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Original Article

Efficacy and safety of percutaneous laser disc decompression using double-needle realignment method for lumbar disc herniation

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Abstract: Background and aim: Lumbar disc herniation (LDH) is often treated by percutaneous laser disc decompression (PLDD). At present, there is no report on the application of double-needle realignment method in PLDD for LDH. This study investigated the clinical efficacy and safety of PLDD using a double-needle realignment method for treating LDH. Methods: A retrospective analysis was performed on 111 patients with contained LDH receiving PLDD treatment. The patients were divided into groups A (56 cases) and B (55 cases), which were treated by a double-needle realignment method and a single-needle method, respectively. The treatment efficacy, visual analogue scale (VAS) back pain scores, peripheral blood IgG and IgM levels and adverse reactions in two groups were evaluated and compared. Results: After 30 days from surgery, the excellent and good rate and effective rate in group A were significantly higher than group B ($P < 0.05$ or $P < 0.01$). After 3 days and also 30 days from surgery, the VAS back pain scores in group A were significantly lower than group B ($P < 0.01$), and the IgG and IgM levels in group A were significantly lower than group B ($P < 0.01$). After surgery, there were 2 cases of end-plate osteochondritis in group B, but no end-plate osteochondritis occurred in group A. Conclusion: PLDD is a safe and effective choice for patients with contained LDH. The double-needle realignment method can reduce the risk of laser treatment, and obtain better excellence and a good rate and effective rate, compared with the single-needle puncture method.

Keywords: Lumbar disc herniation, percutaneous laser disc decompression, double-needle realignment

Introduction

Lumbar disc herniation (LDH) is a common and frequently occurring disease, with a high recurrence rate [1]. Severe LDH can lead to disability which seriously affects quality of life [2]. It is one of the common diseases seen in the pain department. In this disease, under the action of external factors, the nucleus pulposus protrudes due to a fibrous ring rupture that stimulates and compresses the nerve root, blood vessels or spinal cord tissue, leading to lumbago. It is also accompanied with radiation pain of the sciatic nerve. The treatment methods for LDH include medication and physical therapy, nerve root block, minimally invasive techniques and open surgery [3-5]. In recent years, with the rapid development of minimally invasive surgery, more and more patients are choosing this surgery. Percutaneous laser disc decompression (PLDD) is one of the minimally invasive surgeries. Compared with open surgery, PLDD has an equivalent efficacy in treating LDH, but with less trauma, faster recovery and lower cost [6]. PLDD is divided into a double-needle method and a single-needle method. Based on the double-needle method, the two needle canals are connected, which is why it is called the double-needle realignment method and it has clear improvement. At present, there is no relevant report on the application of the double-needle realignment method in PLDD of LDH. This study conducted a retrospective analysis on 111 patients with contained LDH receiving PLDD by the double-needle realignment method and single-needle method. The treatment outcomes of the two methods were compared. The objective was to provide a reference for further application of double-needle realignment method to PLDD for treating LDH.

Figure 1. The puncture needle entered the target intervertebral disc through the security triangle area.

Figure 2. The puncture needle entered the target intervertebral disc through the lateral margin of the small joint, avoiding the iliac crest.

Patients and methods

Patients

One hundred and eleven patients with contained LDH receiving treatment by PLDD in Jiashan First People's Hospital from December 2015 to October 2012 were enrolled in this study. There were 51 males and 60 females. Their ages were 35-76 years, with mean age of 57.71±5.42 years. The inclusion criteria were as follows: LDH with back pain combined with radiation pain of lower limbs; abnormal sensation and (or) decreased muscle strength and (or) decreased tendon reflex and pain lateral limbs; positive in nerve root traction test; contained LDH indicated by CT or MR examination, which compressed the nerve root; ineffective healing after conservative treatment for more than 12 weeks. The exclusion criteria as follows: patients with bleeding tendencies or puncture site infection; bony spinal stenosis; injury of the cauda equine; calcification of the fiber ring and posterior longitudinal ligament indicated by imaging; lumbar spine instability and lumbar spondylolisthesis; psychiatric history and communication difficulty. The course of disease was between 4 months to 25 years. There were 151 intervertebral discs needing interventional treatment (L2/3, 5; L3/4, 27; L4/5, 64; L5/S1, 55). A maximum two intervertebral discs were treated in one patient. The patients were divided into a double-needle realignment group (group A; 56 cases) and a single-needle group (group B; 55 cases). This study was approved by the ethics committee of Jiashan First People's Hospital. Written informed consent was obtained from all participants.

