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SURGICAL OUTCOME OF FULL-ENDOSCOPIC INTERLAMINAR BILATERAL DECOMPRESSION WITH UNILATERAL APPROACH FOR LUMBAR SPINAL STENOSIS: A CLINICAL STUDY OF 24 PATIENTS

İlyas Dolaş[1], Tuğrul Cem Ünal[1], Ali Güven Yörükoğlu[2], Duygu Dölen[1], Onur Öztürk[3], Cafer İkbal Gülsever[1], Duran Şahin[1], Pulat Akın Sabancı[1], Aydın Aydoseli[1], Yavuz Aras[1], Altay Sencer[1]

[1]*İstanbul University, İstanbul Faculty of Medicine, Department of Neurosurgery, İstanbul, Turkey*

[2]*Florence Nightingale Hospital, İstanbul Scoliosis and Spine Center, Department of Neurosurgery, İstanbul, Turkey*

[3]*Acıbadem Taksim Hospital, Clinic of Neurosurgery, İstanbul, Turkey*

ABSTRACT

Objective: This study aimed to evaluate the surgical outcomes of 24 patients with lumbar spinal stenosis (LSS) treated by full-endoscopic interlaminar bilateral decompression using a unilateral approach.

Materials and Methods: Twenty-four patients (seven males and 17 females) treated for LSS by the senior author and followed up for 18 months were included in the study. The pre-operative and postoperative clinical statuses were assessed using a neurological examination, a visual analog scale (VAS) score, and the Oswestry disability index (ODI). Preoperative lumbar magnetic resonance imaging, computed tomography (CT), and postoperative lumbar CT were performed.

Results: Eight patients had isolated lateral recess stenosis, six had central lumbar stenosis, and 10 had both. A total of 31 spinal levels were treated using full endoscopic percutaneous interlaminar decompression. In patients undergoing a single-level procedure, the pre-operative mean VAS score was 9 and the postoperative mean VAS score was 2.5. The mean ODI was 43.5 before surgery and decreased to 11 after surgery. In patients with multi-level intervention, the mean VAS score was 8.5 and the mean ODI was 40 before surgery. Postoperatively, both decreased to 3.5 and 14.5, respectively. All pre- and postoperative values were significantly different.

Conclusion: Full-endoscopic interlaminar bilateral decompression using a unilateral approach provided adequate decompression in selected patients. It also prevents unnecessary surgical trauma and tissue damage and enables better preservation of spine stability, even in patients operated on at multiple spinal levels.

Keywords: Spinal stenosis, endoscopic decompression, interlaminar approach

INTRODUCTION

Lumbar spinal stenosis (LSS) is characterized by sensory dysfunction, gait disturbance, and pain, mostly due to degenerative alterations around the spinal canal and compression of the thecal sac and nerve roots[1,2]. The prevalence of degenerative LSS is approximately 25% and the incidence rate increases after age 50[3]. Moreover, LSS is the most common cause of spinal surgery over the age of 65[4]. This intervention aims to relieve the compression of neural structures, which constitutes the actual purpose of the intervention. Although several surgical techniques have been developed, a laminectomy with partial or total facetectomy, usually followed mainly by spinal stabilization and fusion, remains the traditional approach[5-7].

In patients who have not yet developed segment instability, the traditional surgical method may cause instability of the spinal structure. Many surgeons prefer minimally invasive procedures to avoid increasing the risk of significant complications and to decrease the need for spinal stabilization. Different laminotomy techniques have been introduced to prevent destabilizing the level operated[5-10]. Various authors have advocated bilateral microscopic decompression using a unilateral approach as a less invasive technique[11-16]. As endoscopic tools for spinal surgery are becoming more prevalent, different endoscopic methods for spinal decompression have been described to minimize surgical complications[1,17,18].

