Short review article

Percutaneous Laser Disc Decompression in the Treatment of Lumbar Radicular Pain

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Abstract

Lumbar radicular pain is defined as pain in the lumbar spine with propagation to the lower extremities. It is a major public health, social and economic problem in the modern society, and is one of the most common reasons for visits to the doctor. Lumbar radicular pain is often the reason for absenteeism and occupational disabilities. It is estimated that about 70-85% of the world's population have experienced lumbar spine pain once in their lifetime. There are numerous modalities for the treatment of lumbar radicular pain, ranging from pharmacotherapy to surgery. In order to avoid systemic side effects of analgesics, anaesthesia and long-term and extensive surgery, minimally invasive procedures are increasingly used for treating lumbar radicular pain. Percutaneous laser disc decompression (PLDD) is one such procedure, first performed by Dr Choy and Dr Ascher in 1986. PLDD is an outpatient surgery performed under local anaesthesia, its success rate is high and the complication rate is low. This method therefore certainly attracts the attention of clinicians dealing with this issue.

(Budrovac D, Radoš I, Tot OK, Haršanji Drenjančević I, Omrčen I. Percutaneous Laser Disc Decompression in the Treatment of Lumbar Radicular Pain. SEEMEDJ 2020; 4(2); 62-68)

Received: Apr 1, 2020; revised version accepted: Sep 16, 2020; published: Nov 12, 2020

KEYWORDS: herniated disc, laser, percutaneous diskectomy, radiculopathy

Introduction

Improper posture, sedentary lifestyle and frequent weightlifting are the most common causes of herniated intervertebral discs, which is the reason why young, working-age people suffer the most from such pain. It is estimated that 80% of people experience low back pain in their lifetime (1). Lumbar pain with or without a radicular component most commonly occurs in adults, but it may also occur in the paediatric population (2). Lumbar radicular pain is first treated conservatively, and if the pain persists, the gold standard is surgical microdiscectomy. In most patients who experience the first episode of lumbar radicular pain, it decreases to a level that does not impair daily functioning after 6 weeks (3). The increase in incidence of low back pain caused by herniated intervertebral disc increased the attention given to minimally invasive pain management (1). Due to faster recovery than after surgical microdiscectomy, percutaneous laser disc decompression (PLDD) has attracted much attention. The first PLDD was performed in 1986 and the procedure was approved by the FDA in 1991 (4). Percutaneous laser disc decompression is a minimally invasive method in which the risk of damage to muscles, bones, ligaments and nerves is reduced. The aim of this study is to present PLDD as one of the treatment modalities of lumbar pain caused by disc herniation.

