia and replace microsurgical lumbar discectomy (MLD) and microendoscopic discectomy, which are more invasive techniques. The final answer to this question may be obtained in randomized controlled trials of clinical efficacy, which evaluate all intracanal endoscopic approaches and techniques. However, we found only 5 prospective studies comparing the efficacy of only transforaminal intracanal PELD with that of MLD and/or microendoscopy [11–15]. The transforaminal PELD technique does not provide all opportunities upon lumbar discectomy, in particular when suprasacral disc herniation is combined with a high iliac crest, sequestra are located in a blind area, etc. [10, 16]. Therefore, this transforaminal PELD technique cannot be equivalent to microdiscectomy.

Ruetten et al. [16] studied both posterior interlaminar and lateral transforaminal approaches in PELD. Of course, the results of their study are valuable for an objective analysis of the efficacy of the considered techniques. But the only study is not enough to definitively evaluate the advantages of PELD and MLD. Over the past 10 years since the publication of that study, the capabilities of percutaneous endoscopy have increased significantly.

The purpose of the study is to analyze the efficacy of intracanal techniques of PELD and MLD.

Material and Methods

The cohort consisted of 441 patients. The mean age of patients was 45.2 (19–85) years. Males and females accounted for 59 % and 41 %, respectively. All removals of primary disc herniation using PELD and MLD were performed in 2015–2018.

The criteria for inclusion of patients in the study were as follows: pain intractable for four weeks or development of a neurological deficit due to compression of the nerve structures by a single herniated disc at the L1–L2 to L5–S1 levels confirmed by MRI or CT findings.

The exclusion criteria were as follows: multilevel symptomatic disc herniation, recurrent disc herniation, spinal canal stenosis, spondylolisthesis, instability, spinal deformity, previous lumbar spine surgery, inflammatory diseases, and severe concomitant somatic pathology.

The patients were divided into two groups: Group 1 consisted of 110 patients after PELD, and Group 2 included 331 patients after MLD. The surgical effect was assessed based on changes in the neurological status, pain intensity, and quality of life, which were measured using conventional assessment tools (NRS-11, ODI, SF-36, MacNab). Postoperative follow-up examinations were performed at the 7th day and 6th, 12th, and 24th month. The follow-up period amounted to 42 months. For statistical data processing, we used the IBM SPSS Statistics Version 23 and R Version 3.5.0 software. Statistical hypotheses were tested using non-parametric criteria and analysis methods. Results were considered statistically significant at $p < 0.05$. All patients included in the study gave written voluntary informed consent. The study was performed in accordance with requirements of the Helsinki Declaration of the World Medical Association (2013).

Surgical technique. MLD was performed through a posterior approach using a Caspar retractor, according to a standard technique. All interventions were performed under magnification using an operating microscope.

Approaches for PELD were chosen based on the level and lateralization of disc herniation, its location relative to the nervous structures, migration of the sequestrated disc in the craniocaudal direction, and individual anatomical features of the spine. Half (55 of 110) endoscopic operations were performed through posterior approaches: interlaminar (n = 53) and translaminar (n = 2); the second half of interventions was performed through lateral approaches: transforaminal (n = 47), posterolateral (n = 5), and transpedicular (n = 3). More than 80 % (89 of 110) of PELDs were performed through interlaminar and transforaminal (according to the Hoogland technique) approaches, which are the most universal ones (Fig. 1).

Operations in both groups were performed under general anesthesia, with the patient in the prone position. A C-arm was used for fluoroscopic assistance. Wound drainage was used only in the MLD group. Patients in Group 1 were operated on by specialists having experience of more than 30 PELDs, and patients in Group 2 were operated on by neurosurgeons with experience of more than 100 MLDs.

Results

The main characteristics of patient groups before surgery are presented in Table 1.

We measured the duration of fluoroscopy and calculated the effective dose for patients (E, mSv) upon fluoroscopy during PELD (n = 40) and MLD (n = 24) according to the recommended formula [17]:

$$E = F \cdot Kd,$$

where F is an exposure characteristic (a dose-area-product (DAP) (Gy • cm^2) for C-arm devices); K*d* is a DAP-to-effective dose conversion factor with dimension of mSv/(Gy • cm^2), K*d* ≈ 0.2 [18].