With technical advances and increased experience, spinal endoscopic procedures have become a promising method for primary interventional treatment. The endoscopic technique

Address for Correspondence: Cafer İkbal Gülsever, İstanbul University, İstanbul Faculty of Medicine, Department of Neurosurgery, İstanbul, Turkey
Phone: +90 542 823 88 45 **E-mail:** cafer.gulsever@gmail.com **Received:** 30.08.2023 **Accepted:** 04.10.2023
ORCID ID: orcid.org/0000-0002-9246-1378

allows the exploration of both sides of the spinal canal through undercutting with minimal skin incision and muscle retraction. Visual control, supported by a high-definition camera and constant irrigation, enables a minimally invasive intervention for sufficient bone and ligament resection. Additionally, the surrounding joint structures can be protected(1,17,18). Therefore, we considered that the endoscopic technique provides favorable short and long-term benefits for decompression in patients with LSS. Our study presents the clinical outcomes of patients with LSS treated with bilateral decompression using a unilateral full-endoscopic interlaminar approach.

MATERIALS AND METHODS

The study was approved by İstanbul University, İstanbul Faculty of Medicine, and the Ethics Committee for Clinical Trials (reference no: 655, date: 15.04.2014). Informed consent was obtained from each patient and their parents. It included 24 patients with LSS subjected to bilateral decompression using the unilateral endoscopic interlaminar approach by a surgeon having experience more than five years of full-endoscopic spinal surgery. The patients were followed up for 18 months. Demographic data were collected, and physical, neurological, and radiological investigations were conducted for all patients. A computed tomography (CT) scan and magnetic resonance imaging (MRI) were used preoperatively to identify the lumbar region pathology. Patients with clinical or radiological instability revealed during their preoperative assessment were excluded from the study. Additionally, all patients were evaluated using the visual analog scale (VAS) and the Oswestry disability index (ODI). After surgery, all patients underwent lumbar CT, and spinal stability was evaluated clinically and radiologically (Figure 1). The physical, neurological, and radiological examination data, VAS score, and ODI obtained postoperatively were noted and compared with the preoperative findings.

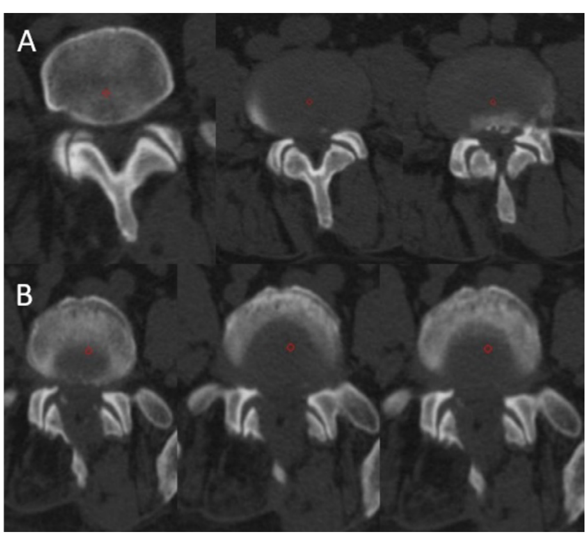

Figure 1. Preoperative **(A)** and postoperative **(B)** CT scans showing bone resection for unilateral access for bilateral recess stenosis

Surgical Procedure

The patient was placed in the prone position using thorax and pelvis support pillows. Endoscopic and optical instruments were set. A C-arm was required for the procedure. All operations were performed using a Vertebris Spine and Endoscopy System produced by Richard Wolf GMHB, Knittlingen, Germany. The intended interlaminar space was determined using the C-arm (Figure 2). The entry point had to be close to the midline to achieve lateral visualization. A deep 8 mm incision was made through the fascia of the paraspinal muscle. The dilator was placed just above the ligamentum flavum, toward the facet joint, using the C-arm (Figure 3). The working sleeve was inserted over the dilator with the beveled edge facing medially. The C-arm was fixed laterally to check the position of the working sleeve in the craniocaudal axis (Figure 4). Then, the dilator was removed, and the endoscope was introduced through the working sleeve. The operation was performed under visual control and continued irrigation with a physiological saline solution. Paravertebral muscles and soft tissues were removed using a rongeur and a bipolar radiofrequency device to expose the ligamentum flavum and the inferior tip of the descending facet (Figure 5). Bone was removed from the medial side of the inferior tip of the descending facet up to the cranial lamina using an oval burr with lateral protection (Figure 6). Then, the ascending facet and its superior tip were exposed. A round burr and an oval burr with lateral protection were used for thinning the ascending facet. Then, the flaval ligament was resected with a punch starting from the midline. The resection of the