Surgery method

Patients lay prostrate on the CT examination bed, and the preparation work was completed. After skin disinfection and paving sterile towel shop, 2% lidocaine was used for local anesthesia. Under CT guidance, a 15 cm 18G puncture needle was used for positioning and measurement. It entered the target intervertebral disc through the security triangle area (**Figure 1**). When inserting the L5/S1 needle, the needle tail was cephalad tilted 25°, and the needle entered the target intervertebral disc through the lateral margin of the small joint, avoiding the iliac crest (**Figure 2**), or the needle entered the target intervertebral disc through the inner margin of the small joint (**Figure 3**). When the puncture needle entered the intervertebral disc tissue in the spinal canal, it stayed for 10 s. Next, 0.5 ml iohexol was injected, and the contained LDH was confirmed. The lower tip of needle was located in the central nucleus. The quanta-808 laser machine (power, 10 w; pulse irradiation time, 1.0 s; interval time, 1.0 s) was used for laser vaporization. A 400 μm optical fiber was placed, with its tip 5 mm beyond the puncture needle.

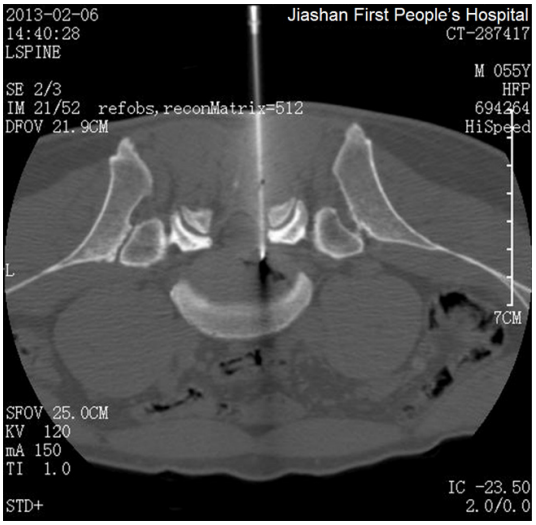

Figure 3. The puncture needle entered the target intervertebral disc through the inner margin of small joint.

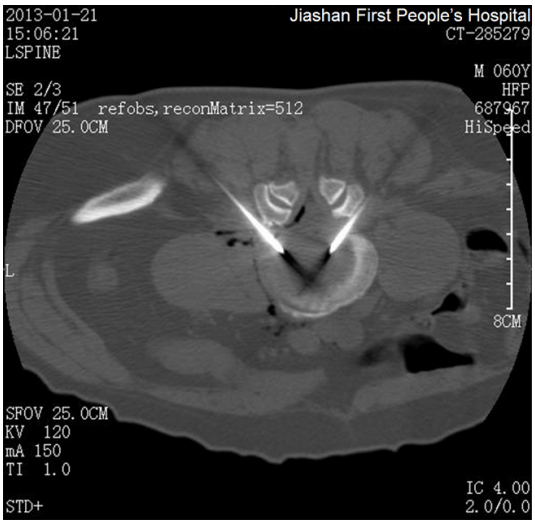

Figure 4. The distance between two needle tips was 1.5-2.5 cm.

In the single-needle group, the total energy for each disc was 1200 J. During the laser vaporization process, if obvious back pain appeared, the operation was stopped. The gas was slowly withdrawn, followed by vaporization again. After the laser gasification was finished, the fiber was pulled out. The puncture needle was inserted again to measure the intervertebral disc space after laser vaporization. Finally, the puncture needle was pulled out, followed by sticking with sterile materials.

