Journal of Clinical and Medical Images

Clinical Paper

ISSN: 2640-9615 | Volume 7

Percutaneous Endoscopic Decompression for the Treatment of Symptomatic Lumbar Spinal Epidural Lipomatosis

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Received: 26 Feb 2024
Accepted: 02 Apr 2024
Published: 08 Apr 2024
J Short Name: JCMI

Citation:

You Y, Percutaneous Endoscopic Decompression for the Treatment of Symptomatic Lumbar Spinal Epidural Lipomatosis. J Clin Med Img. 2024; V7(13): 1-7

Keywords:

Spinal epidural lipomatosis; Percutaneous; Minimally invasive surgery; Uniportal; Modified TESSYS

1. Abstract

1.1. Background: Spinal epidural lipomatosis (SEL) is an extremely rare occupational lesion characterized by an abnormal growth of epidural fat in the spinal canal. The condition can cause clinical symptoms by compressing the spinal cord or nerve roots, and this symptomatic SEL often needs surgical treatment. Today, improvements in percutaneous endoscopic instrumentation and technological advances allow for minimally invasive treatment of most degenerative diseases of the spine. The purpose of this article was to validate the safety and efficacy of the percutaneous endoscopic foraminal approach for the treatment of SEL.

1.2. Methods: A retrospective analysis was performed to analyze the data of 10 patients with SEL admitted to our hospital between January 2010 and October 2020. After local anesthesia, a targeted puncture of the surgical segment was performed under C-arm fluoroscopy, and the procedure was completed using a modified percutaneous endoscopic intervertebral foraminal approach. Postoperative surgical efficacy was assessed using a combination of pain visual analog scale (VAS) scores, Oswestry dysfunction index (ODI), and MacNab criteria.

1.3. Results: All 10 patients completed the surgery and follow-up without complications such as organ damage, intervertebral space infection, incomplete decompression, and nerve injury. All patients were followed up from 12 to 24 months with an average of 13.4 months. VAS scores and ODI values at 1 month, 3 months, 6 months, and 12 months postoperatively were significantly lower than the preoperative scores, and the difference was statistically significant ($P < 0.01$). According to MacNab criteria, seven patients achieved excellent results, one had a good outcome, one was fair, and one was poor, resulting in an excellent rate of 90%.

1.4. Conclusions: The modified transforaminal endoscopic spine system (TESSYS) technique of percutaneous endoscopy was successfully applied with the minimally invasive treatment of SLE. The key points of this technique were the expanded molding of the three-dimensional Kambin's triangle and the decompression of the contralateral saphenous fossa.

2. Introduction

Spinal epidural lipomatosis (SEL) is an extremely rare intravertebral space-occupying lesion, which is characterized by an overgrowth of unencapsulated adipose tissue in the extradural space. The condition is often associated with obesity, exogenous steroid use, or endogenous steroid secretion [1-2]. The first case of abnormal epidural fat increase in the spinal canal due to high doses of prednisolone after renal transplantation was reported by Lee et al. in 1975 [3]. With an enhanced understanding of SEL, one study has demonstrated a 6.26% incidence of SEL in patients with spinal stenosis. Moreover, the authors have suggested that the coexistence of SEL should be considered in patients with spinal stenosis [4]. The results of the Fujita et al. study indicated that spinal epidural fat accumulation should be considered when planning treatment for patients with lumbar spinal canal stenosis (LSS) together with an estimation of the efficacy of lumbar decompression surgery [5]. SEL usually manifests in the lumbar spinal canal, however it has also been reported in the cervical and thoracic spinal canals. These instances are often presented as case reports [6].

The diagnosis of SEL relies on imaging tests such as computed tomography (CT) and magnetic resonance imaging (MRI), and about one in 40 patients undergoing a spine MRI exhibit SEL; 23% of whom have no symptoms, 72% with spine-related symptoms, and 5% with symptoms specific for SEL [7]. An increase in epidural adipose tissue can lead to spinal cord and nerve root compression resulting in symptoms such as low back pain and discomfort, lower limb pain, numbness and weakness, intermittent claudication, and more in patients. The compression of the cauda equina nerve results in cauda equina syndrome subsequently. Symptomatic SEL is usually treated with surgery after failure of conservative treatment. Surgery interventions should also be considered for patients in whom clinical symptoms deteriorate rapidly [1].

