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Puncture laser microdiscectomy in the treatment of sequestered herniation of lumbar intervertebral discs

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Objective. to improve the results of treatment of sequestered herniation of lumbar intervertebral discs by the puncture laser microdiscectomy (PLM) method. *Methods.* During the period from 2000 to 2023, 132 patients with sequestered lumbar disc herniations were operated on by the PLM method. There were 88 males and 34 females. The age of the patients was from 23 to 64 (42.3 ± 3.5) years. Surgeries were performed using a C-arc operating fluoroscope. The laser pulse duration — 0.3–0.5 sec, and radiation exposure — 500–600 J. Approach to the sequestrum was mainly posteromedian transdural. For laterally located sequestra, posterolateral approach was used. The efficacy of PLM was assessed by pain intensity reduction according to the VAS scale one month after surgery, and according to the McNab scale 3 months after surgery. *Results.* One month after PLM, the maximum reduction of radicular pain intensity was noted in patients with posteromedian hernias, to a lesser extent — with paramedian hernias, and the least pronounced — with lateral hernias. However, no statistically significant differences in pain intensity one month after surgery depending on hernia location were found ($p > 0.05$). As for the intensity of lumbar pain, in all groups, regardless of hernia location, it significantly decreased and did not exceed 1 point after one month. 3 months after surgery, 95 (71.9 %) patients had an excellent result according to the McNab scale, 13 (9.8 %) — good, 7 (5.3 %) — satisfactory, 17 (12.8 %) — unsatisfactory, indicating that the PLM method of sequestered hernias can be quite effective in a certain selection of patients. According to our data, positive results can reach 81.8 % (95 % CI 74.2–87.9 %) (CI — confidence interval). *Conclusions* Sequestered hernias, which can be operated by the PLM method, should not exceed 9 mm in height on axial sections, should have a smooth rounded lenticular shape without signs of migration. The positive effect of PLM of sequestered hernias reached 81.7 %. The results were better with PLM of posteromedian hernias.

Мета. Поліпшити результати лікування секвестрованих гриж поперекових міжхребцевих дисків (МХД) методом пункційної лазерної мікродискектомії (ПЛМ). *Методи.* За період із 2000 по 2023 роки прооперовано методикою ПЛМ 132 пацієнти з секвестрованими грижами поперекових МХД. Чоловіків було 88, а жінок — 34, вік від 23 до 64 ($42,3 \pm 3,5$) років. Втручання проводили з використанням операційного флюороскопа С-арка. Протяжність лазерного імпульсу — 0,3–0,5 с, променеве навантаження — 500–600 Дж. Доступ до секвестру переважно був задньосерединний трансдуральний. За латерально розташованих секвестрів використано задньобічний доступ. Ефективність ПЛМ оцінювали за зменшенням інтенсивності болю за шкалою ВАШ через місяць після операції, і за шкалою McNab — через 3 міс. *Результати.* Через місяць після ПЛМ максимальне зниження інтенсивності радикулярного болю відмічено у хворих із задньосерединними грижами, менше — із парамедіанними, найменше — із латеральними. Проте статистично значущих відмінностей інтенсивності болю через місяць після операції залежно від локалізації грижі не виявлено ($p > 0,05$). Стосується інтенсивності поперекового болю у всіх групах, незалежно від локалізації грижі, вона суттєво знижувалася і через місяць не перевищувала 1 бал. Через 3 міс. після операції у 95 (71,9 %) пацієнтів відзначений відмінний результат за шкалою McNab, у 13 (9,8 %) — добрий, у 7 (5,3 %) — задовільний, у 17 (12,8 %) — незадовільний, що відображує достатню ефективність використання ПЛМ секвестрованих гриж у випадку певного відбору пацієнтів. Визначено, що позитивні результати можуть досягти 81,8 % (95 % довірчий інтервал 74,2–87,9 %). *Висновки.* Для використання методу ПЛМ у хірургічному лікуванні секвестрованих гриж слід обирати їх за такими характеристиками: висота на аксіальних зрізах не більше ніж 9 мм, рівна округла лінзоподібна форма без ознак міграції. Позитивний ефект ПЛМ досягав 81,7 %, краще результат у випадку задньосерединних гриж. *Ключові слова.* Поперекові міжхребцеві диски, секвестрована грижі, пункційна лазерна мікродискектомія.

