Percutaneous Laser Disc Decompression (PLDD)

1) Introduction

The long term outcome, the complications and suboptimal results which may accompany open disk surgery have led to the early development of other treatment techniques that would avoid a surgical approach through the spinal canal and an extensive disk ablation. Percutaneous removal of nucleus pulposus has been performed with a variety of chemical and mechanical techniques for the past several years. These techniques consist of removing all or part of the nucleus pulposus to induce more rapid healing of the pathological lumbar disk. Percutaneous nucleotomy is now widely used, as it is much less invasive than surgical discectomy. To date, the most promising of these minimaly invasive therapies used for treatment of disk herniations is Percutaneous Laser Disc Decompression (PLDD).

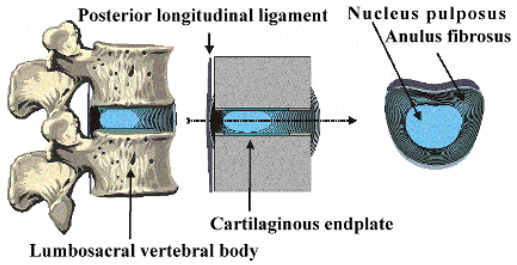


Fig 1:Lumbosacral disk anatomy

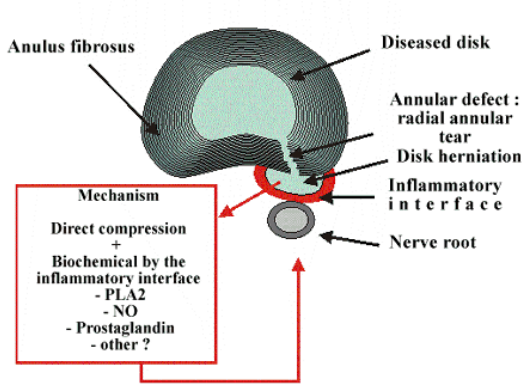


Fig 2: Pathology of disk herniation

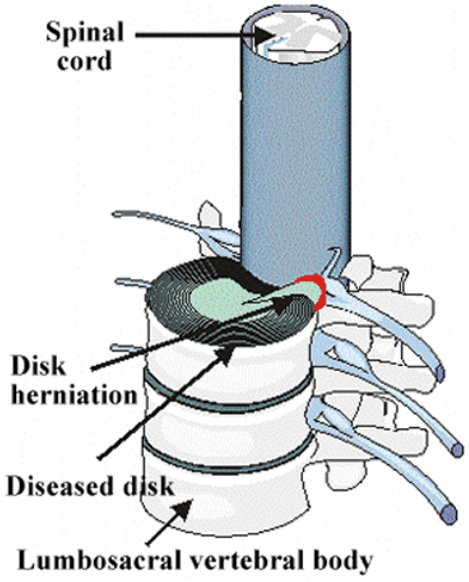


Fig 3: Disk herniation

2) Principle of PLDD

The advantage of this percutaneous technique is to reduce volume and pressure of the pathological disk without damage to other spinal structures. All minimaly invasive techniques like PLDD are based on the reduction of volume of the pathological disk. In this procedure the laser energy is transmitted through a thin optical fiber into the intervertebral disk. The aim of PLDD is to vaporize a small portion of the nucleus. The ablation of a relatively small volume of the nucleus results in an important reduction of intradiscal pressure thus inducing reduction of disk herniation.

