

Laser Therapy in Lumbar Disc Surgery – A Narrative Review



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Abstract

Introduction: Low back pain is one of the most chronic debilitating conditions involving considerable loss of cash, work, and quality time. Lasers are utilized in different fields of drugs, providing unique advantages. They are useful and advantageous in treating lumbar disc disease. In this research, an attempt is made to examine the role and importance of different lasers in lumbar disc surgeries.

Methods: We conducted studies about laser therapy in lumbar disc surgery. Our primary search began with reviewing English-language citations from PubMed and Scopus between 1990 and 2019 using the keywords: (laser therapy) OR (lumbar disc AND disc surgery). The initial search yielded 97 articles. However, about 49 articles were selected and used in the present study.

Results: Based on the present study, it can be found that there are several methods of using lasers to treat lumbar disc surgery. These methods all have their strengths and weaknesses.

Conclusion: The development of laser lumbar disc surgery can be very helpful due to the reduction of surgical risks and the length of the patients' hospital stay. However, the choice of method used for this type of surgery should be made according to the patient's condition and based on the opinion of the treating physician.

Keywords: Lumbar discectomy; Endoscopic lumbar discectomy (PELD); Percutaneous laser disc decompression (PLDD); Potassium titanium phosphate laser (KTP); Holmium: yttrium-aluminum-garnet (YAG) laser.



Introduction

Once the intervertebral disc nucleus pulposus protrudes due to the weakness or rupture of the annulus fibrosus, lumbar disc herniation occurs.¹ The hernia symptoms may include back or leg pain or a feeling of numbness and weakness in these areas of the body.² This condition may lead to several complications, such as painful foot drop, bladder dysfunction, or cauda equina.³ The prevalence of lumbar disc herniation is reported to be about 5 to 20 per 1000 people annually (0.5%-2.0%). Based on the studies, most people experience this disease in the third to fifth decade of their lives, and its prevalence in men is almost twice as high as in women.⁴⁻⁷

Disc herniation often occurs as a result of a degenerative process in which the hydration rate of the nucleus pulposus decreases with age.^{8,9} Trauma, connective tissue disorders, and congenital diseases are among other causes of the disease.^{8,10-12}

Today, more attention is paid to a variety of effective and modern treatments due to the increasing number of people with lumbar disc herniation. In many cases, treatments that do not require open surgery are more popular,

with more limited side effects and risks. Therefore, it is essential to evaluate and report appropriate information on the safety and effectiveness of new methods.

In order to treat the symptoms of lumbar disc herniation, there are three types of approaches, including supportive therapy, percutaneous techniques, and open surgery.¹³⁻¹⁶ Further, lumbar discectomy can be effective if there is severe pressure on the nerve or in cases of persistent symptoms that do not respond to supportive care.^{14,15} In such cases, the surgical techniques used include open discectomy or existing minimally invasive procedures, using a laser and percutaneous endoscopy approach.¹⁷⁻²⁰ Many factors such as the patient's symptoms and the disc size and location can affect the treatment type.²¹

Open discectomy is the most common treatment for lumbar discectomy.²²⁻²⁵ The optimal treatment, however, is prescribed to minimize the invasion of the functional method, speed up the recovery of patients, and decrease complications during the recovery period. The reduction of laser disc pressure in the form of percutaneous nucleotomy is based on the decrease in volume in a closed hydraulic space, resulting in a sharp drop in pressure.²⁶

Evaporation and shrinkage of the nucleus pulposus can lead to a rapid reduction in nerve root pressure since water is the main component of the intervertebral disc, and the disc pain is caused by pressure from the disc protrusion in front of the nerve root.²⁷⁻²⁹

In the present study, different studies on the use of lasers in lumbar disc surgery are evaluated.

