Epiduroscopic Laser Disc and Neural Decompression

Jae-Do Kim¹, Jae-Ho Jang¹, Gu-Hee Jung¹, Ji-Youn Kim¹, & Su-Jin Jang¹

Abstract: This study sought to evaluate the effectiveness of epiduroscopic disc and neural decompression with laser to epiduroscopic neural decompression alone, among patients with chronic refractory low-back and/or leg pain. A total of 109 patients with chronic low-back and/or leg pain were operated on epiduroscopically, with or without the addition of laser-based disc and neural decompression. Eleven patients were excluded because they had not yet met the minimum 6-month follow-up period criterion. The clinical outcomes of 20 epiduroscopic neural decompression (END) patients, and 78 epiduroscopic laser disc and neural decompression (ELND) patients were evaluated during a follow-up period. Outcomes were evaluated using the visual analog scale (VAS) for back and leg pain, the Roland Morris Disability Questionnaire (RMDQ), and Mac Nab criteria. Among END patients, the mean back and/or leg pain VAS score improved from 8.5 to 4.6 one month after the operation. For ELND patients, the mean back and/or leg pain VAS score improved from 7.6 to 4.9 one month after the operation. The long-term END follow-up patients reported mean back and/or leg pain VAS score change from the initial 8.5 to 6.1, and for ELND patients from the initial 7.6 to 3.6. Mean RMDQ scores improved from 11.3 to 9.6 with END, and from 18.8 to 11.4 with ELND during the 1-month follow-up period. However, in the long-term follow-up data, the mean RMDQ score worsened from initial means of 11.3 to 11.4 for END patients but continued to improve from the one month mean of 11.4 to 10.6 for ELND. Results using the Mac Nab criteria were positive in 82% of the ELND group compared to 45% with the END group. Eighty-two percent of the patients treated with ELND (laser disc and neural decompression) reported positive treatment results as opposed to 45% receiving END alone (non laser neural decompression). Thus ELND, with its considerably higher percentage of positive outcomes, is judged to be a more effective therapeutic modality for patients with chronic refractory LBP.

Keywords: lumbar spine, chronic refractory low-back pain, epiduroscopic laser neural decompression, adhesiolysis.

INTRODUCTION

Although the underlying mechanisms of chronic refractory low-back and/or leg pain (LBP) have not been fully investigated, its pathophysiology has been addressed in clinical, as well as research situations by applying a range of treatment methods from conservative therapy to surgical approach. Surgical treatment, in particular, has been one of the most common for patients with refractory chronic LBP (e.g. intervertebral disc hernia in the lumbar spine and lumbar spinal stenosis). However, chronic LBP treatment options are limited for patients who have received surgical treatment more than once. Repeat surgery for lesions not clearly seen on magnetic resonance imaging (MRI) often causes difficulty in making an accurate diagnosis. Recently, to address these problems, spinal surgeons have been paying increasing attention to epiduroscopy. This allows visual access to the epidural space to potentially identify the cause of LBP and make a more accurate diagnosis, treat any adhesion or inflammation therein, and/or inject drugs into the lesion(s).

Epiduroscopy was first introduced in 1931 by Burman who examined the epidural space via endoscope [2], but it would be decades before the technology was put to use for a wider range of clinical applications including adhesiolysis and neuroplasty as popularized by Racz [17]. In 1991, Heavner used a flexible fiberscope, as well as optical instruments to perform epiduroscopy [5]. More recently, a working channel scope has been developed, allowing lasers, and other working tools to be used; thus helping enhance the effectiveness of surgery. Performing epiduroscopy helps surgeons verify epidural inflammation or adhesion that could not be identified via MRI and enable them to offer immediate treatment [7]. Epiduroscopy also can be useful when MRI examination discovers multiple lesions of disc hernia or spinal stenosis in the lumbar region. For example, the decompression procedure described here allows surgeons to make a single incision through which they can access multiple lumbar segments; which is less invasive and potentially more effective than traditional surgery. In addition, clinicians can apply epiduroscopy for patients who, despite hav-
ing undergone one or more surgeries on their herniated lumbar disc suffer from recurrent disc problems, including difficulty in receiving another surgery due to the formation and adhesion of scar tissue.

For this study, we evaluated the long-term clinical results of epiduroscopic laser neural decompression (ELND) and epiduroscopic neural decompression (END). Epiduroscopy allows direct examination of the epidural space in patients for whom imaging tests such as MRI examinations fail to show clearly where the lesion(s) is (are) located. By offering first-hand visualization of the inflammatory progression in the disc and its surrounding tissues, epiduroscopy enables spinal surgeons the ability to deliver accurate diagnosis and treatment at once, as well as to approach the extra-dural space via the sacral hiatus using a flexible endoscope and operate within the space with greater freedom. Thus, surgeons need to make only a single incision in the skin to get direct, simultaneous access to multiple lesions in the lumbar area.