The mean effective dose per patient in transforaminal PELD was 4.4 mSv (1.4; 10.8); the mean duration of fluoroscopy was 74.3 s (26; 175). The effective dose in patients of the MLD group and a subgroup with an interlaminar approach for PELD was 0.8 mSv ($p = 0.58$), and the mean duration of fluoroscopy was 10.4 s and 12.7 s, respectively.

The surgical outcomes are presented in Table 2.

There were no serious complications in both groups (Table 3). The rate of perioperative complications was 7.7 % (34/441).

Because long-term (more than 24 months) clinical outcomes were evaluated in less than half of the patients in the sample (46 %), we used a special modification of the repeated measures analysis of variance (Repeated Measures ANOVA) [19, 20] designed for missing data analysis based on ergodic centralization of model. This method avoids loss of information upon deletion of incomplete data or distortion of results upon recovery of missing data with artificial data during the so-called imputation [21]. In the ergodic method, a model displacement due to incomplete data is calculated, and a covariance error matrix is recalculated upon appropriate centralization; the matrix is then used to calculate all necessary statistics.

It is assumed that the data depends on its relation to a certain group, observation at a certain point in time, and interaction between these factors. The significance of these factors in each particular case can be determined from appropriate probability confidence levels: p. gr. is the significance of the differences in studied parameters between the PELD (oper 1) and MLD (oper 2) groups, regardless of the time factor (basically, all values are more than 0.05, which indicates general comparability of these groups); p. time indicates the significance of the studied indicator dynamics; the results of analysis revealed an improvement in the studied clinical indicators in both groups (there is usually an improvement on day 7 and a further slight variation at a level set in the first week); p. gr. time is the significance of the interaction between time and group factors, and its value less than 0.05 indicates a significant time-dependent difference in the changes between groups (Fig. 2–4).

During the entire follow-up period, there were no significant differences in the intensity of pain in the back and lower extremities as well as in the quality of life (ODI) and the physical component of health (SF-36 questionnaire). There was an earlier achievement of a high level of the physical health component in group 1 (significance of the interaction effect $p < 0.0001$) and a statistically significant intergroup difference in improvement in the level and dynamics of the mental health component (SF-36) in the case of PELD (significance of the interaction effect $p = 0.0001$). Good and excellent results (MacNab scale) were observed in 78.2 % (86/110) of cases in Group 1 and in 84.9 % (281/331) of cases in Group 2, without significant differences in this criterion ($p = 0.23$).

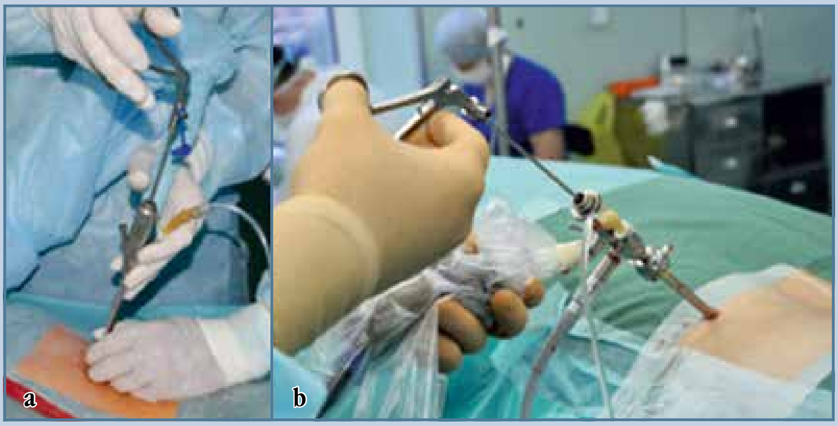

Fig. 1
Interlaminar **(a)** and transforaminal **(b)** percutaneous endoscopic lumbar discectomy: the endoscopic stage of the intervention

Discussion

The groups were comparable in the main criteria at the preoperative stage. Similarly to the reported data [13, 16, 22, 23], the operating time was significantly shorter in Group 1 ($p < 0.001$). The effective dose per patient and the time of fluoroscopy in PELD, especially in the transforaminal technique, were higher than those reported in the literature [14, 24]. This was mainly associated with insufficient experience of specialists who performed PELD. For example, according to Iprenburg et al. [24], the effective dose per patient and surgeon is reduced about 3.5-fold as the surgeon performs more than 100 transforaminal PELDs.

