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THE ROLE OF LASER DISC DECOMPRESSION AND EPIDUROSCOPY IN THE TREATMENT OF LUMBAR DISC HERNIA

LOMBER DİSK HERNİSİ TEDAVİSİNDE LAZER DİSK DEKOMPRESYONU VE EPİDUROSKOPİNİN YERİ

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SUMMARY:

Lumbar disc hernia usually responds to conservative treatment, but occasionally minimally invasive procedures or surgical interventions are necessary. Currently, the most commonly preferred surgical treatment for persistent sciatic pain caused by lumbar disc herniation is microdiscectomy. Minimally invasive procedures, including percutaneous therapies under local anesthesia, are being increasingly applied in recent years. Percutaneous laser disc decompression (PLDD) is an interventional procedure replacing surgery for some cases of disc protrusion. This treatment can be carried out in an outpatient setting and quick recovery is expected. Epiduroscopy is a minimally invasive diagnostic and therapeutic technique used for patients with chronic lower back pain with or without radiculopathy. It has been thought that epiduroscopy offers an ideal combination of diagnostic and therapeutic interventions in a single session. In this study, we aim to evaluate these two techniques, which are being increasingly applied, and review the recent literature.

Key words: Lumbar disc herniations, surgical treatment, laser decompression, epiduroscopy

Level of evidence: Review article, level V

ÖZET:

Lomber disk hernisi genellikle konservatif tedaviye cevap veren bir hastalık olmakla birlikte bazen minimal invazif veya cerrahi yöntemlerle müdahale gerekebilmektedir. Günümüzde lomber disk herniyasyonunun sebep olduğu inatçı siyatik ağrısının en sık tercih edilen cerrahi tedavi yöntemi mikrodiskektomidir. Lokal anestezi altında uygulanan ve perkütan tedavileri içeren minimal invazif yöntemler son yıllarda daha fazla uygulanmaktadır. Perkütan Lazer Disk Dekompresyonu yöntemi disk protrüzyonu olan bazı olgularda cerrahinin yerini almaktadır. Bu yöntem ile hastanede yatış gerekmeden çabuk iyileşme beklenmektedir. Epiduroskopi, radikülopati olsun ya da olmasın bel ağrısı olan hastalarda kullanılan tanısal ve tedavi edici minimal invazif bir yöntemdir. Epiduroskopinin tek seansta ideal bir tanı ve tedavi kombinasyonu sağladığı düşünülmektedir.

Bu çalışmada son zamanlarda uygulama imkanı artan bu iki tekniğin literatür eşliğinde incelemesi amaçlanmıştır.

Anahtar Kelimeler: Lomber disk hernisi, cerrahi tedavi, lazer disk dekompresyonu, epiduroskopi

Kanıt Düzeyi: Derleme, Düzey V

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INTRODUCTION:

Many different methods have been developed and used for surgical and medical treatment of intervertebral disc herniations generally observed in the lumbar region[23,37]. Many patients with severe clinical signs due to lumbar disc hernia show significant improvements in one month. Patients with lumbar disc hernia without surgical indications are initially treated with a conservative method for at least two weeks, because symptoms often decrease with this approach. In addition to bed rest, analgesics, myorelaxants and non-steroidal anti-inflammatory drugs can be given as part of conservative treatment. In the period when the pain has disappeared, lumbosacral exercises can be helpful for the prevention of recurrence, as long as care is taken over body mechanics, correct posture, and correct sitting-rising and sitting methods.

If conservative treatment is not sufficient, surgical methods should be considered. Definite surgical indications are cauda equina syndrome, severe muscle weakness (lower leg) and progressive motor deficit[16]. While the results for patients receiving surgery are better in the first year than for patients without surgery, there is no significant difference between these results in the fourth or tenth years[36].

Minimally invasive methods have been used in lumbar disc hernia surgery since the 1970s, and currently there are many varied methods. In percutaneous lumbar discectomy (PLD), the disc is reached with an 18G cannula with endoscopic control with a posterolateral approach. In this approach, cutting, laser, and electrocauterization systems are used.