### Materials and Methods

In this study, END and ELND were performed on patients with chronic LBP and radiculopathy and who had received conservative therapies, such as epidural steroid injections and oral medicine administration, for at least 3 months without significant response. According to surgical protocol with such patients, pre-operative MRI examinations are required to verify lesion(s) in their lumbar region. Epiduroscopy may be carried out if the results of the examinations reveal a clear case of protruded or extruded disc, sequestrated disc, or identify a lesion of spinal stenosis in the lumbar region. However, the procedure may still be performed even when the MRI exams fail to identify the aforementioned cases or lesions in the lumbar region, if the patient complains of chronic pain in their lumbar region and/or radiculopathy in the lower extremities.

In this study, we also had patients with bleeding tendency, or with increased likelihood of bleeding due to anti-platelet administration. In these cases, we first corrected the bleeding tendency or had the patients discontinue the oral drug administration for 5 days prior to the epiduroscopic surgery. For our subjects who were diabetic and who consequently had difficulties in regulating their blood sugar levels, as well as an increased risk of developing infections, we helped them regulate their blood sugar levels first prior to the surgery. We excluded patients who had renal failure or chronic liver disease; those who showed adverse reactions to local anesthetics; those who were pregnant; those who had serious mental disorder(s), and those who were unable to cooperate during the surgery for various reasons. We found ELND non-viable for — and consequently avoided performing such on — patients who showed severe calcification and adhesion inside the spinal canal due to chronic spinal stenosis. Patients with osseous lesion(s) and resulting severe degenerative conditions were also excluded from this study since these severe bony related causes of chronic LBP are unlikely to be treatable with laser-based decompression therapy.

Between October 2008 and April 2011, a total of 109 patients diagnosed with chronic refractory LBP participated in this study, receiving either END or ELND treatment in their affected lumbar region. We received post-operative follow-up observations for 6 months, or longer, with 98 of the 109 patients. Among the 98 participants, 20 (11 males and 9 females) underwent END only (Gp1). Ages ranged from 55 to 82 years, with a mean age of 65.6 years. The remaining 78 patients (40 males and 38 females) received ELND treatment in the lumbar region (Gp2). Ages ranged from 18 to 82 years, with a mean age of 58.5. The mean follow-up observation period was 23 months for Gp1 and 20.7 months for Gp2. Diagnoses in Gp1 included: spinal stenosis (N = 18), lumbar disc extrusion (N = 1), and post-operative pain after lumbar disc surgery (N = 1). Diagnoses in Gp2 included: lumbar spinal stenosis (N = 42), lumbar disc extrusion (N = 25), post-operative pain after lumbar disc surgery (N = 8), and chronic refractory LBP whose lesion was not identified via MRI tests (N = 3).

To perform END (adhesiolysis and foraminoplasty without laser disc decompression- Gp 1), the patient was instructed to lie on a radiological testing table in prone position; the skin in the region of the sacral hiatus was swabbed with disinfectants for sterilization, and local anesthesia with 1% lidocaine (Xylocaine®, AstraZeneca, Wilmington, Delaware) was administered in said region under radiological amplification and without administration of sedatives. Afterward, a 1 cm-long longitudinal incision was made on the skin in the sacral hiatus region; an 18G Tuohy epidural needle was used for puncturing the sacral hiatus, and a guide wire was inserted into the opening via the needle that was removed. A dilator was then inserted through the opening to secure the needed bony space (separate the sacral cornu, take down the filum terminale) and was removed once the space was secured. The introducer was then inserted followed by a flexible endoscope (Myelotec, model # 75298871, Roswell, Georgia) into the epidural space through the introducer. The flexible endoscope was then maneuvered to reach the suspected root lesion. Epidural saline solution was used to irrigate and clear the area visualized, exert pressure to expand the epidural space, and improve clarity through the endoscopic video screen.

This allowed visualization of the adhesion status, inflammatory tissues, fibrous connective tissues, and adipose tissue around the nerve roots in the lesion (Fig. 1). In addition to securing epidural visibility endoscopically, a contrast agent (OmnipaqueTM, Nycomed, Ireland) was injected to perform epidurography to identify the adhesive lesion clearly. We even stimulated the nerve roots in the lesion via the endoscope. This was to test if the stimulation induced concordant sensations or pain reproduction in the patient, and to ensure a higher level of ac-
accuracy for our diagnosis if it did. Next, we manipulated the flexible endoscope inside the epidural root lesion and performed adhesiolysis and foraminoplasty.