In our study, the effective dose per patients in PELD was analyzed separately for transforaminal and interlaminar techniques. This is due to the fact that the transforaminal approach (according to Hoogland) involves foraminotomy performed by bone burrs under fluoroscopic control, which obviously increases the effective dose. The effective dose for patients in transforaminal discectomy was 5.5-fold higher than that in Group 2 and a subgroup with the interlaminar technique in PELD ($p < 0.0001$).

The median hospital stay in Group 1, as in most studies [11, 13–15], was significantly less than that in Group 2. A similar trend was noted for the duration of disability in working patients ($p < 0.001$). According to Ruetten et al. [16], the duration of disability amounted to 25 days for PELD and 49 days for MLD, which is approximately consistent with our results. There were no statistically significant differences between the groups in the rate of complications ($p = 0.54$).

An important feature was the absence of infectious complications in Group 1. The rate of detected complications is consistent with the data of Liu et al. [22], but different from that in other studies [14–16]. Despite the absence of statistically significant differences in the rate of recurrent disc herniation ($p = 0.07$), it should be noted that the risk of its recurrence in Group 1 doubles that in Group 2 (10.0 % and 4.80 %). A greater number of recurrences after PELD than after MLD have been marked by many authors [12, 16, 22].

The causes for this pattern were not analyzed in the present study, but it may be associated with additional disc resection in the interbody space. In our study, 40.0 % (44/110) of patients in Group 1 and in 75.8 % (251/331) in Group 2 underwent an additional disc resection after removal of disc extrusion. Several studies have demonstrated the effect of aggressive discectomy on a significant decrease in the rate of recurrences [25–27].

There were no significant differences in the number of re-operations between the groups (Table 3). Their rate slightly exceeded that previously reported in the literature, but the present study was characterized by a longer follow-up period [12, 15, 22]. The clinical outcomes of PELD and MLD were generally equivalent, as confirmed by the literature data [14–16, 23].

Conclusions

1. Accessibility of the surgical substrate in the lumbar spinal canal in MLD and PELD is comparable, but the latter technique is less invasive.
2. The duration of surgery and hospital stay in the MLD group exceed those in the PELD group.
3. The differences in the immediate and long-term clinical outcomes as well as rates of complications, recurrences, and re-operations between the PELD and MLD groups are statistically insignificant.
4. Infectious complications are not typical of PELD in comparison with MLD.
5. The risk of recurrent disc herniation after PELD is about 10 %, which doubles that after MLD.
6. The effective dose per patient is significantly higher for the Hoogland's

transforaminal technique than for the interlaminar technique of PELD and MLD.

7. Given the absence of an obvious superiority of one of the techniques based on the clinical outcomes, it is advisable to analyze PELD and MLD to rationalize the choice of a medical technology based on an integrated assessment of clinical and economic efficacy.

The study was conducted without financial support.
The authors declare no conflict of interest.

