ORIGINAL ARTICLE

Percutaneous Laser Disc Decompression for lumbar discogenic radicular pain

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Abstract
Purpose: The aim of our study was to directly evaluate the effectiveness of percutaneous laser disc decompression (PLDD) for the treatment of lumbar discogenic radicular pain.

Materials and methods: From June 2006 through July 2009, 205 patients with contained disc herniation demonstrated on computed tomography (CT) or magnetic resonance, concordance between the radicular pain and the nerve root compressed by the herniated disc, neurological findings referring to a single nerve root and no improvement after conservative therapy for a minimum of six weeks were enrolled. All patients were treated with PLDD under CT guidance and local anesthesia. Follow-up was scheduled at 1, 2 days, 3, 6 months. Subsequent follow-ups at 12, 24 and 36 months were carried out through visits or by telephone. Clinical outcome was quantified using the MacNab criteria.

Results: The age of patients ranged from 27 to 78 years (mean 58 ± 11 years). The levels of involvement were 18 cases at L3-L4, 123 cases at L4-L5 and 64 cases at L5-S1. Using the MacNab criteria, the results were as follows: 67% (n=137) showed a good outcome and 9% (n=18) a fair outcome. There were no serious complications in our series.

Conclusion: PLDD is effective treatment for lumbar discogenic radicular pain, associated with only minimal discomfort to the patient. This minimally invasive technique is a valid alternative for those patients not responding to conservative medical treatment, allowing in many cases to obviate the need of spine surgery.

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PALABRAS CLAVE
Radiología intervencionista;
Dolor lumbar;
Tratamiento con láser

Descompresión percutánea discal con láser para el tratamiento del dolor lumbo-radicular de origen discal

Resumen
Objetivos: El objetivo de nuestro estudio fue evaluar la eficacia de la descompresión percutánea discal con láser (DPDL) en el tratamiento del dolor lumbo-radicular de origen discal.

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Material y métodos: Desde junio de 2006 hasta julio de 2009 se incluyeron en este estudio 205 pacientes con hernia discal contenida demostrada mediante tomografía computarizada (TC) o resonancia magnética (RM), que presentaban concordancia entre el dolor radicular y la raíz nerviosa comprimida por el disco herniado, con hallazgos neurológicos referidos a una única raíz nerviosa y que no mejoraron tras un tratamiento conservador de al menos seis semanas. Todos los pacientes fueron tratados con DPDL guiada mediante TC y con anestesia local. Se realizaron controles al primer y segundo día y a los tres y seis meses. Los controles posteriores fueron a los 12, 24 y 36 meses y se realizaron mediante visita o por teléfono. Para la valoración del resultado clínico se aplicaron los criterios de MacNab.

Resultados: El rango de edad fue de 27-78 años (media: 58 ± 11 años). La afectación fue en 18 casos a nivel de L3-L4, en 123 casos a nivel de L4-L5 y en 64 casos a nivel de L5-S1. Siguiendo los criterios de MacNab, los resultados fueron: un 67% (n = 137) mostraron un resultado bueno y un 9% (n = 18) un resultado aceptable. No hubo complicaciones importantes en nuestro estudio.

Conclusion: La DPDL es un tratamiento efectivo para el dolor lumbo-radicular de origen discal, que solo causa ligeras molestias al paciente. Esta técnica mínimamente invasiva es una alternativa adecuada para aquellos pacientes que no responden al tratamiento médico conservador, obviando en muchos casos la necesidad de intervenir la columna quirúrgicamente.

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Introduction

The lifetime prevalence of chronic low back pain has been reported as high as 80%. Discogenic lumbar radicular pain due to lumbar disc prolapse, protrusion, or herniation accounts for less than 5% of low back problems. However, it is estimated that 90% of cases of radicular pain are due to disc herniation with nerve entrapment or compression.

The majority of patients with acute sciatica recover within two to six weeks of conservative treatment and may avoid surgery. However, about 20% of patients do not respond to conservative treatment and usually undergo surgery. Some absolute indications for surgery include bladder dysfunction and progressive muscle weakness, although fortunately these complications are rare.

Minimally invasive intradiscal techniques have been developed in order to reduce tissue trauma and the relatively high rate of complications and the necessity of repeated surgery.