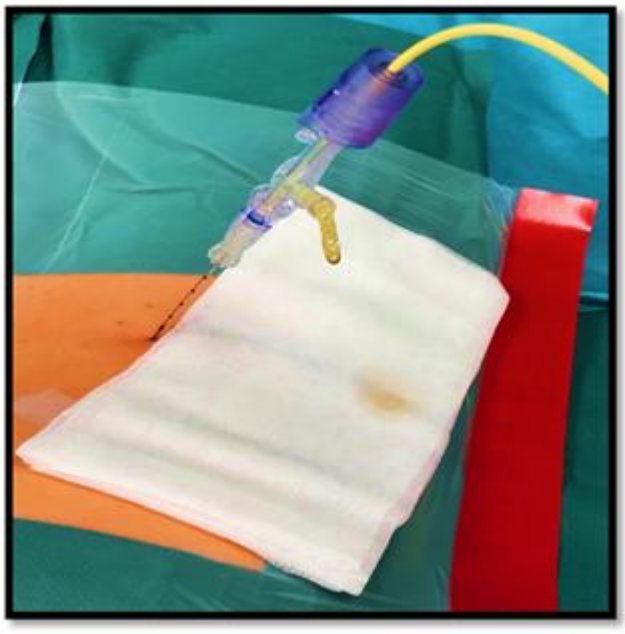
Mechanism of pain onset

Lumbar radicular pain can be caused by compression of the herniated disc on the nerve, but it may also be caused by local inflammation. Acute pressure on the nerve root causes numbness, paraesthesia, weakness and pain. Disc pressure on the nerve root leads to disruption of nutritional supply to the nerve, increased permeability of blood vessels, impaired ionic balance and changes in the conduction of the nerve impulse. When there is no compression of the herniated disc on the nerve root, the cause of pain are substances from the nucleus pulposus, proteoglycans and a lowered pH level. When the integrity of the annulus fibrosus is impaired, a substance leaks into the epidural space, producing a proinflammatory effect. Phospholipase A2 plays an important role in this process. Much higher phospholipase A2 levels were observed in disc extrusion than in intact disc; this substance is involved in the synthesis of prostaglandin and leukotriene, leading to a local inflammatory response (5).

Mechanism of action of percutaneous laser disc decompression

The mechanism of action of percutaneous laser disc decompression is based on the principle that the disc is viewed as a closed hydraulic system containing water, which is incompressible. The water content of the disc is about 50-89%, and decreases with age. Laser energy warms the surrounding tissue. In this way, a small volume of nucleus pulposus water content is evaporated (Figure 1). A small change in the volume of water results in a disproportionate decrease in pressure inside the disk (6). A decrease in pressure within the disc causes the hernia to withdraw and leads to a decrease in pressure on the root of the involved nerve. This reduces lumbar radicular pain caused by disc herniation.

Figure 1. The laser probe is inserted into the needle. Evaporation of water from the nucleus pulposus (author's work).



Anatomy of the intervertebral disc

The intervertebral disc is a complex structure; it is the largest avascular structure in the body and it enables spinal mobility (7). It consists of the outer part, annulus fibrosus, and the inner part, nucleus pulposus (8). Annulus fibrosus consists of 15-25 layers of crisscrossed fibres; the number of layers increases in the lumbar spine segment. Annulus fibrosus consists of about 60% collagen and 20% proteoglycan, and nucleus pulposus consists of 65% proteoglycan and 20% collagen (9). Annulus fibrosus is innervated by spinal nerve branches, while there is no innervation of the nucleus pulposus in an intact disc. The metabolism of the disc is mainly anaerobic and nutrients are diffused through the endplate. Degeneration of the endplate thus results in insufficient nutritional supply of the intervertebral disc (10). Reduced amounts of proteoglycans, collagen, water, and calcified endplate lead to disc damage. Degenerative changes of the disc lead to a reduction in intervertebral distance and thus cause osteoarthritis of the facet joints. The incidence of degenerative disc changes increases with age, and if they occur in younger people, the cause is most often a genetic predisposition or injury. Some of the factors that accelerate degenerative changes of the disc include smoking, atherosclerosis, frequent lifting of heavy loads, and a sedentary lifestyle.

Technique of performing percutaneous laser disc decompression

PLDD is performed in the operating room. During the procedure, the patient lies in a prone position. The skin at the intended puncture site is sterilized, prepared and protected from the surrounding area with sterile compresses. After the relevant intervertebral space (disc) is visualized, the optimal position is found by lateral and craniocaudal angulation. Local anaesthetic infiltration is performed at the puncture site and an 18 G needle insertion is performed at the same place. The needle advances under fluoroscope control to be positioned in the middle of the disk, and the final position is confirmed by lateral projection and contrast application (Figure 2). The laser probe is then inserted into the needle, supplying laser energy according to default parameters, which depend on the device and the protocol of each institution. Laser energy leads to tissue heating and evaporation of a small volume of water within the nucleus pulposus (11, 12).

Figure 2. Confirmation of proper needle position in intervertebral disc after contrast administration. Intervertebral disc L5/S1 (author's work).

Indications and contraindications

An indication for PLDD is symptomatic disc protrusion. The pain may be localized in the lumbar spine or it may radiate into one or both legs. Discogenic pain is likewise an indication for PLDD. Discogenic pain is pain that is not of radicular origin, it occurs in the absence of spinal deformity, and it has no positive signs of nerve tension. The generators of discogenic pain are nociceptive fibres of the annulus fibrosus. The outer posterolateral portion of the annulus fibrosus is rich in sensory fibres.