In microendoscopic discectomy (MED), the disc is reached by a similar percutaneous approach. Decompression of the nerve root in the extra foraminal region can be performed with MED for far lateral disc herniation. In selective endoscopic discectomy (SED), developed separately from MED, various study channels are added to an endoscope and discectomy can be performed with the endoscope directly placed at the disc. In percutaneous intradiscal thermal treatment (nucleoplasty), the nucleus pulposus, which has a high water content, is vaporized using radiofrequency waves by entering the annulus with a 17G needle with endoscopic control. While a shorter hospitalization period and fewer complications are advantages of minimally invasive methods, there are also disadvantages, such as insufficient long-term efficacy and limited use with extruded-sequestered disc hernia.

The macrodiscectomy method, which has been used since the 1930s, is generally not preferred in advanced centers. In this method, hemi-partial laminectomy and medial facetectomy are performed after a large skin incision.

Discectomy is performed after removal of the ligamentum flavum. The disadvantages of this approach are the relatively high risk of injury of large vessels, internal organs, dura and nerve roots, and the longer hospitalization and recovery periods. Microdiscectomy has begun to be commonly used since the 1990s and has become the preferred surgical method. Discectomy is performed after incision of the ligamentum flavum, entering from the interlaminar space under microscopy. The advantages of this technique are the small skin incision, shorter hospitalization and recovery periods and lower risk of tissue damage,

although the disadvantage is that the herniated part cannot be fully removed, due to the small working area. While microdiscectomy is the preferred method of lumbar disc hernia treatment in developed countries, minimally invasive methods are often preferred for non-extruded and non-sequestered disc hernia, and new treatment methods are being revealed. Here, two of these methods, percutaneous laser disc decompression (PLDD) and epiduroscopy, are evaluated, taking the literature into account.

LUMBAR DISC ANATOMY:

The intervertebral discs (IVD) are a series of semi-joint structures that connect the vertebral bodies from the second cervical vertebra to the first sacral vertebra. Each disc is limited by layers of hyaline cartilage called the lower and upper end plates, located on the spongious bone belonging to the vertebral body. All discs are composed of the nucleus pulposus, a semi-fluid center, and the annulus fibrosis, which surrounds the nucleus pulposus and is made up of fibrous cartilage tissue. 80–90% of the mass of the nucleus pulposus consists of water. In adults, no blood vessels, neural crests or lymphatic vessels are found in the IVD structure.

The disc is fed by diffusion from the cartilage end plates and adjacent tissues. Due to the lack of blood vessels, the oxygen density is low and the disc cells mainly perform anaerobic metabolism. Neural crests are found around the disc and at the outermost layer of the annulus fibrosis. It is generally thought that disc herniation occurs due to an increase in the nucleus pulposus inner pressure during loading that exceeds the resistance of the annulus fibrosis. However, degeneration of the disc is accepted as a precondition for disc herniation. The process of disc degeneration occurs concurrently in the annulus fibrosis and the nucleus pulposus.

The ability of the annulus fibrosis to expand on mechanical loading decreases with age and the number of ruptures in the fibers increases. The chondrocytes of the disc also produce less proteoglycans, which have the largest role in water retention. This causes a reduction in the total water content of the disc and a disruption of the ability of the disc to expand.

In intervertebral discs, the endplates and the posterior of the annulus fibrosis are the potential weak points. The nucleus pulposus is most commonly herniated at these two regions[23]. "Bulging" is the effusing of the annulus from the edge of corpus by diffusion, and "protrusion" is the focal bulging caused by the nucleus pulposus pushing the annulus fibrosis. "Extrusion" is the dorsal migration of the nucleus pulposus by passing over a ruptured annulus, and "sequestration" is the disconnection of the nucleus pulposus and the rupture of the disconnected part from the inside.

The risk of disc herniation forming is 2–5% of patients with lower back pain throughout their lives. The most common disc herniation occurs towards the posterolateral part of the spinal cord, between the midline and neural foramen[16].

LASER DISC DECOMPRESSION IN LUMBAR DISC HERNIA:

Percutaneous laser disc decompression (PLDD) is a method that aims to achieve nerve decompression by vaporizing the nucleus using a laser. The use of a laser for the vaporization of nucleus material was first described in 1986

by Ascher and Choy. A laser was applied by a posterolateral approach over a 400 nm wire with an 18G needle percutaneously placed in the lumbar disc space. While the initial success rate was about 30%, this has been increased to 78%[30].