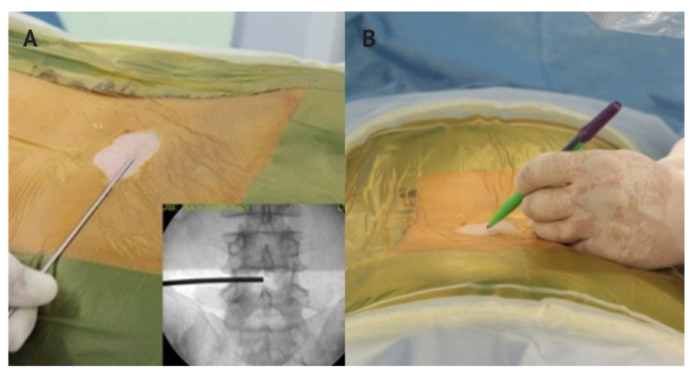

Figure 2. Detection **(A)** and marking **(B)** of the interlaminar space

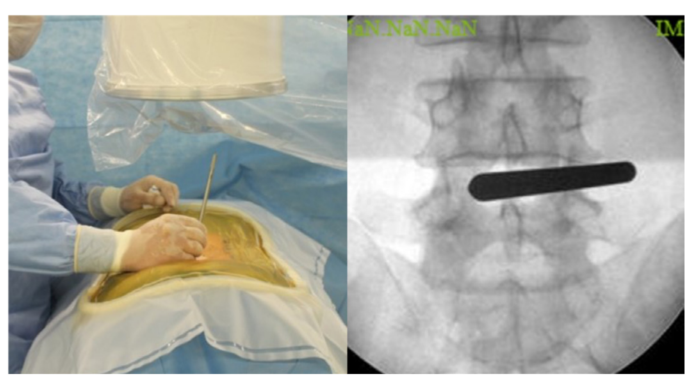

Figure 3. Positioning of the dilator under C-arm guidance

ligamentum flavum was performed in the towards the lateral and caudal directions to access the lateral recess (Figure 7). A Kerrison punch was used to further remove the ascending facet toward the lateral portion. A resection from the tip of the ascending facet to the caudal pedicle and the caudal lamina is recommended. The contralateral facet joint was accessed under the spinous processes. The same procedure for removing bone and ligamentum flavum was performed on the contralateral side. Then, decompression was completed (Figure 8). After hemostasis, the procedure was terminated by removing the endoscopic system. A single suture without any drainage was sufficient for closure.

Statistical Analysis

IBM SPSS Statistics version 28.0 was used for statistical analysis. The normality of the distribution was assessed using kurtosis and skewness tests. Non-parametric tests were conducted because the number of patients was limited. The Mann-Whitney U test was used to analyze the preoperative and postoperative pain scores. A value of $p<0.05$ was considered statistically significant.