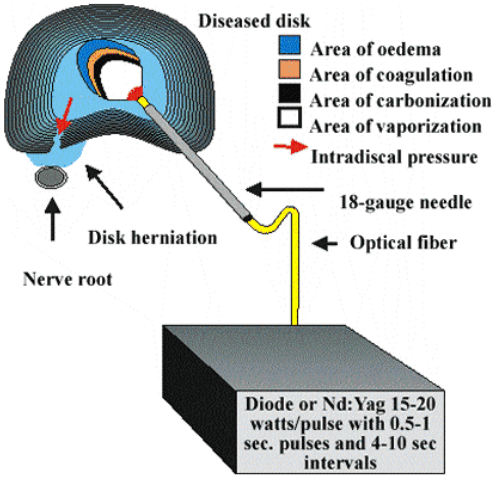


Fig 4:PLDD principle, starting procedure

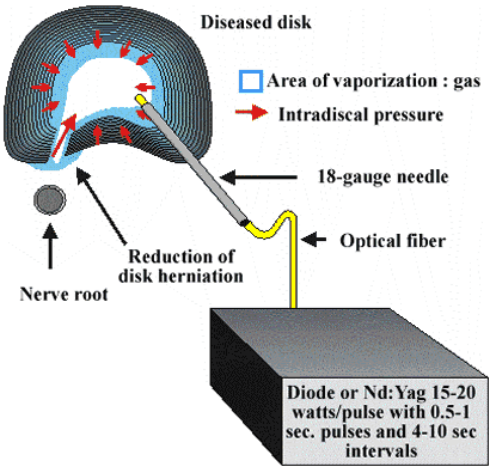


Fig 5: PLDD principle, end of procedure

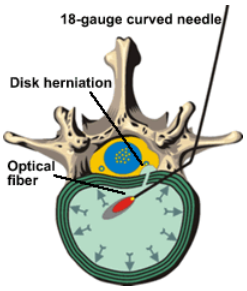


Fig 6: PLDD principle, starting procedure

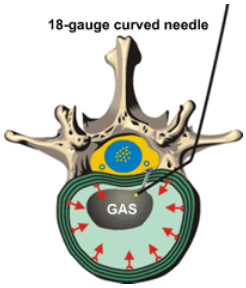


Fig 7: PLDD principle, end of procedure

3) Advantages of PLDD

This minimally invasive technique avoids the drawbacks of classical surgery :

- no significant soft tissue injury no risk of fibrosis
- no extensive hospitalization, outpatient basis
- no general anesthesia; the PLDD can easily be performed under local anesthesia
- minimal recovery time of 6 weeks or less
- no scars
- lower costs (25-30 % of the surgical treatment costs)

4) Indications

Patient selection is crucial for treatment effectiveness.

The indications are : contained disk herniations

- determined by CT scan or MR imaging
- with positive and consistent neurologic findings (leg pain of greater intensity than back pain, positive straight-leg-raising test, decreased sensation, normal motor response and tendon reflex)
- with failure of 6 weeks of conservative therapy

5) Contraindications

The contraindications are nerve paralysis, hemorrhagic diathesis, spondylolisthesis, spinal stenosis, previous surgery at the same level, significant psychological disorders, significant narrowing of disk space, workplace injuries with monetary gain, local infection of cutaneous or subcutaneous or muscular layers.

6) Technique

Placement

The patient is placed in a prone position on the CT table. In order to open up the posterior aspect of the disk space, rolls are positioned under the abdomen to place the lumbar spine in a semiflexed position. This is particularly helpful for the L5-S1 level. The entry point and the pathway are determined by CT, avoiding the nerve root and visceral structures. At the L5-S1 level curved needles are usually necessary.

Fig 8: PLDD CT disk herniation

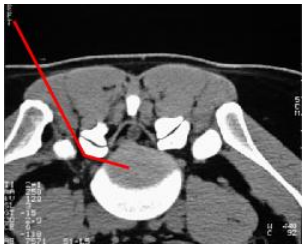


Fig 9: PLDD CT pathway

Fig 10: PLDD CT pathway

Material

Laser : we use a diode laser (Diomed, Cambridge UK) and a neodymium : yttrium-aluminum-garnet (Nd:YAG) 1064-nanometer wavelength laser (LaserSonics, Milpitas, CA) for PLDD.