The treatment principle of PLDD depends on the closed hydraulic system of the intervertebral disc. This closed system consists of the nucleus pulposus, with a high water content. An increase in the water content of the nucleus pulposus causes an increase in the internal pressure of the disc[28]. In PLDD, the water inside the nucleus pulposus is vaporized with laser energy and the structure of the nucleus pulposus is changed. Thus, symptoms caused by the herniated part recover, due to the decreased pressure[8,28].

The main indications for PLDD are no response to conservative treatment at the end of six weeks, neurological signs due to single nerve root irritation, more pain in the lower extremities than in the lower back and compatible radicular symptoms with the radiological signs of the herniated part. The main contraindications for PLDD are systemic or local infections, coagulopathy disorders, large-sequestered or extruded disc herniation, severe disc degeneration or loss of disc length, patients requiring acute surgery due to disc herniation, patients with moderate or advanced spinal stenosis or spondylolisthesis, and patients with vertebral fractures or malignity.

Technique: In PLDD, an 18G needle is inserted into the disc nucleus using fluoroscopy under local anesthesia. During this process, computerized tomography (CT) and magnetic resonance imaging (MRI) can be used in addition to fluoroscopy (Figure-1,2,3)[14,33].

Then, a laser wire (0.4 mm) is sent to the center of the nucleus pulposus through the needle. The laser doses to be applied depend on the lesion level, between 1200 and 2000 J is suggested[15]. Damage of the disc and adjacent tissues by laser energy can cause aseptic discitis.

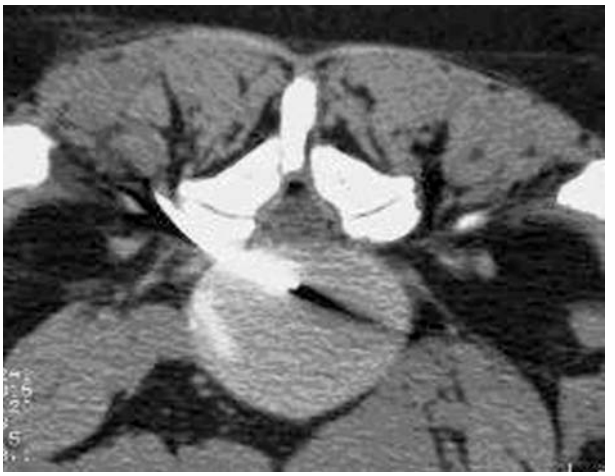

Figure-1. The control of disc punctures with computerized tomography in PLDD.

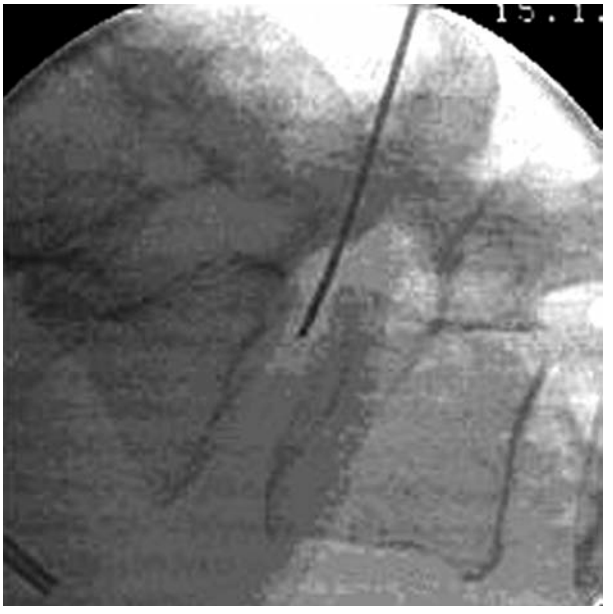

Figure-2. The control of disc punctures with fluoroscopy in PLDD.

To avoid aseptic spondylodiscitis, the location of the laser should be controlled by fluoroscopy. Thermal damage of the nerve root can cause temporary or permanent extremity pain[12].

Different laser types are employed for laser discectomy, such as YAG (yttrium aluminum garnet), KTP (potassium titanyl phosphate), holmium, argon or carbon dioxide, depending on the purpose of use. Due to differences in absorption, the energy need and application doses change.