The main traditional surgical methods are posterior laminectomy and excision of the adipose tissue. In recent years, minimally invasive techniques, such as percutaneous endoscopic lumbar discectomy (PELD), have been developed and improved continuously, and these are widely used in spinal surgery. The minimally invasive PELD technique has the advantages of less damage, faster recovery, and fewer complications compared to invasive surgeries [8]. Endoscopic removal of fat can be performed like common endoscopic spinal surgeries such as removing a herniated nucleus pulposus [9].

Between January 2010 and October 2020, we applied the PELD technique to treat 10 cases of SEL and achieved satisfactory postoperative results. In this retrospective study, we aimed to validate the feasibility of the approach and describe several operative differences based on our experience. Patients who participated in this study had provided informed consent for surgery. The study was approved by the Medical Ethics Committee of our hospital.

3. Materials and Methods

3.1. Clinical Data

Inclusion criteria: (1) Based on three diagnostic criteria of SEL derived from Kumar's as proposed (10): ① History and examination consistent with appropriate symptoms of spinal cord compression. ② MRI findings displaying a significant increase in epidural fat. The presence of epidural fat in the form of a continuous band or shuttle band with an anterior-posterior diameter of >7 mm or more. As a result, the dorsal dural sac was either compressed and narrow or absent. ③ Body mass index＞27.5 Kg /m2. (2) Patients who did not respond to conservative treatment. Exclusion criteria: (1) Arteriovenous malformations in the lumbar spinal canal; (2) Patients with intraspinal tumors; (3) Degenerative lumbar spinal stenosis; (4) Patients who died from other causes and missed follow-up visits.

We retrospectively reviewed 10 consecutive patients who were admitted to our hospital between January 2010 and October 2020, including three males and seven females. The age of the patients ranged from 53 to 82 years, with a mean age of 65.7 years. Decompression plane: L2–3 in three cases; L4–5 in five cases; and L5–S1 in two cases. All patients had unilateral limb pain, three of them had intermittent claudication, and two patients had decreased muscle strength in the lower limbs.

3.2. Surgical Treatment

The operation was performed under local anesthesia. The patient was placed in a prone position on a radiolucent surgery table with appropriate flexion. The procedures were performed using the percutaneous total endoscopic transforaminal approach with decompression segments determined by preoperative CT and MRI parameters. This method is commonly known as transforaminal endoscopic spine system (TESSYS) technology.

After the patient was routinely sterilized and draped, a mixture of 5 mL of 2% lidocaine, 10 mL of ropivacaine, and 10 mL of saline (0.5:1:1) was administered for local anesthesia of the skin, deep fascia, and superior articular process layer by layer. A 10 mm skin incision was made 10 cm laterally from the midline of the spinous process on the symptomatic, following the preoperative drawing of a line for localization. Additionally, a C-arm fluoroscopic lateral percutaneous puncture to the tip of the superior articular process of the inferior vertebral body of the diseased segment was then made and a guidewire was placed and then dilated step by step while the working channel was in position. The tongue of the channel rested against the apical bone of the superior articular process. Subsequently, the endoscope was placed and connected to the display.

Plasma knife electrocoagulation cauterized the soft tissue and revealed the superior articular process. The outline of Kambin's triangle in a two-dimensional plane consisting of the outlet nerve root, the lateral margin of the posterior lateral articular process of the spinal canal, and the superior margin of the pedicle of the inferior vertebral body were visualized accordingly. Then a small portion of the ventral bone of the superior articular process and some bone of the superior lamina were removed with a microscopic grinding drill under endoscopic visualization to enlarge the intervertebral foramina. Further, the original Kambin triangle, intervertebral disc and ligamentum flavum gap in three-dimensional space were revealed (Figure 1).