- Optical fiber, Y connector
- 22-gauge needle, 18-gauge needle, scalpel
- Iodine, 1% lidocaine
- Sterile drapes, tampons

Fig 11: Diomed laser (Diomed, Cambridge, UK)

Fig 12 : optical fiber, 22 and 18-g. needle, scalpel, iodine, 1% lidocaine

Guidance

PLDD is performed under dual guidance with a combination of CT and fluoroscopy.

Two mobile fluoroscopy monitors are placed in front of the physician along with a CT monitor. At any time the operator can switch from CT to fluoroscopy and vice versa.

Once the entry point is determined by CT, a lateral fluoroscopy view is obtained at the desired disk level. In this way, the operator can visualize the pathway and the correct angulation of the needle. In most of the cases the angulation is oblique in the three planes, especially at L5-S1 level.

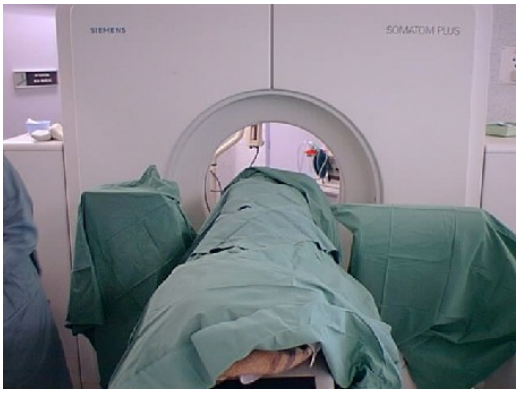


Fig 13: the patient is placed in prone position. dual guidance CT + fluoroscopy

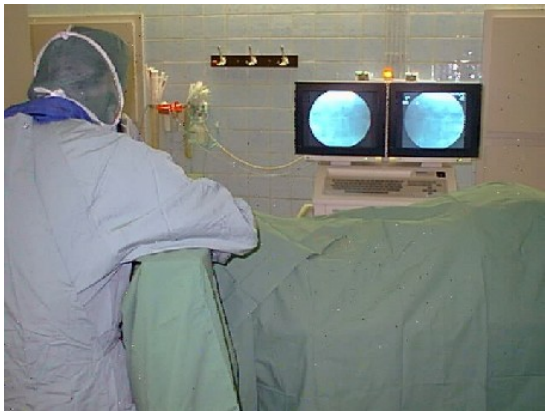


Fig 14: dual-guidance fluoroscopy

Fig 15: dual-guidance CT

Local anesthesia

The procedure is started respecting strict sterility. The skin subcutaneous layer, lumbar muscles and the articular process are infiltrated by local anethesia (1% lidocaine) with a 22-gauge needle 9 cm long. The position of the 22-gauge needle is checked by fluoroscopy and CT.

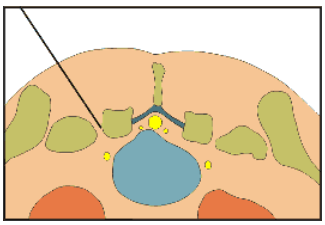


Fig 16: local anesthesia

Fig 17: local anesthesia

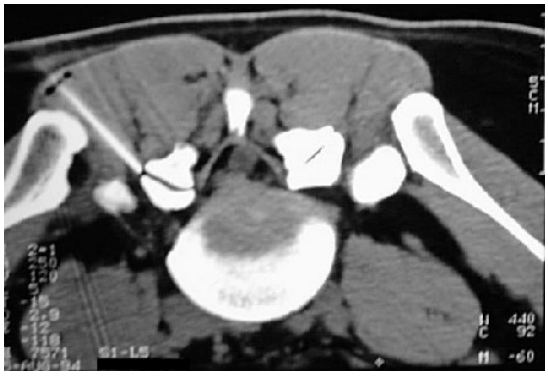


Fig 18 : CT control of local anesthesia

Disk puncture

A short scalpel cut is made in the skin. Through the skin incision the 18-gauge needle is inserted under continuous lateral fluoroscopy control parallel to the 22-gauge needle. The tip of the 18-gauge needle must reach the posterior part of the nucleus pulposus. Patient must be monitored for pain during the whole intervention and the needle has to be repositioned if radicular pain occurs. In order to confirm contained disk herniation, or if any doubt persists, a discography can be performed just before PLDD.