Materials and Methods

The studies were conducted on Laser therapy in lumbar disc surgery. Our primary search began with reviewing English-language citations of PubMed, Scopus, and Medline between 1990 and 2019 using the keywords: Laser therapy OR lumbar disc, Percutaneous Laser Disc Decompression, AND Endoscopic Lumbar Discectomy. The initial search yielded 97 articles. Studies on Laser therapy in lumbar disc surgery were selected by reviewing abstracts. However, about 49 articles were selected and used in the present study.

Evidences

Types of Lumbar Disc Surgery Using a Laser

Two types of laser application were described in the literature: percutaneous endoscopic lumbar discectomy (PELD) and percutaneous laser disc decompression (PLDD). In Table 1 we summarized the characteristics of PELD and PLDD surgical methods.

1. Percutaneous Endoscopic Lumbar Discectomy

In the PELD method, the disc surface area is first

determined for treatment under fluoroscopic control on the skin. Next, the disc space is punctured posterior-transversely at an angle of 50-60 degrees using an 18-degree cannula, inserted into the skin from the midline between 9 and 10 cm. The needle tip is placed in the disc center. At this point, discography is performed to eliminate conflicting morphological symptoms such as possible obstruction. From the opposite side, indeed, the disc space is drilled in the same way, and the two guide wires enter the disk space through the outgoing cannulas.

At the input points of the wires, two knife cuts are made. A Blunt trocar is guided through the central hole to the posterior border of the disc space using the wire as a guide. A cannula (00:5/4 mm) is considered as a guide with the separation of the trocar cone at the same time. Then, the disk space is opened on each side using a circular drill. Also, the parts of the nucleus pulpous are removed from the disc center, creating a hollow space to be used for endoscopic examination. One side of the disk space is exposed to the rigid endoscope of 30 or 70 degrees, while the endoscopic removal of the nucleus pulposus continues on the other side.

A flexible J. Lm 400 fiber with a laser is inserted into the disk space via an adjustable panel. Under endoscopic control, the nucleus pulposus tissue is then coagulated or evaporated, and its vapor is removed by continuous suction via the working tube.³⁰

1. Percutaneous Laser Disc Decompression

In PLDD, a thin 18G needle is inserted into the lower area

Table 1. Comparison of the Characteristics of PELD and PLDD Surgical Methods

Type of Laser Surgery	Usage Situations	Prohibiting Conditions	Purpose	Anesthesia Conditions	Benefits
PELD	Lumbar disc protrusion (complete annulus fibrosus), Subligamentous prolapse should cover less than 30% of the sagittal diameter of the spinal canal and obstruction symptoms should not be seen ³⁰⁻³²	Severe neurological impairment, CONUS and cauda syndromes, severe muscle paralysis (Grade II-0), segmental instability, legal contraindications due to mental disorders, and the obstruction of more than 30% of the sagittal diameter of the spinal canal due to disc herniation and various types of nerve cramps ³²⁻³⁴	Reduction of the size of the protruding disc by exiting the nucleus pulposus ^{35,36}	Local anesthesia with the presence of an anesthesiologist to control the patient's vital parameters ³⁷	Minimal invasiveness, no need to be hospitalized, the possibility of discharge 24 hours after surgery, the possibility of a return to daily activities after 5 days, local anesthesia, high speed of execution, lack of spinal instability after surgery, less damage to the muscles of the back, applicability for patients at risk (e.g., those with diabetes and cardiovascular disease)
PLDD			Evaporation of a small part of the inner nucleus, as well as the reduction of intra-disc pressure and disc herniation	Local anesthesia with the presence of an anesthesiologist to control the patient's vital parameters ³⁷	Minimal invasiveness, no need to be hospitalized, the possibility of discharge 24 hours after surgery, the possibility of a return to daily activities after 5 days, local anesthesia, high speed of execution, lack of spinal instability after surgery, less damage to the muscles of the back, applicability for patients at risk (e.g., those with diabetes and cardiovascular disease)

of the protruding disc under X-ray or CT guidance. The optical fiber is inserted via the needle, and laser energy is transmitted via the fiber. This results in the evaporation of a small part of the disc nucleus. A partial vacuum is, therefore, created that removes the hernia from the nerve root, leading to pain relief.³¹

Types of Lasers Used in Disc Surgery

Three types of laser were used for the treatment of disc disease. Studies about these three types were summarized in Table 2.