In the last two decades, more than 500,000 percutaneous disc compression procedures have been performed, including chemonucleolysis, automated and manual percutaneous discectomy, posterolateral endoscopic discectomy, laparoscopic discectomy and fusion, intradiscal electrothermal annuloplasty therapy (IDET®), percutaneous discectomy with the DekKompressor® probe, nucleoplasty using radiofrequency, intradiscal ozone therapy and percutaneous laser disc decompression (PLDD).

PLDD was first introduced in the 1980s and the concept is based on the fact that a small reduction in volume of the nucleus pulposus results in a significant reduction in intradiscal pressure. This is achieved by introducing an optical fiber into the intervertebral disc under image-guidance and local anesthesia and laser energy is released, vaporizing a small volume of the nucleus pulposus. Treatment of the first patient with PLDD took place in 1985 and from then until 2011, more than 30,000 patients have been treated with this procedure. US Food and Drug Administration (FDA) approved PLDD in 1991.

The aim of this study is to evaluate the therapeutic effect of PLDD for the treatment of discogenic lumbar radicular pain, presenting the clinical outcome of a series of 200 patients.

Patients and methods

Patient population

This is an open uncontrolled nonrandomized prospective study of the clinical outcome obtained with PLDD used in the treatment of discogenic lumbar radicular pain. From June 2006 until July 2009, 205 patients with discogenic lumbar radicular pain who had been referred to our institution and that met the following inclusion criteria were enrolled: contained disc herniation demonstrated on CT or MR, regardless of the size of the herniation; concordance between the radicular pain and the nerve root compressed by the herniated disc; and neurological findings referring to a single nerve root with no improvement after receiving conservative therapy during a minimum of six weeks. Patients with spondylolisthesis, with more than 50% disc height loss, sequestered disc, pregnancy, or previous surgery at the indicated disc level were excluded.

Patients were first examined and evaluated by an orthopedic surgeon who took the clinical history and performed a standard neurological examination. Subsequently, the surgeon decided on the eligibility of the patient for PLDD based on the inclusion and exclusion criteria. Gender distribution was 117 male and 88 female with an age range of 27-78 years (mean 58 ± 11 years). The levels of involvement were: 18 cases at L3-L4, 123 cases at L4-L5 and 64 cases at L5-S1. Follow-up examinations were carried out at 1 and 2 days, and at 3 and 6 months. Subsequent follow-up examinations at 12, 24 and 36 months were carried out during an appointment or by telephone. The clinical outcome was quantified using the MacNab criteria (Table 1).

The ethics committee of our hospital approved the study and all patients gave informed consent.

Percutaneous laser disc decompression procedure

A CT study was performed on a Somatom Emotion 6 with fluoroscopy (Siemens Medical Systems, Germany) in order to
locate the level of the affected disc, to guide needle placement exactly within the nucleus pulposus and to visualize intradiscal vaporization.

For all PLDD procedures, a semiconductor diode laser, portable, operated in pulsed mode (Diomed 25 laser, Cambridge, United Kingdom) and 805 nm wavelength was used. Laser energy was transmitted through a contact optical fiber (400 μm), sterile and flexible.

The procedure is performed with the patient in the prone position on the CT table (Fig. 1). After disinfection of the area, local anesthetic with lidocaine was injected under CT guidance at the entry point of the needle a through the deep fascia and muscle layers (Fig. 2). Using real-time triplanar fluoroscopy under CT guidance, a fine hollow 18 G needle with a stylet (COOK, William Cook Europe, Denmark) was then placed centrally in the nucleus pulposus of the intervertebral disc, between the two end-plates, using a posterolateral approach (Fig. 3). The stylet was removed and, once verified, a 400 μm sterile optical fiber with a proximal mark to prevent penetration of the tip more than 1 cm beyond the end of the needle was inserted into the needle.