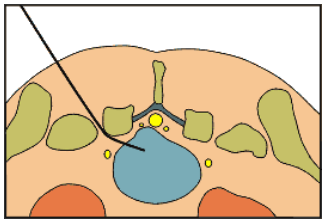


Fig 19:18-g.needle placement

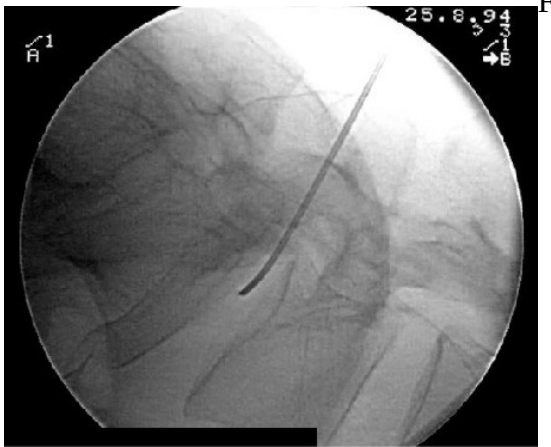


Fig 20: 18-gauge needle placement under fluoroscopy control

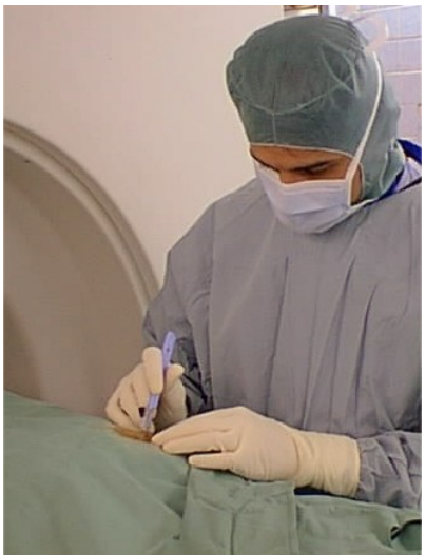


Fig 21: scalpel incision of the skin

Fig 22: 18-gauge needle placement under CT control

Fig 23: 18-gauge needle placement

Optical fiber placement and check

The optical fiber is checked. Before the optical fiber is placed, it is inserted in an 18-gauge needle mounted by a side-arm fitting to measure the appropriate length of the fiber. The distal part of the optical fiber should extend 5 mm beyond the needle tip. The proper length of the fiber is indicated with sterile strip to avoid excessive advancement of the fiber (placement 1). After removal of the stylet of the 18-gauge needle, the optical fiber is inserted into the disk (placement 2,3,4). The distal part of the optical fiber should extend 5 mm beyond the needle tip

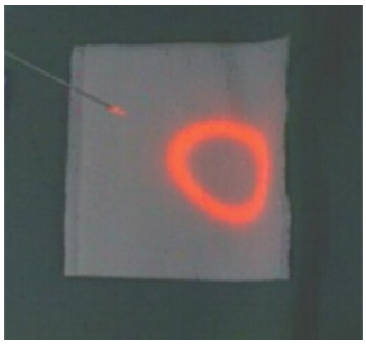


Fig 24: optical fiber check

Fig 25: optical fiber placement 1

Fig 26: optical fiber placement 2

Fig 27: optical fiber

placement 3

Fig 28: optical fiber placement 4

Laser disk ablation

When satisfactory needle position is obtained, the laser procedure begins. The laser is turned on to produce 15-20 watts with 0.5 to 1 second pulses and 4 to 10 second intervals depending on patient comfort. Recommended laser doses for PLDD range from 1200 to 1500 joules for L1-L2, L2-L3, L3-L4 and L5-S1 levels and 1500 to 2000 joules for L4-L5. Using this technique with these short exposure times, there is no heating of the adjacent bone structures. A CT scan is performed every 200 joules at the disk level to visualize the vaporized area. The patient must be able to communicate and respond to pain during the entire procedure. General anesthesia is therefore absolutely contraindicated. If pain occurs, the intervals between pulses are increased and aspiration is applied to reduce pressure within the disk.