1. Nd: YAG Laser

This laser may be applied in non-contact or contact modes both. The Nd: YAG laser is more effective in the contact mode with 20-30 watts of power and a 0.05- to 0.1-second pulse according to studies.³⁸ In the non-contact state, a 400 µm bare fiber with an energy density of 1.2 to 2 kW/cm² with a fiber strength of 2 mm can be used; this results in the coagulation and shrinkage of the nucleus pulposus.³⁹ In the contact mode, an energy density of 10 to 15.6 kW/cm can be applied to the tissue, leading to effective evaporation.⁴⁰

2. Potassium Titanium Phosphate Laser

This laser uses optical fiber and is easily guided into the disk space via a spinal needle. Potassium, titanium, and phosphate (KTP) crystals also produce green lime laser light.⁴¹

3. Holmium: Yttrium-Aluminum-Garnet Laser

This laser has a unique wavelength in the mid-infrared range, being well-absorbed by water. Since this laser

is an optical fiber, an effective dose of energy can enter the disc through the needle or catheter as percutaneous by inducing fibers. The laser advantage is that it creates almost no temperature increase in adjacent tissues with a pulse width of about 250 ms and 10 Hz, as well as 1.6 joules of energy per pulse. A defect of 1 cm × 1.5 cm × 2 cm is created in the nucleus pulposus when 1200 J of Ho: YAG laser energy enters the disk through 400-µm fibers with the same parameters. This defect, located in the posterior quarter of the anterior part of the hernia area, can be identified by the guidance of a fluoroscopic needle in the disc.^{42,43}

Conclusion

Knowledge of applying laser technologies to the spine is limited, and there are no prospective studies on the examination of connective tissue discectomy with typical micro lumbar discectomy or minimally invasive procedures. Such limitations make analyses challenging in the area. However, it is essential to conduct several studies on minimally invasive methods in the field of lumbar disc surgery. Meanwhile, using a laser and expanding this research can be very helpful.

Ethical Considerations

Not applicable.

Conflict of Interests

The authors declare no conflict of interest.

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Table 2. A Review of the Effectiveness of Different Types of Disc Surgery Lasers in Previous Research

Type of Laser	Author	The Title of the Study	Results
Nd: YAG laser	Pfeiffer et al Menchetti et al	Automated percutaneous lumbar discectomy with and without chymopapain pretreatment versus non-automated, discoscopy-monitored percutaneous lumbar discectomy	No significant side effects and radicular symptoms after using PELD treatment were observed, and the length of hospital stay was also reduced. ⁴⁴
	Knight et al	Percutaneous laser discectomy: experience and long-term follow-up	Improving neurological symptoms (such as motor impairment and reflex disorder) ⁴⁵
Potassium Titanium Phosphate Laser	Yeung AT	Consideration for the use of the KTP laser for disc decompression and ablation	The success rate of the applied method during this study was 84%. Also, no side effects were reported after using this laser. ⁴⁶
	Ohnmeiss et al	Laser disc decompression	The results of this retrospective study showed that the removal of disc pressure with these lasers was successful, and incompatibility in the criteria for entering the study led to clinical failure. ⁴⁷
Holmium: yttrium-aluminum-garnet laser	Ahn et al	Percutaneous endoscopic lumbar discectomy for recurrent disc herniation: surgical technique, outcome, and prognostic factors of 43 consecutive cases	The use of lasers to lower blood pressure in L5-S1 L3-S1 duct stenosis can be relatively effective. ⁴⁸
	Sherk et al	Laser discectomy	During this evaluation, no difference was observed between the treated and the control groups. Accordingly, the researchers found that laser discectomy was a safe procedure and effective in improving the symptoms of many patients. ⁴⁹

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