In the double-needle realignment group, the puncture needle was inserted at both sides of the affected vertebra under CT guidance (affected side: the needle was at the median 1/3 behind the intervertebral space; normal side: the needle was at 2/5 behind the intervertebral space). The distance between the two needle tips was 1.5-2.5 cm (**Figure 4**). The laser vaporization was first performed at the normal side. The laser output power, radiation time and pulse interval were the same with those in the single-needle group. The total laser energy was 600 J. After the operation was finished, the optical fiber was pulled out, but not the needle. Then, the laser vaporization was performed at the affected side. The gas after vaporization leaked out from the needle hole at normal side, with no use of suction. The total energy of two needles for each disc was 1200 J. After laser gasification was completed, the optical fiber was inserted in the needle core, and the intervertebral disc space after laser vaporization was measured. Finally, the puncture needle was pulled out, followed by sticking with sterile materials.

Postoperative treatment

After surgery, the patient was kept in bed for rest. Antibiotics and mannitol were intravenously infused for 3 days. The rest continued for 1 month after surgery, and any heavy lifting was prohibited in the next 3 postoperative months.

Observation indexes

Using 30 days as the observation endpoint, the treatment efficacy was evaluated by mofided Macnab lumbocrural pain evaluation standard [7]. In addition, before and after surgery, the visual analogue scale (VAS) back pain scores were measured [8], and the IgG and IgM levels in the peripheral blood of patients were detected [9]. In addition, the adverse reactions of surgery were observed.

Statistical analysis

All statistical analysis was carried out using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). The enumeration data were presented as number and rate, and were compared using χ^2 test. The measurement data were presented as mean ± SD, and were compared using t test. P

Table 1. Comparison of general information between two groups

Group	Age (year)	Gender (male, %)	Disease course (month)	BMI (kg/m^2)
A	58.16±8.23	62.5	19.25±4.87	24.56±3.04
B	56.73±7.88	60.0	20.12±5.13	23.61±2.95
P	> 0.05	> 0.05	> 0.05	> 0.05

BMI, body mass index.

Table 2. Comparison of treatment efficacy between two groups

Group	Excellent	Good	Medium	Poor	Excellent and good rate	Effective rate
A	30	20	3	3	89.3%[b]	94.6%[a]
B	21	18	7	9	70.9%	83.6%

[a]P < 0.05 and [b]P < 0.01 compared with B group.

< 0.05 was considered as statistically significant.

Results

General information

The general information of the two groups was shown in **Table 1**. There was no significant difference of age, gender, disease course or BMI between two groups (P > 0.05).

Comparison of treatment efficacy between two groups

As shown in **Table 2**, after 30 days from surgery, the excellent and good rate and effective rate in group A were 89.3% and 94.6%, respectively, which were significantly higher than 70.9% and 83.6% in group B (P < 0.05 or P < 0.01).

Comparison of VAS back pain score between two groups

Before surgery, there was no significant difference of VAS back pain score between two groups (P > 0.05). After 3 days from surgery and 30 days from surgery, the VAS back pain scores in the two groups were significantly lower than before surgery (P < 0.05 or P < 0.01). At each time point after surgery, the VAS back pain score in group A was significantly lower than group B (P < 0.01) (**Figure 5**).

Comparison of peripheral blood IgG and IgM levels between two groups

Figure 6 showed that, before surgery, there was no significant difference of peripheral blood IgG or IgM levels between two groups (P > 0.05). After 3 days from surgery and 30 days from surgery, the IgG and IgM levels in each group were significantly lower than before surgery (P < 0.05 or P < 0.01). At each time point after surgery, the IgG and IgM levels in group A were significantly lower than group B (P < 0.01).

Comparison of adverse reactions between the two groups

After surgery, there were 2 cases of end-plate osteochondritis in group B, but no end-plate osteochondritis occurred in group A. No other adverse reaction incidences occurred in the two groups.

Discussion

The vast majority of LDH can be treated by conservative treatment. Some LDH patients with poor outcome can be treated by minimally invasive surgery or open surgery. Compared with open surgery, the minimally invasive surgery has the advantages of less trauma, less bleeding, faster onset, shorter hospital stay, lower cost, better spinal stability and less complications. Previous study has performed a 8-year follow-up on the PLDD for LDH patients, and found that PLDD has a lasting efficacy for treating LDH [10]. The main mechanism of PLDD is the intradiscal decompression, and the secondary role is to reduce the algogenic substance and inflammation stimulation [11]. Some scholars [12] believe that PLDD can improve the blood flow and microcirculation in the nerve roots of the LDH patients. Other minimally invasive treatment methods include radiofrequency ablation, collagenase treatment, low-temperature plasma ablation, etc. [13, 14]. However, these treatments have some deficiencies. The application of radiofrequency ablation technology is more extensive, but its decompression effect is less than PLDD. The effect onset of collagenase is slow. If collagenase strays into the subarachnoid space, it may cause the risk of paraplegia and even death. The low-temperature plasma radiofre-