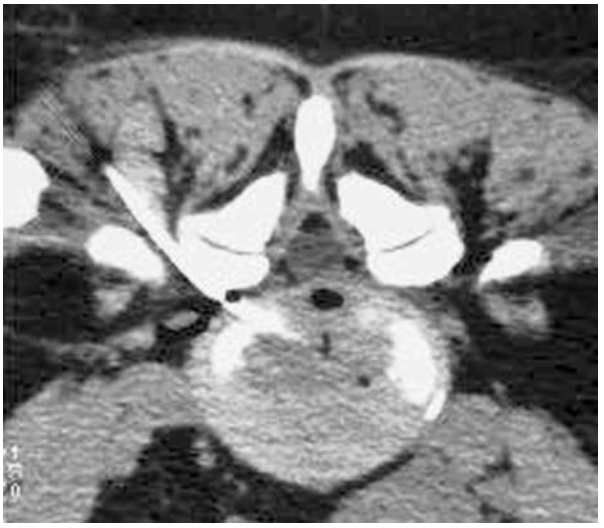

Figure-3. CT image after laser application in PLDD and demonstration of gas formation inside the disc.

It is also not known how much disc material should be removed in order to provide decompression. Therefore, protocols vary according to the total treatment duration, but the laser should typically be applied in short intervals. Some laser devices have been given 510(k) approval by the American Food and Drug Administration (FDA), such as the Trimedyne Holmium Laser System (Yttrium Aluminum Garnet: YAG), Revolix Duo Laser System and 119 Quantum LITHO Laser System, in 2002, 2007 and 2009, respectively. In 2009, the National Institute for Clinical Excellence (NICE) published a guide for lumbar laser discectomy. This guide states that this method should only be performed under clinical supervision with permission, and that patients should be made to understand the uncertainties surrounding the safety and efficacy of the method, by indicating that the current proofs for laser discectomy are qualitatively and quantitatively insufficient[21].

EPIDUROSCOPY IN THE TREATMENT OF LUMBAR DISC HERNIA:

Spinal endoscopy or epiduroscopy is a method that provides diagnosis and treatment of chronic lower back pain and radiculopathy by investigating the epidural space with a minimally invasive approach. In 1969, Ooi et al. obtained clear and colorful endoscopic images of the spinal canal using a newly-designed fiber optic system[22]. In 1989, Blomberg performed percutaneous epiduroscopy using a rigid arthroscope with a lumbar approach for the first time in a live organism[4]. At the beginning of the 1990s, Heavner, Shimoji and Schutze separately described the use of small flexible fiber optic endoscopes to visualize the epidural space[17]. In 1996, epiduroscopy became easier with the use of a video-guided catheter system and inflating the epidural canal with saline, and better images were obtained. In 2005, diagnosis and treatment of all pathologies in the epidural region, from the sacral to cervical regions, became possible with the use of a flexible epiduroscope with FLEX-X2 technology.

Indications for epiduroscopy include a diagnosis of epidural fibrosis developing after invasive approaches and radiculopathy, biopsy, application of epidural pain provocation test,

direct application of drug treatment, irrigation of epidural space, rupture of scar tissue, and placement of stimulation electrodes for radiofrequency treatment. Contraindications include systemic or local infections, coagulopathy disorders, large-sequestered or extruded disc herniation and neural symptoms such as cauda equina, congenital anomalies, intracranial pressure increase, pregnancy, cerebrovascular diseases, and liver-kidney failure.

Technique: Epiduroscopy is performed under local anesthesia when the patient is awake, therefore avoiding possible pressure effects in the epidural canal. In a prone position, the epidural space is reached with an 18G needle passing the sacral hiatus.

Epidural adhesions generally develop after surgery. However, adhesion can sometimes occur in patients without surgery. The reasons for adhesion can be leakage of the disc material from the nucleus pulposus to the epidural space, or an inflammatory response developing in response to annular rupture [34].

The needle tip is seen in the epidural space with roentgen or contrast material. Under fluoroscopy, a 0.8 mm guide wire is sent through the needle. A 4 mm introducer and dilatator are sent over the guide wire to the sacral epidural space using the Seldinger technique. After removal of the dilatator and guide wire, a 0.9 mm endoscope with a video-guided catheter is sent to the epidural space with an introducer. Then, the endoscope is directly observed in the epidural space and carefully moved through the cephalic direction. During the process, distension is provided with saline infusion for a better view of the epidural space. Adhesion dissection can be performed using a video-guided catheter tip. A path is formed for injected drugs to reach the symptomatic nerve root by means of hydrostatic distension with dissection.

