Percutaneous Laser Discectomy: Experience and Long Term Follow-Up

P.P.M. Menchetti, G. Canero, and W. Bini

Abstract The classical microsurgical approach in the treatment of herniated nucleus pulposus (HNP) has been substituted over the years by endoscopical approach, in which it is possible to practice via endoscopy a laser thermodiscoplasty, and by percutaneous laser disc decompression and nucleotomy. Percutaneous laser disc decompression and nucleotomy have been performed worldwide in more than 40,000 cases of HNP. Because water is the major component of the intervertebral disc and in HNP pain is caused by disc protrusion pressing against the nerve root, a 980 nm Diode *(Biolitec AG-Germany)* laser introduced via a 21-G needle under X-ray or CT-scan guidance and local anesthesia, vaporizes a small amount of the nucleous pulposus shrinking the disc and relieving the pressure on the nerve root. A multicentric retrospective study with a mean follow-up of 6 years was performed on 900 patients suffering from relevant symptoms that had been therapy-resistant for 6 months on average before consulting our department. Evaluation included 585 (65%) males and 315 (35%) females. The average age of patients operated was 46 years (18–54). The success rate at a mean follow-up of 5 years (2–6 years) was about 70% with a very low complication rate.

Keywords Diode laser · Herniated nucleus pulposus · Laser discectomy · Percutaneous laser decompression

Introduction

Over the years several treatments have been performed in disc herniation. At present, in order to reduce complications, the gold standard seems to be all minimally invasive techniques, offering not only the best solution for the patient, but also a fast and effective postoperative recovery time. Percutaneous laser disc decompression and nucleotomy is based on a reduction of volume in a closed hydraulic space, resulting in a great fall of pressure. Because water is the major component of the intervertebral disc and in disc herniation pain is caused by the disc protrusion pressing against the nerve root, vaporizing and shrinking the nucleus pulposus leads to immediate decompression of the nerve root [1, 2].

Since its first application [3], several types of lasers (Nd:YAG 1,064 nm, 1.320 nm; KTP 532 nm; CO2 10.6 μm; Ho:YAG 2,100 nm, Diode 940 nm, 810 nm) have been employed over the years.

The authors believe that 980 nm is the optimal wavelength for laser disc decompression and nucleotomy because 980 nm is 10 times more absorbent than 810 nm and 5 times more absorbent than 1,064 nm, requiring less laser energy, which implies less heat diffusion in surrounding tissues and no undesirable side effects.

Materials and Methods

Inclusion Criteria

Nine hundred patients, 585 (65%) males and 315 (35%) females affected by contained disc herniation (magnetic resonance imaging –MRI- documented) *(protrusion, subannular extrusion),* were included in a multicentric retrospective study at a mean follow-up of 5 years (2–6 years). The average age of patients operated was 46 years (18–54), suffering from relevant symptoms that had been therapy-resistant for

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6 months on average before the laser procedure. The level of disc removal was L4/L5 in 409 cases (45%), L5/S1 in 377 cases (42%), L3/L4 in 78 cases (9%), L2/L3 in 22 cases (2.4%), L1/L2 6 cases (0.6%), T12/L1 4 cases (0.4%) and T11/T12 4 cases (0.4%).

Disc herniation had to be contained or at least in contact with the parent disc in order to permit a reduction of the pressure on the nerve root by laser energy. No free disc fragment *(sequestration)* was treated with this technique. Sequestration *was an absolute contraindication*.

Scar entrapment by previous microsurgical approach, because laser energy involves a fibrocartilage replacement in the disc from the inner layer of the annulus returning to normal after 3 months [4, 5], was another *absolute contraindication*. Other exclusion criteria included transannular extrusion, severe spinal stenosis, severe spondylosis with osteophytes and calcifications of the posterior spinal ligament.

The procedure consisted of a 21-G atraumatic tip chiba needle guided under C-arm, or CT-scan percutaneously inserted into a herniated disc under local anesthesia. Diode Laser 980 nm *(Biolitec AG-Germany)*, 1,200–1,500 J of total energy, was delivered through a disposable 360 μm Silica Fiber Optic; the power parameters were 12 W with exposure time 0.60 s in a pulsed wave, with 2 s pauses for heat dissipation. A smoke evacuation system specifically designed and worldwide patented (Menchetti's handpiece) connected to the needle permits to eliminate gas formation during the treatment by reducing postoperative muscle contracture (Fig. 1a–i).