Keywords. Lumbar intervertebral discs, sequestered hernias, puncture laser microdiscectomy

Introduction

Puncture laser disc decompression proposed by W. P. Asher et al. at the end of the 1980s [1], has become a leading technique in the treatment of herniated intervertebral discs (HID) at the cervical, thoracic and lumbar levels [2–6]. It is an intermediate segment between conservative therapy and microsurgery [7–10]. Currently, the limits of its use are clearly established, from protrusions of the HID to small (non-sequestered) hernias, the sagittal size of which does not exceed 6 mm. It has been proven that after laser intervention on the nucleus pulposus of the disc, its volume decreases by almost 25 % [5, 6]. Ukrainian authors and we are inclined to consider this operation a puncture laser microdiscectomy (PLM). The effectiveness of this technique, if all requirements are met, can reach 92 % [11–13]. However, there are not so many patients who fully meet the requirements for PLM. Some of them are often subject to conservative therapy. The same patients who want to be treated by this technique are not suitable for a number of indicators. An absolute contraindication to performing puncture laser microdiscectomy is hernias with signs of rupture of the fibrous ring and sequestration. There are quite a lot of patients who are inclined to be treated by this method. Some of them refuse microsurgical treatment due to fear of open intervention and anesthesia, and in a number of cases, concomitant somatic abnormalities are associated with a high risk of complications. At the same time, patients in this category have to take narcotic analgesics to reduce pain.

We have developed a method of treating sequestered hernias by the PLM method in order to help patients with sequestered lumbar hernias requiring open surgery, but refuse it for various reasons. In 2000, we published our findings [14] of an experimental study on intervertebral discs of deceased people and large sequestrations removed during surgery. It was proved that the heating of the fragment in the center of the HID depends on the length of the laser pulse: for the length of the last pulse up to 1.0 s, at a distance of 2 and 6 mm from the center of the light guide, the temperature rises by 6 and 4°C, respectively, if up to 0.5 s at the same distance, the temperature rises by 2.3 and 1.4°C, respectively. For the total dose of laser irradiation (we used a niodymium laser at the time) at a dose of 1,600 J, the volume of the disc or sequestrum was reduced by 32 %, and with irradiation of 600 J, the volume of the disc or sequestrum could decrease to 22 %. Thus, we have proven that the laser is safe and quite effective when used in this way.

Clinical observations confirmed the results of our experiment, that under certain conditions sequestered hernias can be treated with the PLM technique.

Purpose: to improve the results of treatment of sequestered herniated lumbar intervertebral discs by the method of puncture laser microdiscectomy.

Material and methods

During the period from 2000 to 2023, we operated on 132 patients with sequestered hernias of lumbar HID using the PLM technique. There were 88 men and 34 women (from 23 to 64 years old). The average age of the patients was (42.3 ± 3.5) years. In 43 patients, the examination involved computerized tomography (CT), 52 patients underwent magnetic resonance imaging (MRI), and 37 patients underwent both CT and MRI. Until 2007, a niodymium laser Medilas fibertom 4060 (Dornie, Germany) was used as a source of laser radiation, then a diode laser Surgilas (Germany). Operations were performed using a C-arc fluoroscope (Philips, the Netherlands). The duration of the laser pulse is from 0.3 to 0.5 s, and the radiation load is from 500 to 600 J. The access to the sequestration was mainly posterior-medial transdural. In the case of laterally located sequestrations, a posterior approach was used. The effectiveness of puncture laser microdiscectomy was evaluated by the reduction of pain intensity according to the VAS scale one month after the operation and according to the McNab scale 3 months after the intervention.