The working channel was adjusted and part of the ligamentum flavum was occluded to expose the traveling nerve root. The proliferating scar tissue or bony encumbrances around the nerve root were excised and ablated, ensuring adequate decompression, and achieving complete hemostasis with plasma to the head. Intraoperative continuous irrigation facilitated visualization of the tissue structure. Subsequently, the field of view was adjusted to the dorsal aspect of the nerve root, and the increased fat was excised from this particular aspect. Under direct endoscopic visualization, the ligamentum flavum was further removed to expand the field of view. The spinal canal was entered dorsally by the nerve root, and the increased epidural fat was removed to reveal the dural sac. The fluctuation of the dural sac was observed with the patient's breathing after complete decompression.

The nerve root was meticulously explored and was observed to be flaccid and fluctuating. No obvious compression-causing material was present around any of the nerve roots. Upon confirming the absence of active bleeding, the working trocar was removed, and the wound was sutured subsequently.

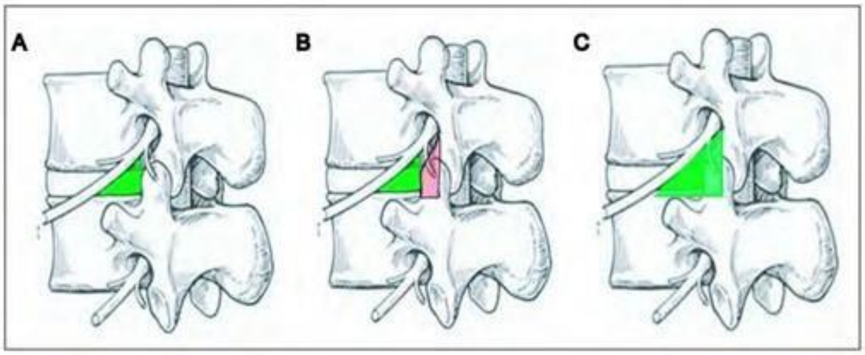

Figure 1: Illustration of foraminotomy. (A) Kambin's triangle before foraminotomy (green zone); (B) The portion of the superior articular process and the lateral pars of the vertebral plate to be resected for foraminotomy (pink zone); (C) Kambin's triangle after foraminotomy (green triangle zone).

3.3. Postoperative Treatment

Dehydration and neurotrophic drugs were used for management during the postoperative period. Four hours postoperatively, the patients were allowed to wear a waist cuff to get out of bed and they were discharged 1–3 days after surgery. Patients were instructed to wear a waist cuff for 2 weeks postoperatively and to avoid prolonged weight bearing on the lower back for 3 months. Follow-up was 1 year after discharge from the hospital.

3.4. Indicators for Evaluating Therapeutic Effects

The patient's clinical symptoms and neurological function were assessed preoperatively and at 1 month, 3 months, 6 months, and 12 months postoperatively using the visual analog scale (VAS) for pain and the Oswestry disability index (ODI). The lower the postoperative pain VAS score and ODI, the better the surgical outcome. Efficacy was assessed at 12 months postoperatively using the MacNab scale, which categorized outcomes as follows: Excellent: no pain or limitation of movement, return to normal activities and work; Good: Symptoms mostly relieved, occasional pain, does not affect work or life; Fair: Symptoms improve, affecting work and life; Poor: no change or even aggravation before or after surgery, requiring another surgical treatment. Postoperative complications such as organ damage, intervertebral space infection, incomplete decompression, and nerve injury were also observed.

3.5. Statistical Analysis

Data were analyzed using GraphPad Prism 8.0 software. All data are displayed as the mean ± standard deviation. Pre-operative and post-operative (1 month, 3 months, 6 months, 12 months) comparisons were made using independent two-tailed Student's t tests. Furthermore, $P < 0.01$ was considered statistically significant.