Processes such as biopsy, adhesion separation, scar tissue resection, lipoma resection, cauterization, removal of foreign substances and abscess drainage can be performed with the use of flexible surgical tools, lasers and catheters by means of the epiduroscope canal. Contributions to the treatment of problems such as failed lower back surgery syndrome, epidural fibrosis and lumbar radiculopathy are provided by the application of drug treatment to the targeted epidural region with epiduroscopy. The use of a laser can provide bleeding control, recanalization of stenosis caused by a tumor and disruption of plaques on vessel walls[29].

Adhesions around the nerve roots can cause ischemia by reducing microcirculation. Diagnostic methods such as magnetic resonance imaging (MRI), myelography and electromyography can fail to reveal this pathology in the epidural canal, and radiculopathy etiology can be revealed with epiduroscopy.

The continuation of resistant lower back pain in 40–80% of patients who have had lower back surgery is called failed lower back surgery syndrome (FLBSS). Possible organic reasons for FLBSS are epidural fibrosis, arachnoiditis, mechanical factors and changes in the nerve root due to pressure. After a second surgery for fibrosis, a 65–70% failure rate has been reported, and symptoms became worse in 15–20% of patients[20]. It is hoped that epiduroscopy could be used to reveal the causes of FLBSS.

Epidural corticosteroids are often used in the treatment of lower back pain accompanied by

radiculopathy. A study by Watts and Silagy showed statistically significant benefits of epidural steroids in radiculopathy treatment when compared to a control group[35]. The addition of clonidine and hyaluronidase to corticosteroids has also been described. After epidural injection of the therapeutic substance, its delivery to the symptomatic nerve root cannot be achieved in some patients due to epidural fibrosis. After separation of the adhesions with endoscopy, delivery of epidural steroids to symptomatic nerve roots can provide benefits for these types of patients.

The advantages of epiduroscopy are that it allows specific detection of nerve root pathology, fibrosis and adhesions (Figures-4,5,6) and imaging of lesions that cannot be observed by MRI, it is a minimally invasive method for the treatment of radicular pathology, it provides a method for the application of therapeutic solutions to affected nerve roots and allows the application of steroids, local anesthetics, hyaluronidase and saline [27].

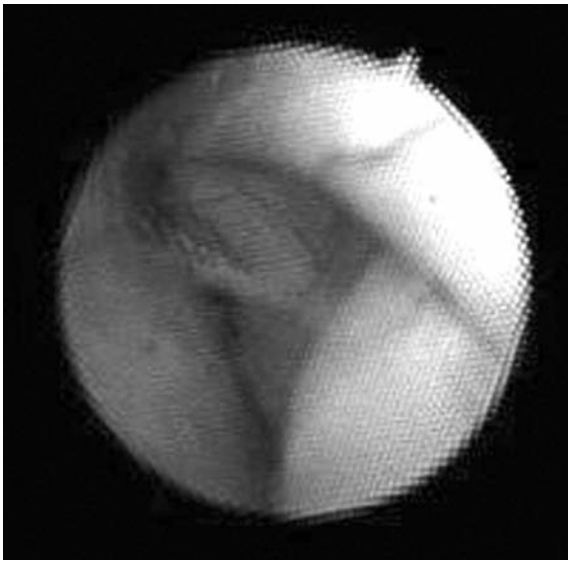

Figure-4. Epiduroscopic image of nerve root.

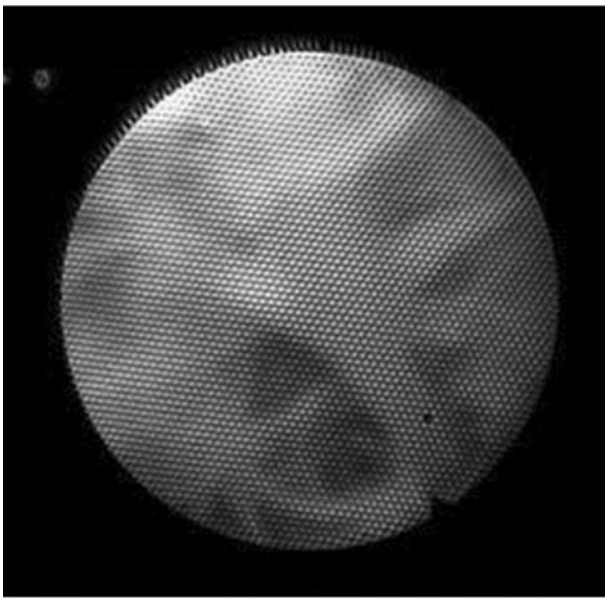

Figure-5. Epiduroscopic image of epidural fibrosis.

