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Treatment of Lumbar Intervertebral Disc Herniation Using C-Arm Fluoroscopy Guided Target Percutaneous Laser Disc Decompression

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Abstract

Objective: To evaluate the safety and therapeutic efficacy of target percutaneous laser disc decompression (T-PLDD) for the treatment of lumbar disc herniation. ***Background data:*** PLDD using the Nd:YAG laser has been regarded as an effective alternative treatment for disc herniation. However, all the previous studies were concentrated on vaporizing the nucleus pulposus in the intervertebral space. We hypothesize that insertion of the needle into the extruded part of the nucleus pulposus will decrease its volume and provide superior clinical effects compared to therapies that decrease the volume of the intradiscal nucleus pulposus. ***Materials and methods:*** A total of 25 patients suffering from posterolateral extruded but nonsequestered lumbar intervertebral disc herniation were treated with T-PLDD. After treatment, the patients were followed up and the therapeutic effect was assessed at 1, 3, 6, and 12 months using the modified MacNab criteria. ***Results:*** The success rate was 80.0% (18 of 25), 88.0% (22 of 25), 92.0% (23 of 25), and 92.0% (23 of 25) at 1, 3, 6, and 12 months respectively. No serious complications occurred in any of the patients. Furthermore, we did not observe any neurological sequelae. ***Conclusions:*** T-PLDD can significantly decrease pain and improve function of patients who have extruded but nonsequestered lumbar intervertebral disc herniation.

Introduction

Percutaneous laser disc decompression (PLDD) is a viable alternative treatment for herniated lumbar disc disease.[1] Choy initially used PLDD to treat extruded but nonsequestered lumbar disc herniations in 2001.[2] In order to achieve optimal safety and efficacy they believed that the needle should be parallel to the disc axis, midway between the two end plates, and with the point just past the annulus fibrosus. However, in some patients, such needle orientation is often difficult to achieve by the routine dorsolateral approach (also called safe triangle approach) because the iliac crest is too high and/or the sacroiliac angle is too small. Therefore, the needle should be inserted into the disc with an extrathecal approach. In 1994 Choy[3] reported that this approach was safe and simple and did not cause radicular pain, postspinal tap headache, nor neurologic sequelae.

PLDD usess laser energy to vaporize a small volume of the nucleus pulposus, which reduces the pressure between the nucleus pulposus and the peridiscal tissue. This pressure loss induces retraction of the herniation away from the nerve root, thus reducing nerve root compression. However, in cases of extruded but nonsequestered lumbar intervertebral disc herniations, the continuity of the annulus fibrosus was damaged. It remains unknown whether an intradisc pressure decrease causes the extruded nucleus pulposus to significantly retract. Zhao et al[4] showed that in both the extrusion and lumbar canal stenosis groups, the excellent and good clinical outcome rate was 55.9% in patients treated with PLDD. The comparable group (contained lumbar intervertebral disc herniations) had an excellent and good rating of 82%. This demonstrates that intradiscal decompression has minimal effects on the extruded nucleus pulposus. In some patients, the height of the intervertebral space was significantly decreased (by ~25–50%), suggesting that the height of the intervertebral space is not a reliable indication for intradiscal laser disc decompression. Furthermore, the failure rate (for technical reasons) is ~1.5/1000.[5] Based on these findings, we hypothesize that insertion of the needle into the extruded part of the nucleus pulposus will decrease its volume and provide superior clinical effects compared to therapies that decrease the volume of the intradiscal nucleus

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pulposus. In this study, we modified the routine method of lumbar PLDD by inserting the needle into the extruded part of the disc rather than into the intervertebral space. We observed 25 patients with extruded but nonsequestered lumbar intervertebral disc herniation over a period of 1 year to investigate whether target PLDD (T-PLDD) is efficacious and safe.

Materials and Methods

This study was approved by the Shandong Provincial Hospital Ethics Committee. The Nd:YAG laser device was purchased from Dong Tai Ji Guang Technologic Ltd. Company, Beijing, China. It is a type of end firing optical fiber with light scatter in the end of the tip.

Inclusion criteria

All patients presented with lower back pain with or without radiation to the leg and had failed a 3-month course of adequate conservative therapy. CT and MRI scans indicated that all the patients had posterolateral extruded but nonsequestered lumbar intervertebral disc herniations. The signs and symptoms of the patients were caused by the extruded disc.

Exclusion criteria

We excluded patients with unstable neurological deficits, cauda equina syndrome, bony spinal canal stenosis, calcification of the extruded disc, uncorrectable bleeding diathesis, metastatic disease of the spine, severe scoliosis, severe spondylolisthesis, psychosis, drug dependency, severe neurosis, or pregnancy.

Clinical materials

A group of 25 patients with extruded but nonsequestered lumbar intervertebral disc herniation during the study period (January–November 2008) were involved in this trial. The average age of the patients was 44 ± 9 years (range 29–73). The 19 male patients were 29–73 years old (average age 43.7 years), and the 6 female patients were 32–68 years old (average age 46.4 years). A total of 21 L5/S1 extruded discs and 4 L4/L5 extruded discs were treated by T-PLDD. Three patients also had an additional contained disc herniation in another segment, which was treated with PLDD using the dorsolateral approach. All the patients met the inclusion and exclusion criteria, and all signed the informed consent for the treatment.