Ethical norms

All procedures performed on patients during the study conformed to the ethical standards of the institutional and national ethics committees and the 1964 Declaration of Helsinki and its amendments or similar ethical standards. All patients gave their written consent to the treatment and the use in scientific research of the data given in the outpatient chart. The conduct of the study was approved by the Commission on Ethics and Bioethics of the State Institution Dnipro Medical University of the Ministry of Health of Ukraine (Protocol No. 10 dated 21.06.2023).

Statistical analysis

Comparison of independent samples with normal distribution of values was carried out using Student's test (t). Multiple comparisons were performed with Holm–Bonferroni corrections.

The results

All 132 patients had HID hernias with signs of sequestration and sizes from 7 to 9 mm. 32 (24.2 %) of L_{IV}–L_V HID hernias were diagnosed, and

100 (75.8 %) of L_4-S_1 lumbar hernias. According to the location relative to the spinal canal, these are the following hernias: posteromedial — 91 (68.9 %), paramedian — 29 (22.4 %), and lateral — 12 (8.9 %). Sequestrations without signs of migration prevailed, there were 105 of them (80.2 %). 18 (14.6 %) of sequestrations that remained mainly at the lumbar level, but shifted caudally (up to 5 mm), migrated cranially (by 5 mm) — 9 (5.2 %).

The pain syndrome prevailed in the neurological status. For the most part, pain was localized in the L_4 root zone in 18 % of patients and in the S_1 root zone — in 65 % of people. Other patients presented with pain in the area of the kidneys (17%), radicular pain was weakly expressed. According to the VAS scale, the intensity of radicular pain ranged from 6 to 8 points, on average (7.2 ± 1.3) points, and lumbar from 4 to 6 points, on average (5.8 ± 0.83) points. Hypoesthesia of the L_4 dermatome was found in 12 % of patients, and hypoesthesia of the S_1 dermatome in 52 %. Weakness of the dorsiflexion of the foot was recorded in 8 % of patients, and plantar flexion in 28 % of individuals.

Peculiarities of surgical intervention

A posteromedial transdural approach was used to perform PLM of hernias located posteriorly and paramedianly. For hernias that were located laterally, a posterolateral approach was used. In all cases, the end of the needle was initially placed in the center of the nucleus pulposus, and the laser load on it was on average (500 ± 42.5) J. The duration of the pulse was 1.0 s. After that, the needle was placed as close as possible to the base of the hernia (Fig. 1) and an average laser load of (400 ± 24.5) J with a pulse length of 0.3 s was additionally applied.

The effectiveness of PLM was visually assessed using CT 30 minutes after the intervention. On the tomogram, signs of a “vacuum effect” appeared in

the operated disk, as a result of gas bubbles that arose due to laser ablation. Our experience proves that the more pronounced the “vacuum effect”, the more favorable the prognosis of PLM. At the same time, the best prognostic factor is the appearance of a “vacuum effect” directly in the hernia itself, as shown in Figure 2.

Early and long-term results of PLMs have proven that their effectiveness depends on several factors. One of which is the age of the patient: in younger patients, the effect of PLM is higher. Thus, among 14 people over the age of 50, the reduction of radicular pain on the VAS scale one month after PLM decreased on average by only (1.6 ± 0.36) points. In 4 of them, the pain intensity did not change, which required a microsurgical operation. The duration of the illness is significantly affected. In all 12 patients with a history longer than six months, one month after PLM, the intensity of radicular pain decreased by only (2.3 ± 0.45) points. We performed an analysis of the effectiveness of PLM with sequestered hernias that differ in their location in the spinal canal: posteromedial, paramedian, and lateral. The table presents information about the intensity of pain according to the VAS scale in patients with sequestered hernias of different localization.