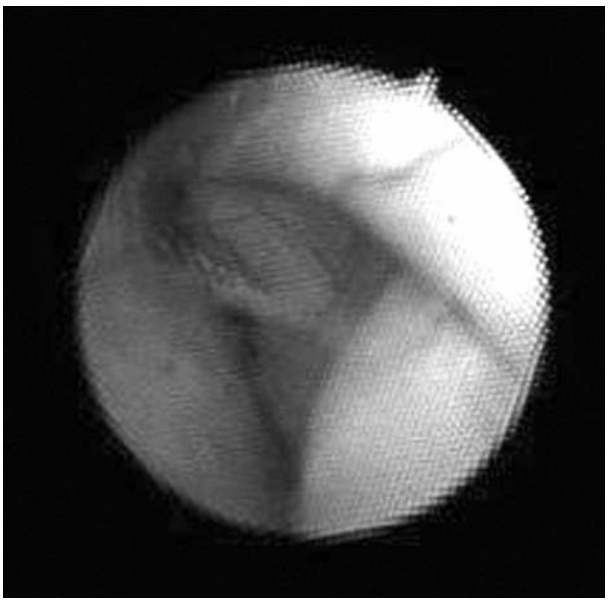

Figure-6. Epiduroscopic image of radiculopathy.

The disadvantages of epiduroscopy are a risk of headache after dura perforation and dural puncture, side effects such as headache and paresthesia developing due to uncontrolled and excessive saline infusion to the epidural space, retinal bleeding and temporary blindness due to rapid displacement of cerebrospinal

fluid after rapid epidural steroid injection, risk of generalized tonic-clonic contraction in patients who received general anesthetic and excessive irrigation solution (300–1200ml) during epiduroscopy (it is thought that general anesthesia should be avoided and the irrigation solution should not exceed 150 ml), and shading of images with epidural fat tissue or, in some cases, vessels[24].

DISCUSSION:

Minimally invasive methods have become popular for the treatment of disc hernia and degenerative disc diseases, due to their easy application and fewer complications as compared to the standard macro- and microsurgery approaches. However, data about the utility of these surgical methods are still not sufficient[9,26]. Although there are many studies showing the efficacies of these methods, there are also some studies that indicate that their efficacies are no better than for micro- and macrosurgery methods, or even that they are less effective.

Ishiwata et al. examined the clinical results of percutaneous laser disc decompression with MRI by using the position of the needle tip in the disc as a reference. They divided an axial image of the disc into four quarters and three concentric pieces, and evaluated the clinical results of each region six months after application. At the end of the study, it was emphasized that the general success rate was 68.8% in 32 patients, and that targeting some regions provided better results[15].

A study conducted by Choy in 2004, which included 1275 patients who received 2400 laser disc decompressions (cervical, thoracic and lumbar) over 18.5 years, stated that the general success rate was 89% in terms of pain and functional recovery criteria, the complication rate was 0.4% (only infectious discitis) and the recurrence rate was 5%, which was generally due to re-injury.

In a systematic review conducted in 2009, Singh et al. stated that the short- and long-term pain reduction provided by percutaneous laser disc decompression was equivalent to that provided by percutaneous lumbar disc decompression[31]. Tassi retrospectively examined the results of 500 patients who received microdiscectomy from six surgeons due to pain from disc hernia from 1997–2001, and the results of 500 patients who received percutaneous laser disc decompression from a single surgeon from 2002–2004[32]. Patients with a sequestered disc were excluded. According to this study, the hospitalization duration (6 days vs 2 days), the general recovery period (60 days vs 35 days) and the re-operation rate (7% vs 3%) were all found to be lower for the groups who received laser treatment, despite the lack of statistical analysis.

In a study that included 11 cases, Ahn et al. reported 88% recovery after laser discectomy[1].

In 333 patients with disc hernia, Gronemeyer et al. reported the reduction rate of lower back pain as 73% with laser decompression after a follow-up period of 2–4 years[7]. Menchetti et al. published a retrospective study that included 900 cases who received laser discectomy due to a herniated nucleus pulposus in 2011. It was stated that 40% of the patients received microsurgery after 1–3 months[19]. In another study, Morelet et al. reported that 45 of 149 patients (30.2%) preferred traditional surgical methods over percutaneous laser disc decompression[2].