4. Results

Surgery was completed in all cases, and the operation time ranged from 50 to 110 min, with an average of 88.9 min; the bleeding volume ranged from 10 to 25 mL, with an average of 16.2 mL. Moreover, no complications, such as organ damage, intervertebral space infection, nerve damage, or cerebrospinal fluid leakage were observed in patients. One case had poor relief of lower limb neurological symptoms after surgery. However, improvement was observed following a regimen of bed rest, dehydration, hormone therapy, and nutritive nerve symptomatic treatment, with no significant discomfort reported. A typical case is demonstrated in Figure 2.

Patients were followed up for 12 months after surgery. Compared to the preoperative period, all patients exhibited significant relief of low back and leg pain postoperatively. The VAS scores of all patients at different postoperative follow-up time points were significantly lower than the preoperative VAS scores ($P < 0.01$). At the 12-month follow-up after surgery, the ODI index was significantly decreased compared to that in the preoperative period ($P < 0.01$). As displayed in Table 1. MacNab ratings revealed: excellent in seven cases, good in one case, fair in one case, and poor in one case.

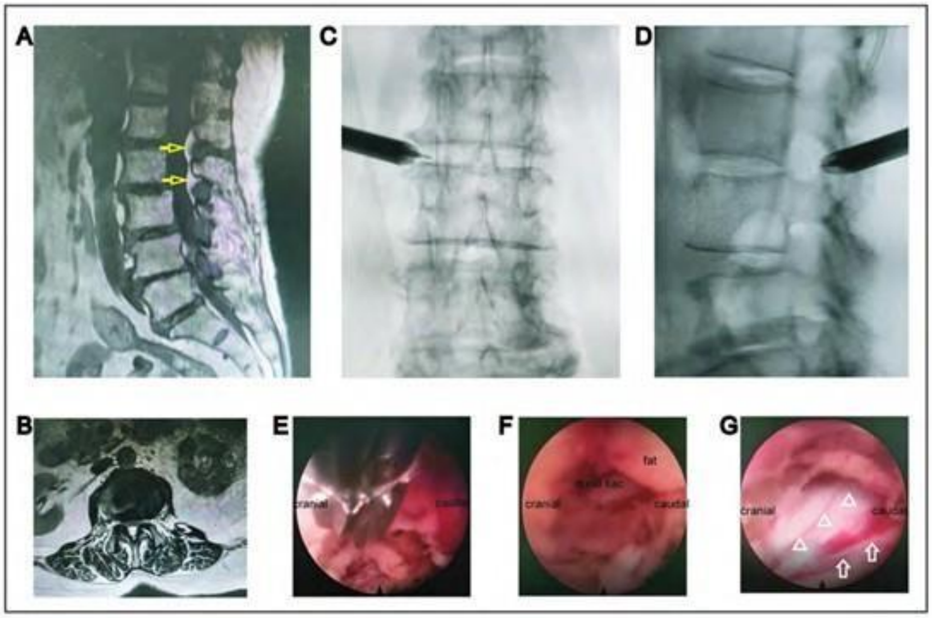

Figure 2: The preoperative imaging data of the patient. Preoperative (A) sagittal magnetic resonance imaging (MRI) image showed epidural fat increase (yellow arrow); preoperative (B) and axial MRI image at the L2–L3 level.
The position of the working cannula was verified using fluoroscopy in anteroposterior (C) and lateral (D) positions (L2–3).
Illustration of percutaneous modified transforaminal endoscopic spine system technique decompression procedures for the treatment of lumbar spinal epidural lipomatosis (E–G). (E) The Kambin triangle window is expanded using a grinding drill (as displayed in the pink zone in Figure 1B); (F) Epidural excess fatty tissues are exposed and removed; (G) Decompression of the dural sac (triangle) and bilateral traversing nerve root (white arrow).