Target PLDD techniques

The procedures were performed in a sterile operating room. The patients were prone on the surgical operation bed with a cushion under the lower abdomen to reduce lumbar lordosis. The treatment level and entry point were localized by C-arm fluoroscopy. The needle entry point was located in the medial border of the facet joint ~0.5–1 cm to the midline.

The point of entry was prepared with antiseptic solution, and the skin, deep fascia, and muscle layers were locally anesthetized. We used caution to avoid injecting the anesthetics into the flavum ligament and the epidural space, in order to keep the spinal nerve "live". An 18-gauge 10-cm needle was slowly inserted toward the extruded disc under fluoroscopic guidance. When the needle was inserted into the extruded part of the disc, a marked increase in resistance can be felt, and some patients complained of light-to-severe radicular pain, which lasted no more than 10 sec. Next, 2 mL of iohexol was injected into the needle. If the resistance was large and the contrast spread into the intradiscal space, it indicated that the position of the needle top was in the extruded part of the disc. All patients experienced pain during contrast injection of a nature, pattern, and distribution similar to what they experienced normally. After the needle position was validated by radiography and contrast, an optical fiber was inserted into the extruded disc through the treating needle. This fiber was then connected to the Nd:YAG laser. The laser procedure was performed with single pulse of 6.5 W each in a series of 1-sec duration. The total laser energy was determined by the volume of the extruded disc and the response of the patients. The energy usually ranged from 300 to 500 J. After the operation, we removed both the fiber and the needle and covered the puncture point with a sterile dressing.

The patients were prescribed oral antibiotics for 1 day, along with bed rest for 24 h. If the patients complained of pain, we prescribed painkillers according to the degree of pain. All the patients were followed up for 12 months.

Criteria for clinical efficacy

The clinical outcome was evaluated according to the modified MacNab criteria (Table 1).

Results

Two patients complained of severe, unbearable radicular pain when the needle reached the epidural space, 6 patients complained moderate bearable pain, and 17 patients complained of slight pain. There were no neurologic sequelae.

The therapeutic efficacy (resolution of leg pain, back pain and self-reported disability) was assessed at 1, 3, 6, and 12 months, respectively, according to the modified MacNab criteria.[6] A satisfactory therapeutic outcome was obtained in this group of patients at 1, 3, 6, and 12 months. The successful (excellent and good outcome) rate was 80.0% (18 of 25), 88.0% (22 of 25), 92.0% (23 of 25) and 92.0% (23 of 25) at 1, 3, 6, and 12 months, respectively (Table 2).

Table 1. Modified MacNab Criteria for Assessing Clinical Outcome After Treatment

Outcome	*Description*
Excellent	Disappearance of symptoms Complete recovery in working and sports activities
Good	Occasional episodes of low back pain or sciatica No limitations of occupational activities
Fair	Insufficient improvement of symptoms Periodic administration of drugs
Poor	No improvement of clinical situation Limitation of physical activities

The criteria of "excellent, good, fair, and poor" for evaluating clinical outcome after treatment are shown.

Table 2. Clinical Outcomes After Treatment

Outcome	*1 Month* (n = 25)	*3 Months* (n = 25)	*6 Months* (n = 25)	*12 Months* (n = 25)
Excellent	44.0%(11)	62.0%(16)	72.0%(18)	76.0%(19)
Good	36.0%(9)	24.0%(6)	20.0%(5)	16.0%(4)
Fair	12.0%(3)	8.0%(2)	4.0%(1)	4.0%(1)
Poor	12.0%(3)	4.0%(1)	4.0%(1)	4.0%(1)

Clinical outcomes of patients after treatment (percentage and number) are shown.

Twenty-five patients underwent an MRI scan at 12 months after the minimal invasive operation. In these patients, we obtained 23 excellent and good clinical outcomes and 2 fair and poor clinical outcomes. Four of the patients with clinical excellent and good outcomes showed a reduction in the disc protrusion by >4 mm, and 17 of these patients showed a reduction in the disc protrusion by 3 mm. In 2 patients, the disc protrusion was reduced by ≤2 mm. The thecal cross-sectional area increased in all the clinically successful patients. The clinically fair and poor patients showed no appreciable change in the disc protrusion and the thecal cross-sectional area. No obvious intervertebral disc height loss and end plate damage were found in this group of patients.

Discussion

Surgery and minimally invasive techniques have been shown to improve the clinical outcomes of patients with herniated disc disease who had failed a 3-month course of adequate conservative therapy.[7] Because traditional open surgery, which has been in practice since 1934, would further weaken an already compromised posterior wall of the disc complex, such an approach may not be in the best interests of the patient with herniated disc disease.[8] Therefore, the minimally invasive therapies should be considered before resorting to traditional open surgery when patients do not respond to conservative therapies.