Results

A retrospective multicentric evaluation with an average follow-up of 5 years (2–6 years) was performed doing MRI or CT scans at 3 months and 1 year. VAS (Visual Analogue Scale) and the Macnab's criteria (Table 1) were applied on a total of 900 patients.

The excellent/good results at mean 5 year follow-up according to Macnab were 68%, the fair results were 10%, and the poor results were 22%. The excellent/good results after mean 3 year follow-up were 78%, fair results were 11% and poor results were 9%. VAS decreased from a preoperative 8.5 to a postoperative 2.3 at 3 year f.u., up to 3.4 at 5 year f.u. MRI or CT scan showed a reduction of disc herniation at 3 months and 1 year in only 70% of excellent/good results, because a disc shrinkage of less than 1.5–2 ml is not detectable on MRI or CT scan [4, 6] (Fig. 2–4). No significant difference in outcome ($p > 0.05$) related to sex, age, disc level, and symptoms duration were found. Fair and poor results correlated ($p < 0.05$) with subannular extrusion, in which microsurgery was performed after 1–3 months in 40% of cases treated under C-arm.

In 72% of excellent/good results there was immediate pain relief with normal straight leg raising (SLR), in 12% after 72 h and in 16% after 3–7 days; improvement of neurological signs (motor weakness and reflex depression) was recorded at 1 month in 65% of cases, 3 months in 20% and 3–6 months in 15% of cases.

Complications

No complete disc herniation removal, 4 cases (0.8%) of spondylitis with good response to steroids, no septic or aseptic discitis was detected, no CSF fistula, no nerve root injury; eight patients (1.6%) advised headache post spinal lumbar puncture, in L5-S1 paramedian approach, returning to normal after 2–3 days bed rest.

Discussion

Percutaneous laser disc decompression and nucleotomy have been performed worldwide on more than 40,000 patients. The more used lasers were KTP 532 nm, Ho:YAG 2,100 nm, Nd: YAG 1,064 nm. Their combined success rate (excellent/good to fair) according to Macnab and Oswestry score were more than 80%, with a complication rate of less than 1.5% [5, 7, 8]. In order to obtain a good result it is very important not only to properly select patients, but also to carefully choose the laser used.

Regarding the use of the Diode 980 nm, we believe it to be the best and more advanced laser in the treatment of disc herniation with optimal water absorption. Because 980 nm is 10 times more absorbent than 810 nm and 5 times more absorbent than 1,064 nm, requiring less laser energy; it implies less heat diffusion in surrounding tissues and no undesirable side effects. A first introduction of Diode 940 nm in disc herniation treatment was performed in 1998 by Hellinger [9] in a prospective randomized study versus Nd: YAG 1,064 nm. The overall success rate (90%) confirmed the proper use of Diode in order to decompress the nerve root in disc herniation. Nakai et al. [10] also confirmed in an experimental study with a Diode 810 nm that Diode is less aggressive in the surrounding tissue, preserving the end plate and the vertebral body from any damage. No secondary changes on the intervertebral disc and adjacent vertebral body after Diode laser disc irradiation were detected.

Experimental studies performed both on human and specimen lumbar discs using the *Diode Laser 980 nm* showed an absorption of laser light of 90.27% in the disc and a retraction of about 55% (±1.7) on 2.7 mm of the tissue after laser treatment [11].