Table 1: VAS and ODI scores at pre- and post-operation

Time point	Pre-operation	1 month post-operation	3 months post-operation	6 months post-operation	12 months post-operation
VAS of low back pain	7.00±1.05	5.50±0.97*	4.80±1.03*	4.70±0.67*	4.30±0.67*
VAS of lower limb pain	7.80±1.23	4.40±1.43*	4.30±1.25*	3.70±1.06*	2.20±1.23*
ODI	60.00±10.35	34.90±6.01*	30.80±5.14*	21.90±6.87*	15.40±5.66*

*P < 0.01, compared to pre-operation

5. Discussion

The pathophysiologic mechanism of SEL remains unclear. The condition may involve excessive accumulation of fat cells in the epidural space, and excessive fat accumulation is associated with exogenous steroid use [1, 2]. Greenish et al. approached the matter from another perspective and considered SEL as one of the postoperative complications of spinal stenosis [11]. Similarly, Youn MS et al. also reported a case of SEL after endoscopic spine surgery [12]. Another study has even suggested that metabolic-related conditions are potentially related to epidural fat deposition and that SEL could be a previously unrecognized manifestation of metabolic syndrome [13].

In physiologic conditions, epidural fat is used as a cushion to protect the spinal cord from injury. However, overgrowth of fat in the spinal canal can lead to compression of the spinal cord or nerve roots resulting in cauda equina syndrome or intermittent claudication. Surgery should be considered as early as possible in patients with progressive neurologic symptoms who are not responding well to conservative treatment, or in those who present with acute nerve injury [14-15]. Mugge et al. demonstrated that SEL outside the lumbar spine confers an increased risk for spinal cord injury following trauma. Patients with cervicothoracic SEL may require close neurological observation and timely surgical decompression [16].

The traditional surgical approach has been total laminar decompression of the corresponding segment, lipectomy, and some scholars have even performed fusion fixation. However, the open surgical procedure has disadvantages such as significant trauma, prolonged operation time, and slow recovery. Although fusion surgery can prevent segmental instability, patients often feel stiffness in their lower back, limited range of motion, and poor postoperative recovery. Advancements in medical technology have led to minimally invasive treatments for degenerative spinal diseases, resulting in a considerable reduction in complications [17].

Minimally invasive spinal endoscopy has grown significantly in recent years. PELD accurately reaches the spinal canal through precise targeted puncture and fixed access. As reported by Yu Y et al, minimally invasive percutaneous endoscopic surgery has many advantages (18), such as ① Reduced invasion of the spine and surrounding attachments; ② Preservation of spinal stability and mobility; ③ High-definition magnified field of view; ④ Improved surgical precision and safety; and ⑤ Reduced rate of postoperative complications.

Sairyo et al. reported a case of endoscopic minimally invasive decompression and fat removal for the treatment of SEL. They concluded that this minimally invasive surgical approach is well-suited for treating SEL due to its anatomical precision and ability to facilitate an early return to normal life for patients [9]. Kang et al. reported three successful cases using a percutaneous bi-portal endoscopic technique as a novel treatment of SEL and no postoperative complications were reported therein [19].

PELD can be categorized into two techniques, Yeung Endoscopic Spine System (YESS) and TESSYS. Each of these two techniques has its advantages. The YESS technique is centered on the intervertebral disc, entering the disc through the Kambin's triangle in the transforaminal region, and gradually removing the disc tissue from the inside to the outside (inside-out). This technique does not allow direct decompression of the compressed nerve root due to the occlusion of the superior articular process.

The TESSYS technique is nerve-centered and enters the spinal canal through an enlarged transforaminal region, avoiding damage to the traveling nerve roots during puncture (outside-in). This technique allows direct decompression of the compressed nerve root while removing the disc because the removal of the articular process is not obstructed by the articular joint. Patient outcomes are also more definitive in the TESSYS technique as compared to those in the YESS technique. Therefore, different scholars have proposed different modified TESSYS techniques based on their experiences, such as the target point technique [20], broad easy immediate surgery technique [21], modified-PELD technique [22], and so on.