PLDD is one of the so-called "minimally invasive" treatment methods. It can vaporize the nucleus pulposus, and decrease its volume. It has been shown that a small reduction in the volume of the nucleus pulposus, which is composed of 60–80% water, is associated with a disproportionate fall in intradiscal pressure.[9] Therefore, PLDD is appropriate for the treatment of contained lumbar disc herniations. It has been shown that PLDD can improve the clinical outcomes of contained lumbar disc herniations.[1] Schenk et al[10] reported success rates in larger studies varying from 75% (with a 95% CI of 69–81%) to 87% (with a 95% CI of 80–94%). The majority of the studies considered uncontained disc herniation (extrusion or sequestered) as exclusion criteria. Therefore, few studies have addressed the treatment of uncontained lumbar disc herniations by PLDD. Choy used PLDD to treat extruded but nonsequestered lumbar disc herniations in 2001, and achieved good pain relief in patients. In some instances, it even reversed neurologic deficits.[2] Zhao et al. reported that in cases of extrusion and lumbar canal stenosis treated with PLDD, the excellent and good rates combined came to only 55.9%.[4]

In this study, treatment of lumbar intervertebral disc herniation by T-PLDD was achieved by inserting the needle into the extruded part of the nucleus pulposus instead of into the intervertebral space. We obtained a combined excellent and good clinical outcome rate of 92.0%. A previous study showed that the symptoms of lumbar intervertebral disc herniation were caused by: mechanical pressure on the nerve root, aseptic inflammation of the nerve root arising from irritating products originating from the intervertebral disc, and annular neoneuralization.[11] The T-PLDD technique can decrease the volume of the extruded part of the nucleus pulposus, therefore directly relieving the pressure on the nerve root. The photochemical effects of the laser can also decrease the volume of the extruded disc, thus alleviating the compression of the extruded disc and the nerve root. Furthermore, the photobiological effects of the laser can reduce nerve root edema.[12] Taken together, T-PLDD can provide faster pain relief than can the traditional PLDD techniques for patients with extruded but nonsequestered disc herniations.

It would appear that using a posterior paramedian approach to inject the needle into the extruded portion of the nucleus pulposus, followed by laser-mediated vaporization, would result in neurologic sequelae. The nerve root, which is adjacent to the extruded portion of the nucleus pulposus, may become injured because of the high energy generated from the laser. However, no neurologic sequelae occurred in our patients who were treated using this approach. A key point of this technique is to use iohexol injection to verify that the needle is present in the extruded portion of the disc. To make sure that the tip of the laser fiber was inserted into the extruded part of the disc, not the intervertebral space, the tip of the laser that we used for T-PLDD technique was adjusted to protrude 0.4 cm from the needle. The shorter the distance between the laser tip and the needle, the more disc tissue can be vaporized and likely get more therapeutic effect. However, it has the higher risk that the fiber tip will "catch fire" and light up the entire proximal fibers and cause nerve damage. Furthermore, another important step in this treatment strategy is to apply a single pulse of 6.5 W each in a series of 1-sec duration when vaporizing the nucleus pulposus.

Because we needed to keep the involved nerve root "live", we did not inject anesthetic into the epidural space. In cases of patients who complained of pain in the lower extremity when punctured (which is primarily caused by aseptic inflammation of the epidural), we always injected normal saline (~5 mL) to dilute the inflammatory factors. Because the duration of pain is very short, neither sedatives nor analgesics were given to the patients during the whole procedure.

T-PLDD is an alternative method for extruded but nonsequestered lumbar disc herniation, when the intervertebral disc height is <75% of normal value or it is difficult to

insert the needle into the intervertebral space through the traditional triangle approach. Target PLDD should not be used as a routine approach for contained lumbar intervertebral disc herniations or for patients with unstable neurological deficits, cauda equina syndrome, bony spinal canal stenosis, or calcification of the extruded disc. T-PLDD may be more effective for patients with extruded but nonsequestered lumbar disc herniations at the L5/S1 level than at other levels, because the thecal is much narrower and the interlaminal space is much wider in L5/S1.

This report is a preliminary study, and the defects of this article are that it is not a randomized controlled clinical trial, and the follow-up is short. We have submitted this report for publication because we found that treatment of lumbar intervertebral disc herniation with T-PLDD is safe and effective and generates good clinical outcomes. Future studies will include a randomized controlled clinical trial to test the efficacy and safety of using T-PLDD to treat lumbar intervertebral disc herniation, and using the Ho:YAG laser, which is better than the Nd:YAG laser in delivery of energy, which will make it will be safer to prevent the damage of adjacent neural structures. In the future, we will try to use the Ho:YAG laser for this target PLDD technique to treat lumbar intervertebral disc herniation.

Conclusion

Extruded but nonsequestered disc herniations can be treated with T-PLDD, a much simpler and less invasive procedure than traditional laminectomy and discectomy.

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Author Disclosure Statement

conflicting financial interests exist.

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