First degree spondylolisthesis, mild scoliosis, and osteoarthritis are not contraindications for PLDD. Prior surgery is also not a contraindication, unless it was a vertebral fusion or there are nerve root adhesions. PLDD can also be performed if there is disc extrusion without sequestration.

There are differing opinions, but the author of the method believes that PLDD can also be used in spinal canal stenosis exacerbated by disc herniation (13).

Contraindications for PLDD are acute pain that has not been treated conservatively, because 80-85% of acute pain disappears after resting, relaxation, non-steroidal anti-inflammatory drugs, and epidural administration of steroids and local anaesthetic. PLDD is contraindicated in severe spondylolisthesis, severe scoliosis, metastatic cancer, vertebral compression fracture, compression of the nerve root with the bone, and the presence of free disc sequestration. Advanced age is not a contraindication, but in the elderly, the amount of water in the disc is reduced, which is more pronounced in males. Haemorrhagic diathesis, near-disc vertebral haemangioma, multiple sclerosis, demyelinating diseases, and systemic infections are also contraindications (14).

Postprocedural recommendations

After PLDD, the patient is recommended to rest and lie, as well as to abstain from sitting and walking. After the first day, it is recommended to limit sitting and walking to a maximum of 20 minutes. Wearing a lumbar orthosis for two weeks in order to reduce mobility is likewise recommended. Patients who do not do manual labour can return to work after 3 days, while those who do manual labour can return to work after 7-10 days. Physical therapy can be performed after 1 week. Antibiotic prophylaxis is recommended to prevent infection (14).

Complications of PLDD

Possible complications of PLDD include nerve root injury, cauda equina syndrome, bowel perforation, thermal injury along the needle path, and thermal necrosis of the endplate. Paraspinal muscle spasm that causes patients discomfort is also described, and in more severe cases, a physical examination will show lateral curvature of the spine with a concavity to the side of spasm. Muscle tension can be sensed by palpation. Muscle spasm disappears after 3-4 days and does not affect the outcome of the treatment. Benzodiazepine as a relaxant and local heat can be used to relieve the spasm. Aseptic or infectious discitis are more serious complications. The most common cause of infectious discitis is Staphylococcus aureus. Symptoms usually occur 3-5 days after surgery and manifest as fever and pain of the affected disc and increased serum inflammatory parameters. If discitis is suspected, an emergency MRI of the affected disc should be performed. This condition requires antibiotic treatment. The incidence is less than 1%. The diagnosis of aseptic discitis is made by ruling out septic discitis. Signs and symptoms are the same as those for septic discitis, but there is no fever or elevated inflammatory parameters. The condition improves after several days of rest and administration of non-steroidal anti-inflammatory drugs.

Inflammation of the sacroiliac joint is likewise possible. It usually occurs several days after an excellent response to PLDD. The mechanism of pain onset is thought to be the cessation of lumbar radicular pain, which leads to the cessation of compensatory "locking" of the lumbosacral (LS) segment and sacroiliac (SI) joint. This condition is treated by infiltration of the SI joint with local anaesthetics and corticosteroids and non-steroidal anti-inflammatory drugs (14).

Discussion

Patients who experience pain caused by herniation of the intervertebral disc and who do not respond to conservative treatment are candidates for surgery (15). Surgical treatment is still the gold standard in the treatment of disc herniation, but classic surgery may impair spinal stability, so consideration should be given to minimally invasive treatments (16, 17). Compared to discectomy/microdiscectomy, PLDD has fewer postoperative complications and tissue injuries (18). A group of Iranian researchers observed the impact of PLDD on pain intensity as measured by the Visual Analogue Scale (VAS) and on disability as measured by the Oswestry Disability Index (ODI). The mean VAS before the procedure was 6.70, and it was 2.60 after the

procedure. The smallest pain reduction was observed in a 27-year-old man and was 43%, while the highest pain reduction was 71%, observed in a 45-year-old female. The mean ODI before surgery was 31.03 and it was 20.60 after surgery, which is statistically significant. ($p < 0.001$) (11).