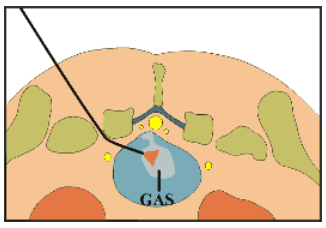


Fig 29: laser ablation

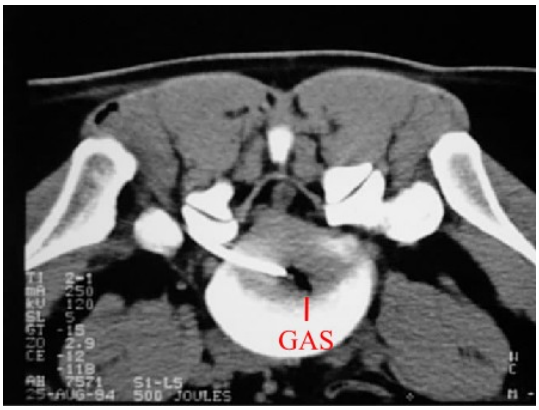
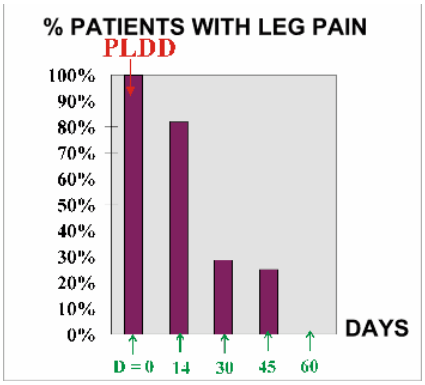


Fig 30: CT control of laser ablation

Follow-up

For 2 weeks after the intervention, some positions that could induce hyperkyphosis as well as athletic activities should be restricted. Resolution of leg pain is usually obtained within one week to two months. The two most critical elements to successful PLDD are proper patient selection and correct needle placement.



Histogram : resolution of leg pain after PLDD MacNab Good. On Yaxis : % of patients with leg pain; on X axis : Days

7) Complications

Complications of PLDD under CT and fluoroscopic guidance are rare :

- The major complication of PLDD is septic discitis. To avoid this complication, severe sterility during the intervention is mandatory.
- Thermic aseptic discitis is another complication, leading to severe backache for 3 to 6 months.
- Recurrence of disk herniation or free fragment evacuation with recurrence of leg pain.

8) Results

From 1987 to 1997, 169 patients with herniated lumbar disk and radicular pain were treated by PLDD on an out-patient basis. There were 93 male and 76 female patients. The oldest was 71 years and the youngest was 12 years old. Mean age was 42 years. The longest follow-up was 6 years, the average follow-up 19 months . MacNab criteria were used to grade the response to treatment. The overall success rate was 76% according to MacNab's criteria with 55.6% of GOOD and 20.2% of FAIR. In four cases, the PLDD was performed at two levels. 11 patients with poor results or recurrence were later treated surgically with a satisfying success rate (68%). After 6-12 months, a reduction of disk herniation was observed with CT or MR imaging. These cases were evaluated a second time with a mean follow-up of 53 months, these long-term results were identical. The complications of PLDD under CT and fluoroscopic guidance are rare. The major complication of percutaneous nucleotomy is septic discitis. One patient suffered from a spondylodiscitis. Another suffered for six weeks from severe backache due to an aseptic discitis (three years follow-up). One patient was readmitted 24 hours after PLDD with severe recurrence of leg pain due to free fragment evacuation with upward migration. These data provide encouraging information substantiating the validity of percutaneous laser nucleotomy for contained lumbar disk herniation. The two most critical elements to successful PLDD are : proper patient selection and correct needle placement. Even if further random comparative studies are necessary to confirm these datas, PLDD is a valuable, minimally invasive alternative to conventional surgery for treating disk herniation.