In recent years, we have achieved favorable results in the minimally invasive treatment of SEL under intervertebral foramenoscopy by applying the modified TESSYS technique. All 10 patients in this group had successful completion of surgery. Postoperative MRI revealed complete removal of epidural adipose tissue, and radiating pain in the lower extremities was effectively relieved in all nine patients, with an excellent rate of 90% on the modified MacNab efficacy scale. Only one patient had an unsatisfactory postoperative result due to insufficient extent of decompression caused by less fat removal. Based on our experience, this modified TESSYS technique requires attention in the following three areas:

First of all, the key to obtaining a good therapeutic effect is to go through a precise target puncture. Under visualized spinal endoscopy, the outline of Kambin's triangle in the two-dimensional sagittal plane is first determined by centering on the tip of the superior articular process, extending up to the lateral pars of the vertebral plate, and downwards to the base of the articular process or the superior margin of the pedicle. Then the tongue of the channel is pressed firmly into the ventral bone of the tip of the superior articular process to prevent slippage. Next, the lower part of the intervertebral foramen is enlarged by using a grinding drill to remove a section of the bone ventral to the superior articular process and a small proportion of the bone from the lateral pars of the superior lamina.

Using the technique mentioned above, the enlarged molding of the intervertebral foramen is completed. The Kambin's triangle in the sagittal two-dimensional plane is converted into a Kambin's triangle in the three-dimensional spatial state, making it a true safety triangle. This allows sufficient maneuvering space and intraoperative channel can be placed posterior to the dural sac to reach the midline, anterior to the dural sac to reach the midline, or even contralaterally, thus accomplishing decompression of the spinal canal over a 270° range with a unilateral approach.

The second point is to pay attention to the order of decompression. Based on our experience, the hyperplastic bony articular process is initially abraded, and then soft tissues such as epidural fat are removed. The obscuring ligamentum flavum is resected followed by perineural decompression, after which the herniated disc is removed as required depending on the patient's condition. Decompression of the lateral saphenous fossa is routinely performed in our experience. The lateral saphenous fossa is typically utilized as the final step in the procedure due to the presence of intervertebral veins in the area that may be prone to bleeding.

The third point is to pay attention to the choice of access for patients with L5–S1 segments. The preoperative pelvic radiographs are carefully assessed, focusing on the height and inclination of the iliac spine in relation to the L5 transverse process. If the patient's bilateral iliac spine is positioned lower and is gently relative to the L5 transverse process, or if the iliac spine is slightly elevated but gentle, an endoscopic foraminal approach may be the surgical option for these patients.

Sometimes, for improved surgical maneuvering, a lateral position with the symptomatic side on top and a sponge cushion underneath can be used as needed, which helps to stretch and expand the L5–S1 intervertebral foramina. Distinguishing this group of patients from those with clinical symptoms caused by far-out syndrome [23] and lumbosacral transitional vertebrae (i.e., Bertolotti's Syndrome) is also important [24].

Overall, many scholars have proposed various modified TESSYS procedures based on their own experiences. We believe that these modified TESSYS methods can be applied at different stages of clinical surgery. To state with certainty that the surgery is accomplished using exactly one of these TESSYS modalities is difficult. In our group of cases, we accomplished epidural fat removal and nerve root decompression endoscopically through foraminoplasty by the complete surgical procedure described previously. This further extends the application of microscopic foraminal access. Based on our knowledge, we believe that for an experienced minimally invasive spine surgeon to accomplish bilateral decompression through a unilateral intervertebral foraminal approach with the available unilateral total endoscopic technology is possible.

6. Limitations

The limitations of this study are the relatively small number of cases and the short follow-up period. Further studies with more cases and long-term follow-up are hence needed. Second, all cases were symptomatic of the single-segment unilateral lower extremity, and a possible case selection bias was present. However, this is the first time that we have performed surgical treatment of SLE using an all-endoscopic approach through foraminoplasty. Our surgical approach and experience could serve as a reference for other surgeons treating similar patients.

7. Conclusion

We have successfully applied the modified TESSYS technique to accomplish minimally invasive treatment of SLE with full endoscopy, which has the advantages of less trauma, few complications, no effect on spinal stability, and rapid postoperative recovery. The key points of this technique are the expanded molding of the three-dimensional Kambin's triangle and the decompression of the contralateral saphenous fossa.

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