Fifteen W of laser energy were delivered in 0.5–1 s pulses with 4–5 s pauses to allow heat dissipation and avoid or minimize the pain caused by the heat. Careful monitoring of patient discomfort is absolutely necessary, and the pulse rate should be increased if the patient experiences discomfort. The laser energy delivered ranged between 1000 and 2000 J, depending on the level of the herniated disc, and the formation of vaporized gas within the disc was also evaluated (Fig. 4). All PLDD procedures were performed

<table>
<thead>
<tr>
<th>Table 1</th>
<th>MacNab criteria for clinical outcome evaluation.</th>
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<tbody>
<tr>
<td>Outcome</td>
<td>Definition</td>
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<tr>
<td>Good</td>
<td>Improved functional capacity</td>
</tr>
<tr>
<td></td>
<td>Occasional backache or leg pain</td>
</tr>
<tr>
<td></td>
<td>No dependency-inducing medication</td>
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<tr>
<td></td>
<td>Appropriate activity</td>
</tr>
<tr>
<td></td>
<td>No objective signs of nerve root damage</td>
</tr>
<tr>
<td>Fair</td>
<td>Intermittent episodes of mild lumbar radicular pain or leg pain</td>
</tr>
<tr>
<td></td>
<td>May be non productive if unchanged from preoperative status</td>
</tr>
<tr>
<td></td>
<td>No dependency-inducing medication</td>
</tr>
<tr>
<td></td>
<td>Appropriate physical activity</td>
</tr>
<tr>
<td></td>
<td>No objective signs of nerve root damage</td>
</tr>
<tr>
<td>Poor</td>
<td>Continued pain</td>
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<tr>
<td></td>
<td>Medication abuse</td>
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<tr>
<td></td>
<td>Physical inactivity</td>
</tr>
<tr>
<td></td>
<td>Objective signs of continuing radiculopathy</td>
</tr>
<tr>
<td></td>
<td>No functional capacity improvement</td>
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<tr>
<td></td>
<td>The patient focuses on compensation or on taking legal action</td>
</tr>
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</table>
by interventional radiologists. Patients underwent only one PLDD procedure.

After the procedure, the patient was sent home on bed rest for 24 h, followed by progressive ambulation at 2 or 3 days. Patients who responded to the treatment could perform activities not requiring exertion within 5–7 days. Patients were told to avoid sitting in the same position for more than 30 or 40 min during the first two weeks, and patients with sedentary jobs were able to return to work within 4–5 days. For heavy work, the recommendation was to wait 4–6 weeks.

![Figure 3](image1.png)

**Figure 3** L4–L5 disc puncture under CT guidance, with the tip of the needle positioned at the center of the disc.

![Figure 4](image2.png)

**Figure 4** CT obtained during laser emission to assess the nucleus pulposus vaporization at the L5–S1 level. The CT shows partial filling of the herniated disc with gas.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Patients (n)</th>
</tr>
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<tbody>
<tr>
<td>Good</td>
<td>123 (67%)</td>
</tr>
<tr>
<td>Fair</td>
<td>18 (9%)</td>
</tr>
<tr>
<td>Poor</td>
<td>64 (24%)</td>
</tr>
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</table>

**Table 2** Clinical outcome (MacNab criteria).

**Results**

In all cases, the needle was correctly placed into the intervertebral disc under CT guidance. The duration of the PLDD was 20–35 min. All the patients underwent follow-up (10 patients during 3 months, 33 during 6 months, 52 during 12 months, 74 during 24 months and 36 during 36 months; range: 3–36 months). Using the MacNab criteria, the results were as follows: good in 67% (n = 137), fair in 9% (n = 18) (Table 2). PLDD was ineffective in 64 patients (24%). These patients were referred to the Orthopedic Surgery Department for surgical treatment but we do not have data on these results since orthopedic surgeons did not carry out any systematic follow-up of these patients.

There were no serious complications in our study such as infectious and aseptic discitis, ruptured discs, epidural hematoma or radicular lesions. However, discomfort in the entry point of the needle within the first 24 h was common and could be controlled with non-steroidal anti-inflammatory drugs (NSAIDs) and rest.

**Discussion**

As it is well known, in most cases, herniated discs will resolve on their own and the possibility of spontaneous regression of herniated lumbar discs is an accepted fact.\(^{12,13}\) However, 20% of patients do not respond to conservative treatment and other treatment options are limited. Surgery has a high cost and morbidity and is associated with serious damage to paravertebral soft tissues, long hospitalization and recovery periods, usually six weeks or more. In addition, the success rate of spinal surgery is 75–80%,\(^{14}\) some patients are not eligible candidates for surgery for health reasons, and others, despite being good candidates, refuse surgery. Therefore, image-guided percutaneous techniques seem to be an interesting alternative to spinal surgery.