PLDD is a minimally invasive procedure and could in some cases be used as an alternative to surgical discectomy. The study compared the success rates and complications between PLDD and microdiscectomy. There was no difference in efficiency between the two methods. The rate of reoperation in the surgical group was 21%, and it was 52% for PLDD, which is higher than expected. Although the rate of recurrence in the PLDD group was relatively high, we can conclude that surgical discectomy was avoided in 48% of patients over a two-year period (19). A randomized controlled trial compared the efficacy of PLDD and conventional microdiscectomy. The study was conducted on 115 patients who had lumbar radicular pain caused by an intervertebral disc hernia no larger than one third of the spinal canal. The Roland-Morris Disability Questionnaire showed that, at 8 and 52 weeks, PLDD is equivalent to conventional surgery. Recovery was expected to occur faster with PLDD. The rate of reoperation was significantly lower with conventional microdiscectomy (38% vs. 16%). At one-year follow-up, PLDD proved to be equivalent to conventional microdiscectomy (20). A study comparing 500 microdiscectomies and 500 PLDDs was performed. In the microdiscectomy group, 428 patients (85.6%) had good or excellent results, as opposed to 419 in the PLDD group (83.8%). The complication rate in the microdiscectomy group was 2.2% (11 patients), while there were no complications in the PLDD group (21). The author of a different study, Dr Choy, presented the results of PLDD over 17 years; this study included 1,275 patients and 2,400 performed PLDDs (neck, thoracic and lumbar segments). The success rate according to MacNab criteria was 89%. The complication rate (infectious discitis) was 0.4%, and there were no cases of nerve root injury or spinal cord injury (22).

Although extrusion was previously considered as a contraindication, Choy et al presented the results of a study that included 21 patients with disc extrusion without sequestration. Eighteen patients experienced significant reductions in pain and, in some cases, a reversal of neurological deficits (23).

A group of authors performed a systematic review and meta-analysis to compare the complication rates of different discectomy methods. The methods that were compared were open discectomy/microdiscectomy (OD/MD) with microendoscopic discectomy (MED), percutaneous endoscopic lumbar discectomy (PELD) and percutaneous laser disc decompression (PLDD) and tubular discectomy. They found 17 randomized controlled trials and 20 cohort studies that met their criteria. Meta-analysis of RCTs showed that the overall complication rates for OD/MD, MED, PELD, PLDD and tubular discectomies were 16.8%, 16.2%, 21.2%, 5.8%, 8.4% and 25.8%, respectively. Reoperation rates were 8.4%, 4.7%, 6.7%, 23.2% and 11.7%, respectively. Meta-analysis of cohort studies showed that overall complication rates were 7.6%, 6.2%, 9.1%, 3.5% and 11.6%, respectively. Reoperation rates were 5.5%, 0.8%, 9.4%, 3.2% and 3.7%, respectively (24). Patel and Singh, in a retrospective study conducted on 65 patients treated with PLDD, reported that the preprocedure VAS score was 7.6/10 and at 2-week, 6-week, 3-6 month intervals, it was 3.7/10, 4.3/10, and 4.1/10, respectively (25). Proper patient selection for PLDD treatment has short-term and long-term benefits.

Conclusion

Percutaneous laser disc decompression is a minimally invasive procedure, with a low complication rate, high success rate, and rapid recovery. Proper selection of patients with lumbar radicular pain caused by herniated intervertebral disc produces good results and may delay surgery or, in some cases, be an alternative to surgery.

Acknowledgement. None.

Disclosure

Funding. No specific funding was received for this study.

Competing interests. None to declare.

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Administrative, technical or logistic support: Budrovac D, Radoš I, Tot OK, Haršanji Drenjančević I, Omrčen I
Analysis and interpretation of data: Budrovac D, Radoš I, Tot OK, Haršanji Drenjančević I, Omrčen I
Conception and design: Budrovac D, Radoš I, Tot OK, Haršanji Drenjančević I, Omrčen I
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Drafting of the article: Budrovac D, Radoš I, Tot OK, Haršanji Drenjančević I, Omrčen I
Final approval of the article: Budrovac D, Radoš I, Tot OK, Haršanji Drenjančević I, Omrčen I