The difference between END (described above), and ELND is that the latter involves laser-based cauterization and decompression of the disc nucleus following the foraminoplasty and adhesiolysis neural decompression procedure. Thus, the patients in Gp 2 received the same procedures just described for Gp 1, with the addition of laser-based cauterization and decompression of the disc nucleus (Fig. 2). Before we performed the disc laser cauterization and decompression portion, we introduced a guide wire probe directly into the extruded or separated disc via the working channel under endoscopic visualization. This allowed us to secure and confirm the physical space inside the disc before inserting a holmium: yttrium-aluminum-garnet (Ho: YAG) laser optic fiber into the disc.

When the disc was cauterized via the endoscopic camera is was seen shrinking in capacity as the discectomy was performed. Both the END and the ELND groups received a locally injected steroid Triamcinolone 80 mg (Keneric®, Bristol Myers Squibb Co. Princeton, NJ) directly at the area treated to maximize the treatment effects.

During surgery, no other sedatives were administered except the intravenous injection of meperidine hydrochloride (Demerol® 25 mg, Sanofi-aventis U.S. LLC, Bridgewater, NJ) to help ease the patients’ pain and to allow verbal communication to continue between the surgical staff and patients throughout the surgery. When the patients complained of nerve root stimulus or other symptoms, we responded by adjusting the position of the endoscope, taking care not to cause nerve root damage. In addition, we deliberately stimulated the pain-inducing mechanism during the surgery to test and verify the association between the patients’ pain memory and the site of the actual pain-causing lesion. We judged that such would reinforce the accuracy of our diagnosis.

In an attempt to quantify procedural outcomes, the two groups visual analogue scale (VAS) [16], Roland Morris Disability Questionnaire (RMDQ) [18], and Mac Nab criteria [11] scores were gathered prior to the surgery, 1 month after the surgery, and during the last follow-up visit.

**RESULTS**

We compared the clinical results of the two procedures ELND and END. The two cohorts’ visual analogue scale (VAS) [16], Roland Morris Disability Questionnaire (RMDQ) [18], and Mac Nab criteria [11] scores were each compared prior to the surgery, 1 month after the surgery, and during the last follow-up visit. The mean VAS performance of Gp1 went from 8.5 (prior to surgery) to 4.6 (1 month after surgery), and then 6.1 (last follow-up visit);
showing a “V”-shaped upward tendency. In contrast, Gp2 scored 7.6 (prior to surgery), 4.9 (1 month after surgery), and 3.6 (last follow-up visit); indicating consistent improvement throughout the extended post-operative evaluation period (Fig. 3). With regard to RMDQ performance, the mean Gp1 scores were 11.3 (prior to surgery), 9.6 (1 month after surgery), and 11.4 (last follow-up visit); again exhibiting a “V”-shaped upward trend that ended with the highest score obtained during the last observation visit. In comparison, the mean RMDQ scores for Gp2 were 18.8 (prior to surgery), 11.4 (1 month after surgery), and 10.6 (last follow-up visit) (Fig. 4). Gp2 again shows consistent improvement throughout the post-operative period. With the Mac Nab criteria scale, Gp1 patients rated their post-operative condition as “Excellent” (N = 3), “Good” (N = 2), “Fair” (N = 4), and “Poor” (N = 11) during the final follow-up visit. Positive results — which were defined as the patients’ response of “Fair” or above — were noted in only 45% of the patients. Gp2 patients rated their condition “Excellent” (N = 25), “Good” (N = 19), “Fair” (N = 20), and “Poor” (N = 14) during the final follow-up session. At least 82% of this group reported positive results, which was far higher than the figure reported by the END group (Fig. 5).

We experienced several endoscopy-related complications, including transient headaches (N=8), transient hyperesthesia (N=1), pain over the endoscope insertion site (N=1), meningitis (N=1), and focal infection (N=2). However, all symptoms improved after bed rest and symptomatic treatment. Laser treatment-related complications included transient motor paralysis (foot drop, N=2), and paresthesia (N=15); these recovered within 6 months following the procedure.