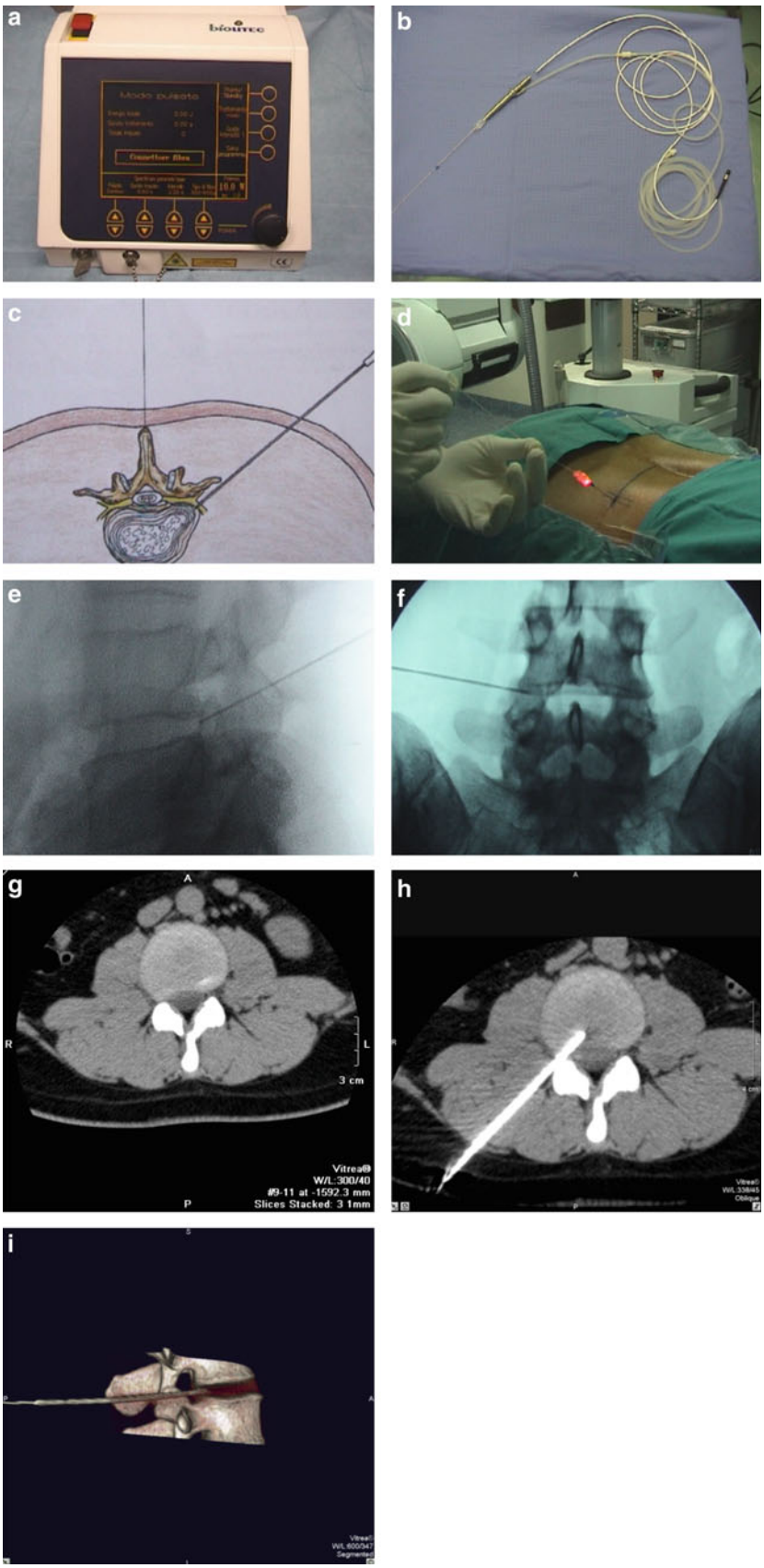

Fig. 1 (**a**) Diode 980 nm laser (Biolitec AG). (**b**) Disposable 360 μm silica fiber optic. (**c**) Access to foramen. (**d**) Optical fiber insertion. (**e**) C-arm guidance, LL view. (**f**) C-arm guidance AP view. (**g**) Foraminal disc herniation. (**h**) Laser discectomy under CT-Scan. (**i**) 3D reconstruction

Table 1 Macnab's criteria

Excellent/good	Resumed preop function, occasional backache, no objective signs of nerve root involvement
Fair	Intermittent episodes of mild lumbar pain and/or low back pain, no objective signs of nerve root involvement
Poor	Subjective no productivity, continued pain, inactive, objective signs of nerve root involvement