Table 1

Main characteristics of patients in Group 1 and Group 2 before surgery

Parameters		Group 1 (n = 110)	Group 2 (n = 331)	(p. value)
Age, years: Me [IQR]/sample range		43.4 [34–57]/ 19–77	45.7 [36–56]/ 19–85	0.11**
Gender, %	male	55.5	60.4	0.37***
	female	44.5	39.6	
Body mass index: Me [IQR]		26.5 [23.6–28.7]	26.9 [22.3–29.7]	0.36**
Smoking, %		33.6	27.8	0.28***
Diabetes mellitus, %		4.5	8.2	0.29***
Back pain, months: Me [IQR]*		24 [2–72]	24 [2–48]	0.39**
Lower limb pain, months: Me [IQR]*		2 [2–7.5]	2 [0.5–7.5]	0.52**
NRS-11, back: Me [IQR]		5 [2–7]	5 [2–6]	0.19**
NRS-11, lower limb: Me [IQR]		6 [4–8]	6 [4–8]	0.04**
Lasegue's sign, %		93.6	83.7	0.01***
ODI: Me [IQR]		42 [28–57.5]	46 [30–58]	0.52**
SF-36 (physical component): Me [IQR]		28.8 [24.7–34.1]	29.9 [25.1–34.8]	0.55**
SF-36 (mental component): Me [IQR]		41.1 [33.5–53.8]	42.2 [32.9–52.8]	0.99**
Disc herniation level, % (n)				
L1–L2		3.6 (4)	1.5 (5)	0.001***
L2–L3		3.6 (4)	0.9 (3)	
L3–L4		3.6 (4)	8.2 (27)	
L4–L5		42.7 (47)	36.6 (121)	
L5–L6		6.4 (7)	0.9 (3)	
L5–S1		40.0 (44)	52.0 (172)	
Lateralized disc herniation (296 MRT), % (n)				
Median		15.8 (16)	18.5 (36)	0.32***
Paramedian		66.3 (67)	69.2 (135)	
Foraminal		7.9 (8)	6.7 (13)	
Extraforaminal		5.0 (5)	1.0 (2)	
Bulging		5.0 (5)	4.6 (9)	
Disc herniation with cranial and caudal migration by 5–24 mm (296 MRT), % (n)		22.3 (23)	23.8 (46)	0.89***

Me [IQR] is the median and interquartile range;
* duration of back/lower limb pain from the onset of disease to surgical treatment;
** Mann-Whitney U-test;
*** Fisher's exact test.

Table 2

Main results of surgical interventions in Group 1 and Group 2

Parameters	Group 1 (n = 110)	Group 2 (n = 331)	p. value
Duration of surgery, min: Me [IQR]	85 [65–110]	105 [80–125]	<0.001*
Hospital stay, days: Me [IQR]	5 [3–8]	10 [8–13]	<0.001*
Disability after surgery, days: Me/sample range	30 [0–182]/0–182	50 [20–120]/20–120	<0.001*
Complications, % (n)	9 (10)	7.3 (24)	0.54**
Recurrent disc herniation, % (n)	10 (11)	4.8 (16)	0.07**
Recurrence-free period, months: Me/sample range	5.0 [1–25]/1–25	6.0 [1–22]/1–22	0.86*
Re-operations, % (n)	10 (11)	6 (20)	0.31**

Me [IQR] is the median and interquartile range;

* Mann-Whitney U-test;

** Fisher's exact test.

Table 3

Perioperative complications in the studied groups, % (n)

Complication	Group (n = 111)			Group (n = 331)	
	complication	conversion	re-operation	complication	re-operation
DM injury	3.6 (4)	–	–	3.9 (13)	–
DM and root injury	2	0.9 (1)	–	–	–
CSF leak	–	–	–	0.3 (1)	–
Infection in surgical area	–	–	–	2.1 (7)	1.2 (4)
Transient paresis	1.8 (2)	–	–	–	–
Lower limb cramps	0.9 (1)	–	–	–	–
Residual disc herniation	2.7 (3)	–	1.8 (2)	0.9 (3)	0.6 (2)
Total	9.0 (10)	0.9 (1)	1.8 (2)	7.2 (24)	1.8 (6)

In Group 1, 111 patients are indicated instead of 110 patients (+1 patient whose treatment results after conversion were not analyzed).

DM is the dura mater.