**DISCUSSION**

Surgical treatment of a herniated lumbar disc started in 1934 when Mixter and Barr first introduced discectomy using lumbar laminectomy [13]. Since then, various techniques have been invented and tried. Hijiikata’s group attempted percutaneous discectomy using a 5 mm cannula and rongeur forceps to create a void inside the disc and to perform indirect decompression [6]. In 1991, Schaffer and Kambin reported another technique called arthroscopic microdiscectomy [20]. These methods allow surgeons to operate percutaneously, to minimize the incision, limit damage to normal tissues, reduce post-operative instability, reduce degenerative progression, and decrease the likelihood of epidural fibrosis. Johansen and Smith, and Owens et al., cited surgical benefits of using laser treatment for lumbar disc extrusion with outstanding treatment results [8,15]. The reported method cauterized the disc nucleus with the small reduction of intra-discal capacity offering benefits such as the reduction of pressure in the same area. As the least invasive technique for patients with lumbar disc extrusion or spinal stenosis, epiduroscopy (which approaches the herniated disc via the sacral hiatus) enables surgeons to do so with only a small incision at S4. Through that dissection, the flexible endoscope enables clinicians to move freely within the
epidural space from the sacrum to the lumbar region. This highly useful technique gives direct access to multiple lumbar levels ipsilaterally or bilaterally. Other strengths include clear, visual identification of inflammatory tissues or post-operative adhesions in patients with lumbar disc extrusion, spinal stenosis, chronic LBP, or pain after lumbar disc surgery non responsive to conservative therapies. In patients with chronic low back and leg pain from adhesive epidural fibrosis, epiduroscopic adhesiolysis is enhanced when steroids and saline solutions are injected via a flexible endoscope. Specifically this therapeutic improvement is due to the drugs injected having improved access to the adhesive fibrotic lesions during adhesiolysis [12]. Epiduroscopy is often performed under local and/or monitored anesthesia, thereby decreasing the risks and complications associated with general anesthesia. This extends the technique to patients who could not receive surgical treatment due to risks of general anesthesia. The use of laser in ELND also enables clinicians to perform disc decompression and sinuvertebral nerve deactivation simultaneously, potentially enhancing pain alleviation. This allows the patient resume ambulation immediately post-op and helps shorten their hospital stay.

In this study we used Ho: YAG laser, and a working channel-based flexible endoscope for ELND treatment. Ho: YAG laser double pulse mode enables surgeons to ensure greater stability for the surrounding tissues by minimizing damage to the surrounding tissues and nerve roots [3]. The flexible endoscopic working-channel allowed us to visualize the laser placed directly in the lesion. Hayek et al. compared studies wherein spinal endoscopic adhesiolysis without laser treatment was offered to patients who complained of pain as part of their post-lumbar surgery syndrome. According to the comparison, the long-term follow-up studies lasting 6 months or more revealed positive outcomes in only 1 out of 6 [4]. Whereas in a 2003 study by Ruetten et al. conducted among 93 patients with chronic refractory low back and radiating leg pain receiving ELND with Ho: YAG laser; a 45.9% improvement was reported [19].

Common complications of END performed in the spinal column include dural puncture, infections (meningitis, arachnoiditis, epidural abscess), increases in spinal fluid, and oversensitivity to drugs. In addition, nerve root damage, vascular damage, intravascular injection, cerebral or pulmonary embolism, and visual impairments have been reported as END-related complications [4]. Korean researchers have also reported cases of LBP and radiculopathy [10], as well as headaches, craniovascular rigidity, erythema, pruritus, and epidural abscess [9,14]. Laser treatment-related (ELND) complications have also been reported, such as motor paralysis resulting from thermal damage to the nerve roots, local sensory disorder, probe breakage, and discitis [1]. Compared to the conventional, more invasive nerve decompression techniques, it is our impression that ELND causes a smaller decrease in the intervertebral space following surgery, as well as reduces the likelihood of complications involving intervertebral instability and minimizes the fibrosis of the epidural structures. This reduces the risk during re-operation, and offers greater prognosis for chronic LBP patients. Nonetheless, ELND shows limitations in patients who have osseous lesions and severe degenerative lumbar conditions. Such limitations call for the development of flexible endoscopic instruments (such as a flexible bur and drill) to access to the osseous lesions via the working-channel endoscope.

**Conclusion**

In this study, we treated 109 chronic LBP patients with END and ELND techniques, and obtained post-operative follow-up data from 98. Eighty-two percent of the patients treated with ELND (laser disc and neural decompression) reported positive treatment results as opposed to 45% receiving END alone (non laser neural decompression adhesiolysis foraminoplasty). Thus ELND, with its considerably higher percentage of positive outcomes, is judged to be a more effective therapeutic modality for patients with chronic refractory LBP.

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