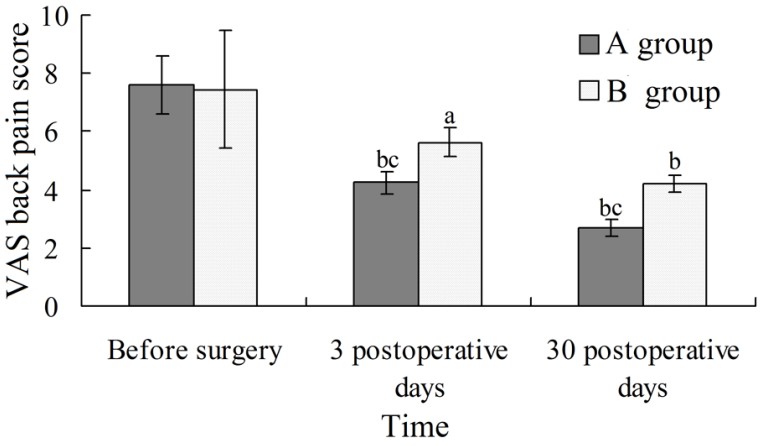

Figure 5. Comparison of VAS back pain score between two groups. VAS, visual analogue scale. [a]P < 0.05 and [b]P < 0.01 compared with before surgery; [c]P < 0.01 compared with B group.

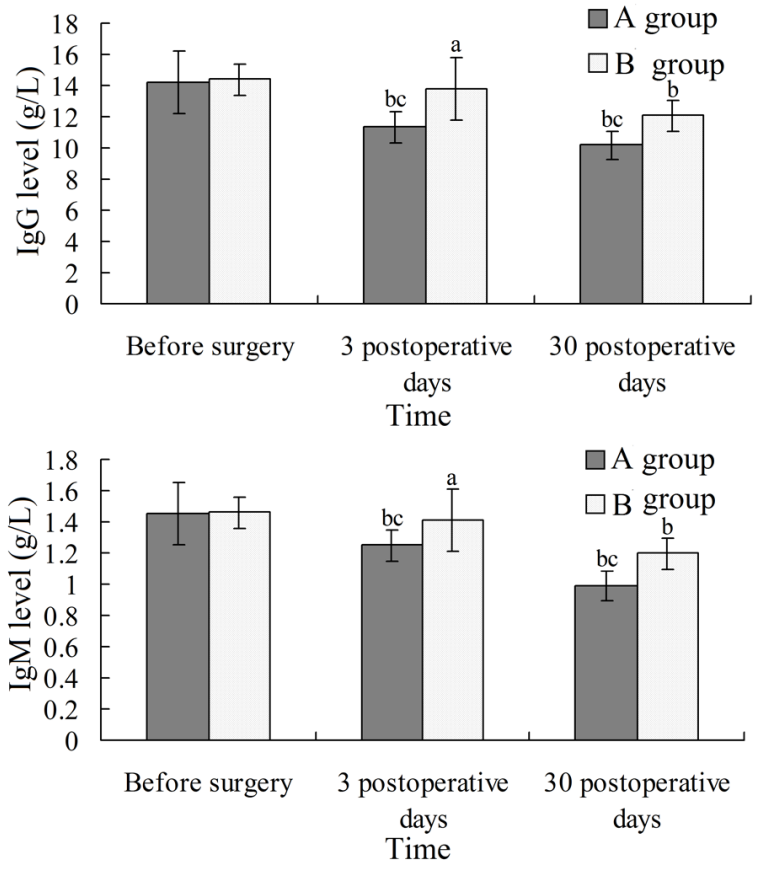

Figure 6. Comparison of peripheral blood IgG and IgM levels between two groups. [a]P < 0.05 and [b]P < 0.01 compared with before surgery; [c]P < 0.01 compared with B group.

quency has high treatment cost and risk of intervertebral disc infection and needle canal infection, which limit its application [15]. Therefore, in terms of indications, patients with middle and small contained LDH but not fiber ring rupture are more suitable for PLDD.