Gibson et al. published a review including a laser discectomy method in the treatment of lumbar disc prolapse. In this review, in which all surgical methods were investigated, 27 randomized controlled clinical studies were described and none of them showed the efficacy of laser discectomy[32]. In a study conducted in 2007, Goupille et al. stated that although the laser disc decompression method was attractive, it could not be considered for the treatment of radiculopathy associated with disc herniation that is resistant to medical treatment[6].

In a prospective study including 58 patients with spinal stenosis, Richardson et al. stated that pain scores and weakness significantly reduced between six months and one year with epiduroscopic adhesion separation and steroid/local anesthetic injection[25]. In a study conducted by Manchikanti et al., a group of patients with adhesion separation after epiduroscopy who received local anesthetic and steroids was compared to a control group who received local anesthetic and steroids after sacral level epiduroscopy without adhesion separation. When compared to the control group, the recovery in pain level and functional status of the first group continued at months one, three and six, and 57% of the patients had a significant recovery[11].

In a prospective study conducted by Di Donato et al., 234 patients with chronic lower back pain higher than 5 on the Visual Analog Scale (VAS) were divided into three groups according to the Low Back Pain Disability Index (LBPDI). A flexible fiber optic endoscope was sent to the caudal epidural region, and saline and hyaluronidase solution were given. Ozone and ciprofloxacin were applied to the affected region. Short and long term efficacies (1 week and 3, 6, 12, 24, 36 and 48 months) were evaluated. It was shown that the treatment significantly reduced the VAS score from the first week to the end of the process in all groups. LBPDI showed recovery, particularly in the third month, and this recovery was maintained for a long-term period. This prospective study shows that the separation of mechanical adhesion with epiduroscopy and the application of ozone and ciprofloxacin to a targeted region provide continuous and perceivable pain recovery for patients with chronic lower back pain, and affects the recovery of LBPDI[10].

In 2007, Avellanal et al. applied epiduroscopy with an interlaminar approach to 19 patients with FLBSS who showed no response to other treatments. Separation of adhesions and injection of triamcinolone, hyaluronidase and bupivacaine were performed. While there was no recovery in six patients, the other six patients showed significant recovery[3]. In a study conducted by Geurts et al., epiduroscopy was performed for 20 patients with sciatic pain and adhesions were detected in 19 out of 20 patients. For eight of these 20 patients, the adhesions could not be revealed by MRI. Epidural injection was performed for all patients, and 11 of the 20 patients (55%) showed significant recovery in three months[13].

In a study conducted by Heavner et al., adhesion separation was performed for 59 patients using hyaluronidase or hypertonic saline, and at least a three-point reduction in pain scores with a ratio of 80–88% was obtained in the patient groups at the end of a 12-month follow-up. In addition, it was observed that extra treatment methods such as second adhesion separation, lumbar facet injection, hypogastric plexus block, muscle injections, nerve root injections or spinal cord

stimulation were applied once or more than once for about 70% of the patients. The mean duration between adhesion separation and the first extra treatment was 2.3 months[18].

The recurrence rate in the surgical treatment of lumbar disc hernia is high, particularly for patients who have two or more operations. Patient selection should be performed carefully when surgical treatment is considered, except in some circumstances (cauda equina syndrome, lower leg and progressive motor deficit). Surgery should replace percutaneous laser disc decompression in some cases with disc protrusion. Rapid recovery without hospitalization is expected with this method. When the many patients who required traditional surgical methods after laser disc treatment are considered, the current proofs for laser discectomy are not qualitatively or quantitatively sufficient.

Epiduroscopy is a diagnostic and therapeutic method for patients with lower back pain with or without radiculopathy. It is thought that epiduroscopy provides an ideal combination of diagnosis and treatment in a single session. For the treatment of painful radiculopathy, adhesion separation with epiduroscopy and the application of an epidural injection to the targeted region is a promising, relatively safe, and minimally invasive intervention. In terms of diagnosis, the direct observation of epidural pathology is superior to MRI. However, the effectiveness of this method is still unclear, when the need for a second epiduroscopy or extra treatment methods in some cases is taken into account. To evaluate the long-term benefits of both laser disc decompression and epiduroscopy, further large studies with long-term follow-up periods will be helpful.

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