The mechanism of action of PLDD is based on the reduction of intradiscal pressure, which is achieved by reducing the volume of the intervertebral disc through vaporization of a portion of the nucleus pulposus using the photothermal effect.\(^ {5,8,10,15}\)

The effectiveness of PLDD in the treatment of discogenic lumbar radicular pain was evaluated according to the MacNab criteria, which are the most widely used criteria to assess the treatment of lumbar disc herniation.

In 2004, Choy, pioneer of this technique, reported a series of 2400 PLDD procedures performed in 1275 patients during almost two decades, with a success rate of 89% according to the MacNab criteria.\(^ {15}\) These results were also confirmed by Gagi et al. who reported a success rate of in 77% in 119 patients, according to the MacNab criteria.\(^ {16}\)

In 2006, Tassi compared a series of 500 patients treated with microdiscectomy with a series of 500 patients...
treated with PLDD and did not find significant differences in the clinical outcome. In addition, in the microdiscectomy group, more complications occurred and longer recovery time was required.\textsuperscript{17}

The overall success rate of our series was of 76%, which is in line with the outcome reported by several cohort studies with larger series.\textsuperscript{15-17}

Complications associated with PLDD are rare. Choy \textit{et al.}\ reported a complication rate of 0.4% (only infectious discitis) in the largest series analyzed to date, under fluoroscopic control.\textsuperscript{19} In our study, all the procedures were carried out under CT guidance, which easily avoids disc perforation and nerve and adjacent structure lesion. This would explain the absence of serious complications in our series. Another advantage of percutaneous procedures is that the spinal canal is avoided eliminating the risk of postoperative periradicular fibrosis, in contrast to spinal surgery which is frequently associated with persistent or recurrent back pain ("failed back surgery syndrome").\textsuperscript{18} Furthermore, PLDD may be repeated in the same patient without precluding conventional spinal surgery.

The success rate, the technical approach to the herniated disc, the clinical indications, the possible complications, as well as the instructions that must be followed after the procedure are similar for the percutaneous techniques most widely used. Among them, nucleotomy with radiofrequency and PLDD are the most promising.\textsuperscript{19} PLDD has some advantages over radiofrequency nucleotomy, such as the cost of the laser fiber, which is significantly lower than the cost of the electrode (seven times less), and the fact that unlike the 17 G probe used in radiofrequency, the 18 G needle used in PLDD is easy to bend which can be very useful for complex L5–S1 approach. However, one of the PLDD drawbacks is that it takes longer than nucleotomy to achieve disc decompression since laser energy has to be delivered slowly in order to avoid thermal damage to the adjacent end plates.

Our study presents the following limitations: first, it is a prospective, open and uncontrolled study. Second, we have not compared the effectiveness of PLDD with that of surgery. Brouwer \textit{et al.}\ are now carrying out the first randomized prospective trial to compare the effectiveness of PLDD versus conventional open discectomy for the treatment of disc herniation,\textsuperscript{20} which could help to overcome some of our limitations.

In conclusion, PLDD provides in selected patients with discogenic lumbar radicular pain a minimally invasive technique that is safe and that requires short hospitalization and recovery times. It has proven to be safe and effective for selected patients with lumbar discogenic radicular pain. This technique can be a valid alternative for those patients who do not respond to conservative treatment, avoiding in many cases the need for surgery.

\textbf{Authorship}

Responsible for the integrity of the study: RD, JCC.

Conception of the study: RD, JCC.

Design of the study: RD, JCC.

Acquisition of data: RD, JCC.

Analysis and interpretation of data: RD, JCC.

Statistical treatment: RD.

Bibliographic search: RD.

Drafting of the paper: RD, JCC.

Critical review with intellectually relevant contributions: RD, JCC.

Approval of the final version: RD, JCC.

\textbf{Conflict of interest}

The authors declare not having any conflict of interest.

\textbf{References}