PLDD includes both double-needle and single-needle methods. At present, the most commonly used method is the single-needle puncture at the affected side. It has clear decompression effects at the rear of the affected side. However, for the central-type or central radical-type LDH, the single-needle method is very difficult to complete the decompression, resulting in poor efficacy. The double-needle realignment method can not only decompress the affected side, but also directly decompress the opposite side. After the realignment, the scope of the decompression is expanded, so the decompression effect is improved. In addition, in single-needle PLDD, the excessive gas after laser vaporization will lead to increased pressure in the disc, which needs to be solved by termination of the gasification and repeated pumping using the empty needle.

In the double-needle realignment method, the insertion of the first needle is the same as the single-needle method. When performing the second needle laser vaporization, the canals of the two needles are opened and connected. The gas can overflow in a timely manner from the first needle, which avoids excessive pressure in the disc. At the same time, the pinhole at the opposite side can be blocked for appropriate suction. Due to a thorough decompression, the disc retraction of the double-needle realignment method is better than in the

single-needle method. Results of this study showed that, after 30 days from surgery, the excellent and good rate and effective rate in group A were significantly higher than group B ($P < 0.05$ or $P < 0.01$). This is basically consistent with Choy's study [16]. In addition, after both 3 days and 30 days from surgery, the VAS back pain scores in group A were significantly lower than group B ($P < 0.01$).

Results of this study showed that, after 3 days from surgery and 30 days from surgery, the IgG and IgM levels in each group were significantly lower than before surgery ($P < 0.05$ or $P < 0.01$). This indicates that, PLDD can inhibit the autoimmune reaction caused by LDH. The mechanism is related to the inhibition on local immune factors. At each time point after surgery, the IgG and IgM levels in group A were significantly lower than group B ($P < 0.01$). This indicates that, the inhibitory effect in PLDD with the double-needle realignment method is stronger than the single-needle method.

After surgery, the incidence of adverse reaction in group A was significantly lower than group B. This indicates that, the double-needle realignment method has fewer complications, compared with the single-needle method. When performing the single-needle method, the poor decompression effect will require repeated needle adjustment and multi-point ignition, which inevitably leads to increased incidence of intervertebral disc inflammation due to thermal injury. The intervertebral disc inflammation is the main adverse reaction of PLDD caused by thermal injury, with incidence rates of 0.3%-1.0% [16]. For double-needle realignment operations, due to good decompression, the adjustment of the needle is reduced. In addition, the vaporized gas is eliminated in a timely manner. So the intervertebral disc inflammation caused by thermal injury is reduced. In this study, there were 2 cases of end-plate osteochondritis in the single-needle group, with no end-plate osteochondritis occurring in double-needle realignment group. Of course, good operating technology is also the basis for avoiding intervertebral disc inflammation due to thermal injury. When puncturing, the front end of the puncture needle should be in parallel with the end plate. This makes it not easy to burn the end plate, which reduces the incidence of end plate inflammation and intervertebral space infection. The tip of the puncture needle should reach the nucleus pulposus zone between the upper and lower end plates. In addition, the stability of the spinal cord also affects the outcome of surgery. Although there is a report on the simultaneous involvement of 3 intervertebral discs in PLDD [17], only a maximum 2 intervertebral discs were intervened in this study. If the patient has a relapse or the effect is not good, PLDD can be repeatedly implemented [18].

In conclusion, PLDD is a safe and effective choice for patients with contained LDH. The double-needle realignment method can reduce the risk of laser treatment, and obtain better excellence and good and effective rates, compared with the single-needle puncture method. This study has provided a reference for further application of the double-needle realignment method to PLDD for treating LDH. However, the sample size of this study is relatively small, which is a limitation. A larger sample size will make the results more convincing. In our next studies, the sample size will be further increased for obtaining more satisfactory outcomes.

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Disclosure of conflict of interest

None.