MacNab Criteria

GOOD	Resumed preoperative function. Occasional backache or leg pain. No dependency-inducing medications. Appropriate activity. No objective signs of nerve root damage
FAIR	May be nonproductive if unchanged from preoperative status. Intermittent episodes of mild lumbar radicular pain or low back pain. No dependency-inducing medications. Appropriate activity. No objective signs of nerve root damage
POOR	Subjective : no productivity, continued pain behavior, medication abuse, inactive, compensation litigation focus. Objective : signs of continuing radiculopathy

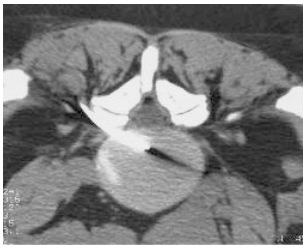
Location of disk herniation : 169 Cases

Location	Cases
L5-S1	87
L4-L5	71
L3-L4	11

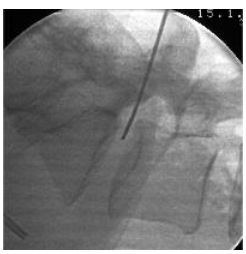
9) Cases

Case 1 : PLDD for disk herniation with leg pain, satisfactory results of laser vaporization at CT control with air filling the herniation. No complications, good clinical results.

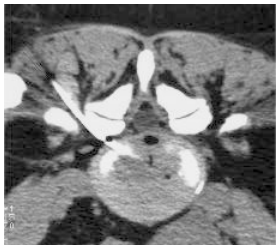
PLDD : CT pathway



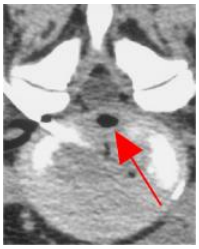
PLDD : disk puncture CT control



PLDD : disk puncture fluoroscopy control

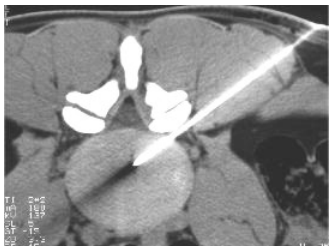


PLDD : laser vaporization CT control



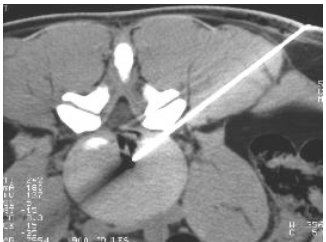
PLDD : CT control, laser vaporization gas inside disk herniation (arrow)

Case 2 : PLDD with satisfactory results. Note air filling the disk herniation. No complications, good clinical results.

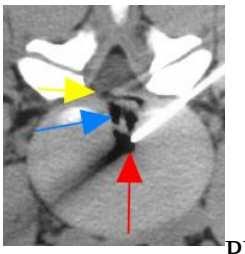


PLDD : disk puncture CT control

PLDD : disk puncture under fluoroscopy control



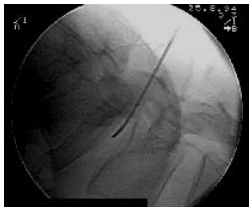
PLDD : laser vaporization CT control

 PLDD : CT control, laser vaporization (red arrow), gas filling annular tear (blue arrow), gas filling disk herniation (yellow arrow)

Case 3 : PLDD with good clinical results and no complications.

disk herniation

PLDD : disk puncture CT control



PLDD : disk puncture fluoroscopy control

PLDD : laser vaporization CT control