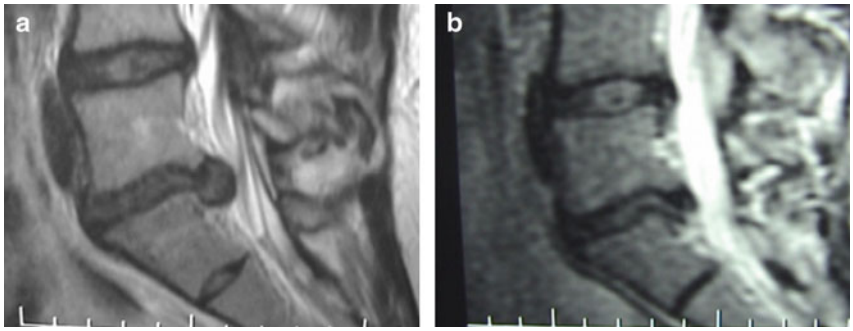

Fig. 2 (**a**) Twenty-seven year female L5-S1 HNP. (**b**) After Diode laser 980 nm

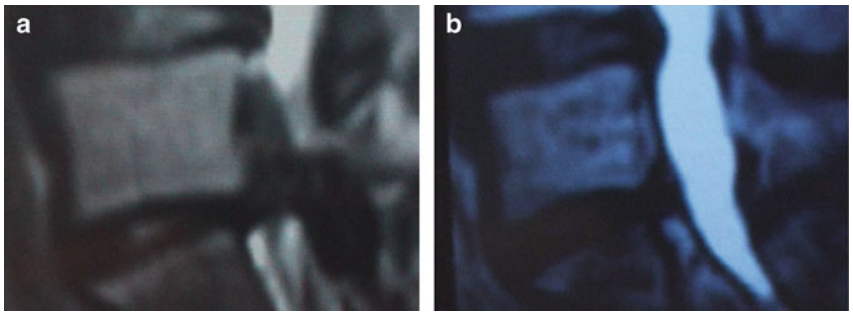

Fig. 3 (**a**) Thirty-eight year female L5-S1 transannular extrusion. (**b**) After Diode laser 980 nm

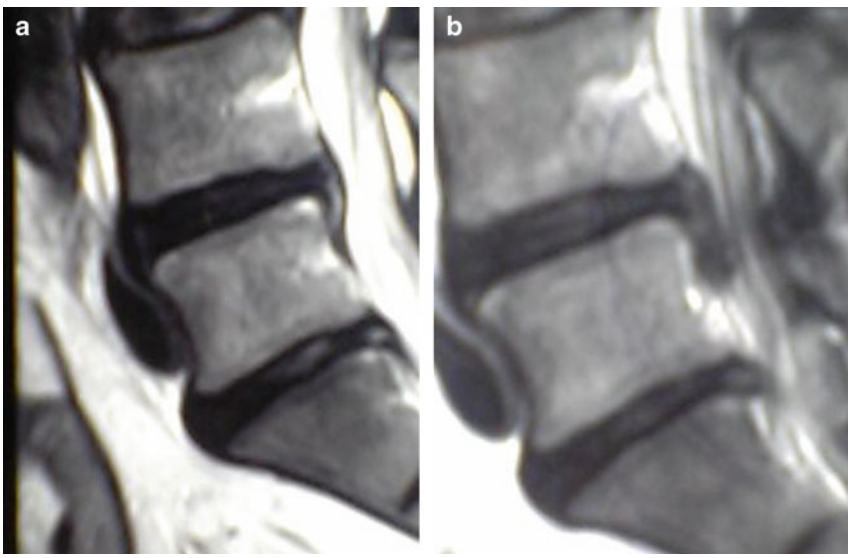

Fig. 4 (**a**) Forty-six year male L4-L5 HNP. (**b**) After Diode laser 980 nm

For these reasons the authors believe that using the specially designed and optimised Diode 980 nm Laser in the treatment of disc herniation is the method of choice, confirming the overall success rate of the literature [4, 5, 7, 8, 10] without any complications [12–14] related to heat diffusion in surrounding tissues (aseptic discitis and spondilytis, bladder injuries, vascular injuries to the abdominal cavity, abdomen injuries).

Conclusion

In conclusion, we strive for maximal use of this minimally invasive surgical technique that has proven to be safe and effective, is minimally invasive, is performed in outpatient setting, requires no general anesthesia, avoids skin incision (with reduced infection rate), no muscle damage (no post-operative pain), no bone removal (no vertebral instability), no peridural scar, and does not preclude microsurgery, if needed.

Conflict of interest statement I declare that I have no conflict of interest..

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