The indicators in the table indicate that a month after PLM, the maximum decrease in the intensity of radicular pain was noted in patients with posterior medial hernias. A slightly smaller reduction in pain intensity was noted in individuals with paramedian hernias. In patients with lateral hernias, the decrease in the intensity of radicular pain was the least pronounced, but it was noticeable for the patients themselves. However, there were no statistically significant differences in pain intensity one month after surgery depending on the location of the hernia ($p > 0.05$). As for the intensity of lumbar pain, in all

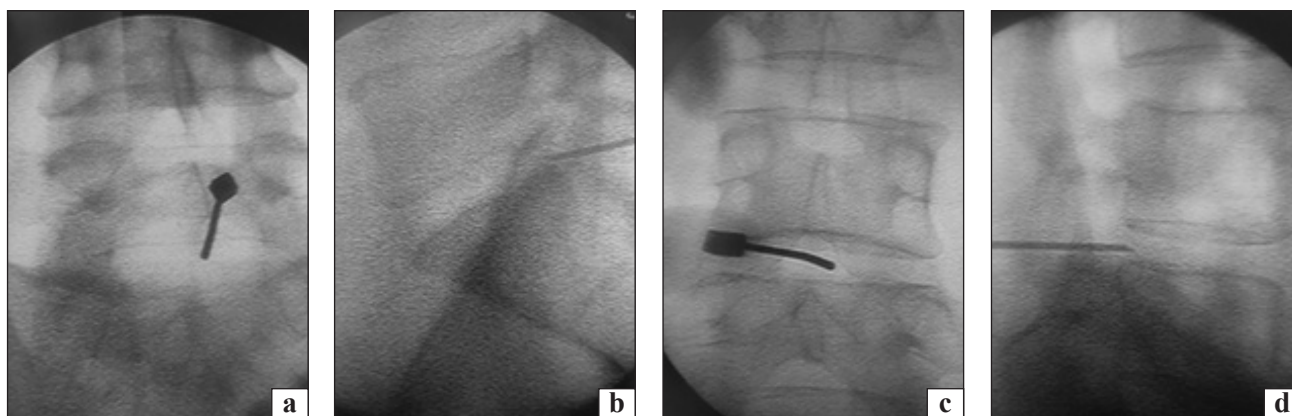


Fig. 1. Features of setting the needle: a, b) posterior transdural access; c, d) posterior access

Changes in the intensity of radicular pain according to the VAS scale one month after PLM

| Localization of the hernia (№) | Number of observations | Intensity of radicular pain according to VAS | | |
|--------------------------------|------------------------|--|-----------------------------|--------------------------|
| | | average score before surgery | average score after 1 month | p |
| Posterior middle (1) | 91 | 6.9 ± 1.36 | 2.4 ± 0.53 | p ₁₋₂ = 0.112 |
| Paramedian (2) | 29 | 7.1 ± 1.22 | 4.4 ± 0.89 | p ₁₋₃ = 0.612 |
| Lateral (3) | 12 | 7.3 ± 1.45 | 5.1 ± 1.04 | p ₂₋₃ = 0.069 |
| Total number | 132 | 7.0 ± 1.3 | 3.1 ± 0.96 | — |

Notes: p — differences in intensity of radicular pain according to VAS after 1 month, after surgery depending on the location of the hernia according to the Student's test for independent measurements (t) with the Holm–Bonferroni correction; p₁₋₂ — differences between the posterior median and paramedian localization of the hernia; p₁₋₃ — differences between the posterior medial and lateral location of the hernia; p₂₋₃ — differences between the paramedian and lateral location of the hernia.