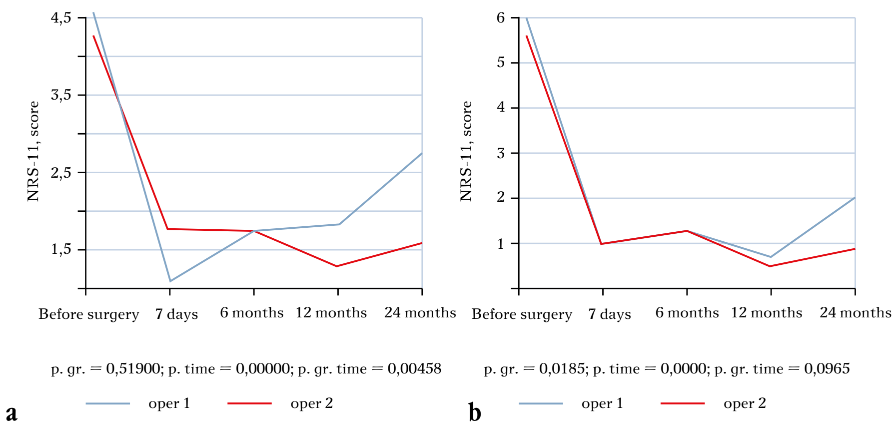

Fig. 2

Changes in indicators of pain in the back **(a)** and lower extremities **(b)** (NRS-11 scale) after percutaneous endoscopic lumbar discectomy and microsurgical lumbar discectomy: oper 1 – PELD; oper 2 – MLD; p. gr., p. time, p. gr. time – appropriate probability confidence levels

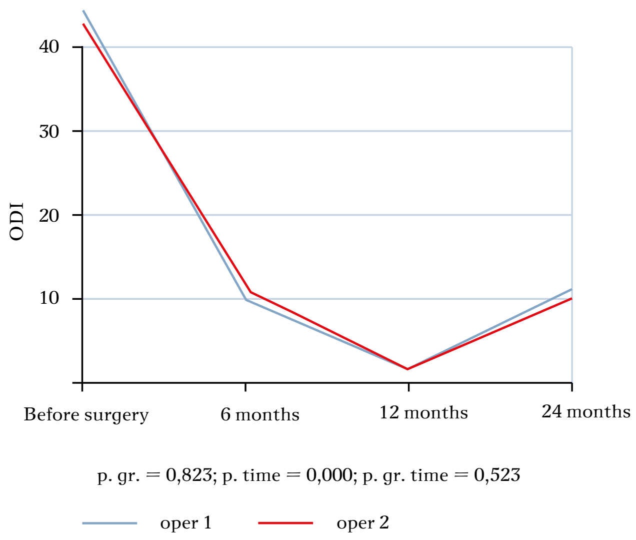

Fig. 3
Changes in quality of life indicators (ODI) after percutaneous endoscopic lumbar discectomy and microsurgical lumbar discectomy: oper 1 – PELD; oper 2 – MLD; p. gr., p. time, p. gr. time – appropriate probability confidence levels

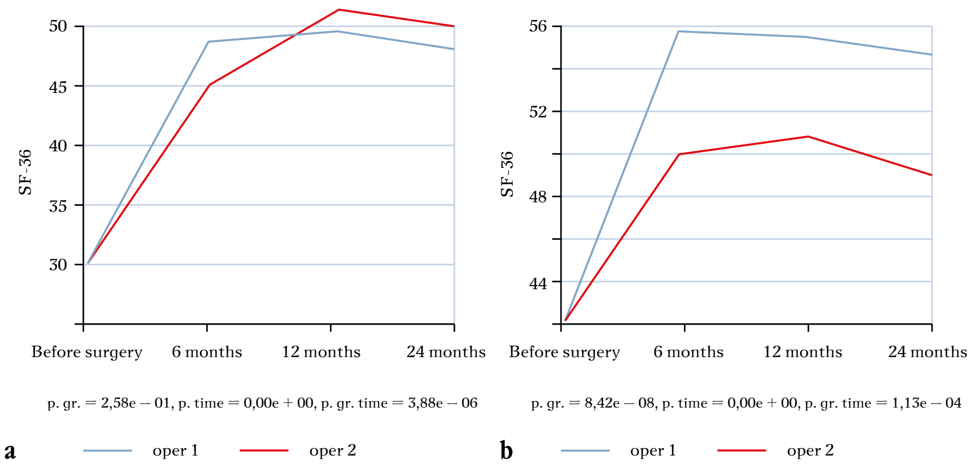

Fig. 4
Changes in physical (a) and mental (b) health indicators (SF-36 questionnaire) after percutaneous endoscopic lumbar discectomy and microsurgical lumbar discectomy: oper 1 – PELD; oper 2 – MLD; p. gr., p. time, p. gr. time – appropriate probability confidence levels

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Received 22.04.2019
Review completed 05.05.2019
Passed for printing 07.05.2019

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