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References

[1] Kim MS, Park KW, Hwang C, Lee YK, Koo KH, Chang BS, Lee CK and Lee DH. Recurrence rate of lumbar disc herniation after open discectomy in active young men. Spine (Phila Pa 1976) 2009; 34: 24-29.

[2] Atlas SJ, Chang Y, Keller RB, Singer DE, Wu YA and Deyo RA. The impact of disability compensation on long-term treatment outcomes of patients with sciatica due to a lumbar disc herniation. Spine (Phila Pa 1976) 2006; 31: 3061-3069.

[3] Peterson CK, Pfirrmann CW and Hodler J. Are modic changes related to outcomes in lumbar

disc herniation patients treated with imaging-guided lumbar nerve root blocks? Eur J Radiol 2014; 83: 1786-1792.
[4] Yeung AT and Yeung CA. Minimally invasive techniques for the management of lumbar disc herniation. Orthop Clin North Am 2007; 38: 363-372.
[5] Suk KS, Lee HM, Moon SH and Kim NH. Recurrent lumbar disc herniation: results of operative management. Spine (Phila Pa 1976) 2001; 26: 672-676.
[6] Abrishamkar S, Kouchakzadeh M, Mirhosseini A, Tabesh H, Rezvani M, Moayednia A, Ganjeifar B, Mahabadi A, Yousefi E and Kooshki AM. Comparison of open surgical discectomy versus plasma-laser nucleoplasty in patients with single lumbar discherniation. J Res Med Sci 2015; 20: 1133-1137.
[7] Le H, Sandhu FA and Fessler RG. Clinical outcomes after m inimal-access surgery for recurrent lumbar disc herniation. Neurosurg Focus 2003; 15: El2.
[8] Takashima H, Takebayashi T, Yoshimoto M, Terashima Y, Ida K and Yamashita T. Efficacy of diffusion-weighted magnetic resonance imaging in diagnosing spinal root disorders in lumbar disc herniation. Spine (Phila Pa 1976) 2013; 38: E998-1002.
[9] Ma XL, Tian P, Wang T and Ma JX. A study of the relationship between type of lumbar disc herniation, straight leg raising test and peripheral T lymphocytes. Orthop Surg 2010; 2: 52-57.
[10] McCormick ZL, Slipman C, Kotcharian A, Chhatre A, Bender FJ 3rd, Salam A, Menkin S, Kennedy DJ and Plastaras C. Percutaneous lumbar disc decompression using the dekompressor: a prospective long-term outcome study. Pain Med 2016; 25: 122.
[11] Iwatsuki K, Yoshimine T, Sasaki M, Yasuda K, Akiyama C and Nakahira R. The effect of laser irradiation for nucleus pulposus: an experimental study. Neurol Res 2005; 27: 319-323.
[12] Hellinger J, Linke R and Heller HA. A biophysical explanation for Nd: YAG percutaneous laser disc decompression success. J Clin Laser Med Surg 2001; 19: 235-238.
[13] Zhang D, Zhang Y, Wang Z, Zhang X and Sheng M. Target radiofrequency combined with collagenase chemonucleolysis in the treatment of lumbar intervertebral disc herniation. Int J Clin Exp Med 2015; 8: 526-532.
[14] Eichen PM, Achilles N, Konig V, Mosges R, Hellmich M, Himpe B and Kirchner R. Nucleoplasty, a minimally invasive procedure for disc decompression: a systematic review and meta-analysis of published clinical studies. Pain Physician 2014; 17: 149-173.
[15] Knight K, Woods DM and Mchaourab A. Nucleoplasty for disc protrusion: a novel percutaneous decompression technique. Tech Reg Anesth Pain Manage 2009; 13: 93-101.
[16] Choy DS, Hellinger J, Hellinger S, Tassi GP and Lee SH. 23rd anniversary of percutaneous laser disc decompression (PLDD). Photomed Laser Surg 2009; 27: 535-538.
[17] Erbas YC, Pusat S and Erdogan E. Percutaneous laser disc decompression: retrospective analysis of 197 cases and review of the literature. Turk Neurosurg 2015; 25: 766-770.
[18] Choy DS. Percutaneous laser disc decompression: a 17-year experience. Photomed Laser Surg 2004; 22: 407-441.