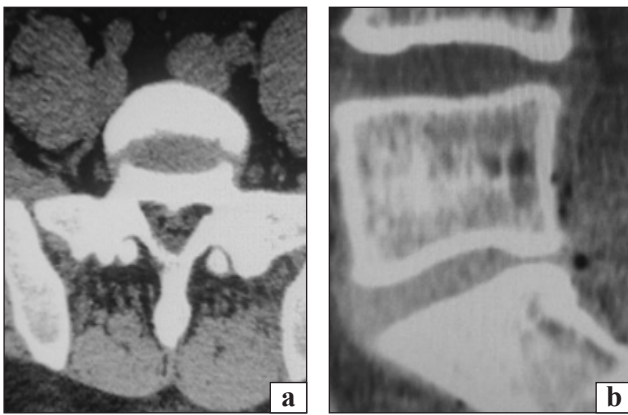


Fig. 2. CT “vacuum effect” on the L_v–S₁ disc after PLM: a) axial section, b) sagittal

groups, regardless of the localization of the hernia, it significantly decreased and after a month did not exceed one point. Separately, sequestered hernias that have a tendency to migrate both cranially and caudally should be highlighted. In our observation, there were 28 of them. The results of the study showed that the presence of a slight migration of the sequestrum (no more than 5 mm) does not affect the outcome of the operation. Only the process of pain regression was somewhat delayed.

Three months after surgery, 95 (71.9 %) patients had an excellent result according to the McNab scale, 13 (9.8 %) had a good result, 7 (5.3 %) had a satisfactory result, and 17 (12.8 %) had an unsatisfactory result, which indicates that PLM of sequestered hernias in the case of a certain selection of patients can be quite effective. According to our data, positive results can reach 81.8 % (95 % confidence interval 74.2–87.9%).

Discussion

We consider it necessary to emphasize that the effectiveness of PLM in conditions of protrusions and

non-sequestered hernias of the lumbar intervertebral discs is not in doubt [1–6]. Sequestered hernias, for the most part, are operated on by a microsurgical or endoscopic method [8–10]. But there is a category of patients who, for various reasons, refrain from invasive treatment methods. At the same time, some of them have sequestrations that can be successfully operated by the PLM method. Our previous clinical and experimental studies proved that the direct laser effect on the sequestration, according to our modified technique, does not pose a danger to the patient. Further clinical studies allowed us to highlight certain requirements for sequestrations that are subject to PLM. That is, their size should not exceed 9 mm in height on axial scans. At the same time, all of them must maintain the rear longitudinal connection. Migration of the sequestrum, cranially or caudally, should not exceed 5 mm. Posterior-median sequestrations are preferred. Regarding paramedianly located sequestrations, their PLM is possible, but the effectiveness of such interventions is significantly lower. The least effective PLMs are for lateral hernias, although the statistical validity of this has not been proven due to the small number of observations.

Thus, in our opinion, PLM can be safe and quite effective for certain sequestrations described by us. Of course, their effectiveness is lower than the previously established indications for this method of treatment. But, if it is not possible to carry out more radical methods of treatment of sequestered hernias, PLM can improve the quality of life of such patients.

Conclusions

The technique of puncture laser microdiscectomy is effective for the treatment of non-sequestered lumbar hernias. Our modified and developed method of using puncture laser microdiscectomy is safe in the treatment of some sequestered hernias. Its positive effect during the treatment of sequestered her-

nias reaches 81.7 %. In the case of posteromedial hernias, the results are better.

Analyzing the modern scientific literature, we note that currently the high efficiency of the use of puncture surgical technologies during the treatment of degenerative-dystrophic lesions of the arcuate joints of the lumbar spine is emphasized. The use of this technique has a number of advantages: reduction of injury to soft tissues and bone structures; preservation of the anatomical structures of the spinal canal, which is an important factor in preventing the formation of epidural fibrosis; faster activation of the patient; reduction of hospitalization and early rehabilitation. However, we note that treatment tactics are chosen individually in each case.

Conflict of interest. The author declare no conflict of interest.

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PUNCTURE LASER MICRODISCECTOMY IN THE TREATMENT OF SEQUESTERED HERNIATION OF LUMBAR INTERVERTEBRAL DISCS

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