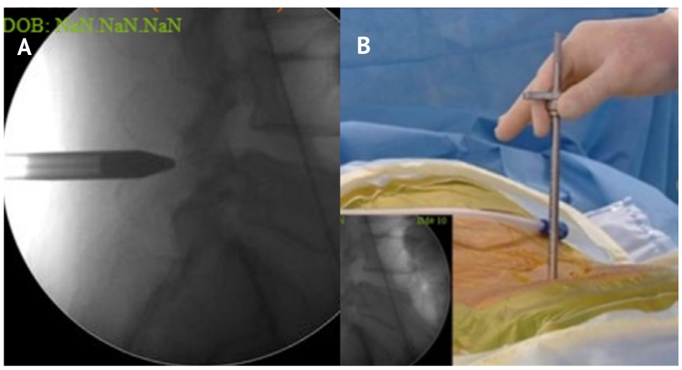

Figure 4. Positioning **(A)** and manipulation **(B)** of the working sleeve

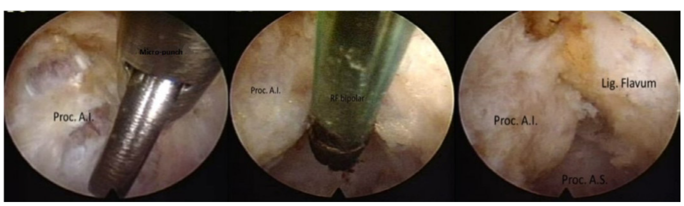

Figure 5. Exposure of the ligamentum flavum and facet joint. (Lig. Flavum: Ligamentum flavum, Proc. A. I.: Inferior articulating process, Proc. A. S.: Superior articulating process)

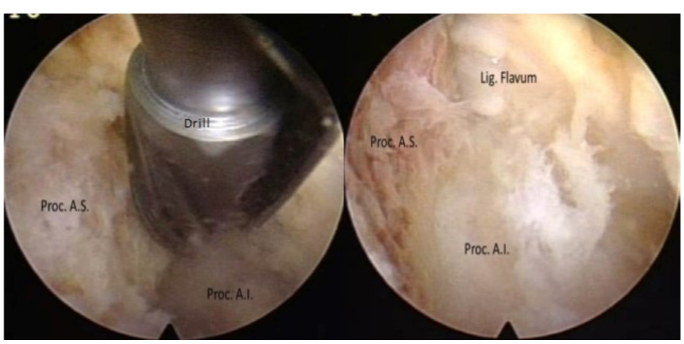

Figure 6. Bone resection. (Lig. Flavum: Ligamentum flavum, Proc. A. I.: Inferior articulating process, Proc. A. S.: Superior articulating process)

RESULTS

Twenty-four patients (seven males and 17 females) underwent surgery for LSS. The mean age of the patients was 61, and the age range was 44-85. At admission, all patients experienced leg pain and gait disturbance. Four patients also described paresthesia in their lower extremities. All patients had neurological claudication, and four presented paresis in distal myotomes of the lower extremities on clinical examination. The femoral nerve stretch test results of two patients were positive. One patient also had spasticity due to a previous cervical spondylosis operation. Lumbar MRI revealed isolated lateral recess stenosis in eight patients, central lumbar stenosis in six patients, and both entities in 10 patients.

A total of 31 spinal levels were targeted using the full-endoscopic percutaneous interlaminar approach. The number of endoscopic decompression procedures was two for the L2-L3 level, 10 for the L3-L4 level, 17 for the L4-L5 level, and two for the L5-S1 level. A decompression on two levels occurred in five patients, and one underwent the procedure on three levels. The average skin-to-skin operation time was 62 min for patients treated at a single level (51-74 min), 96 min for patients undergoing a two-level procedure (83-110 min) and

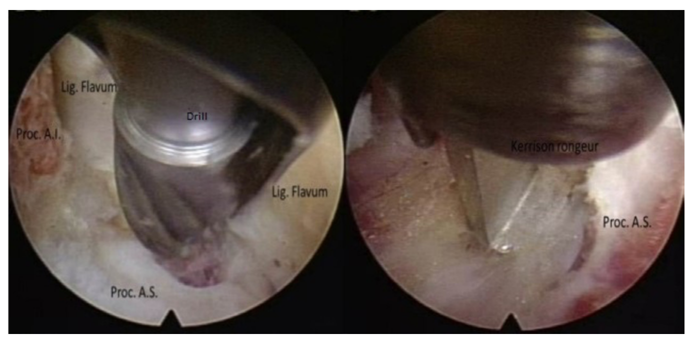

Figure 7. Completion of the ipsilateral bone resection. (Lig. Flavum: Ligamentum flavum, Proc. A. I.: Inferior articulating process, Proc. A. S.: Superior articulating process)

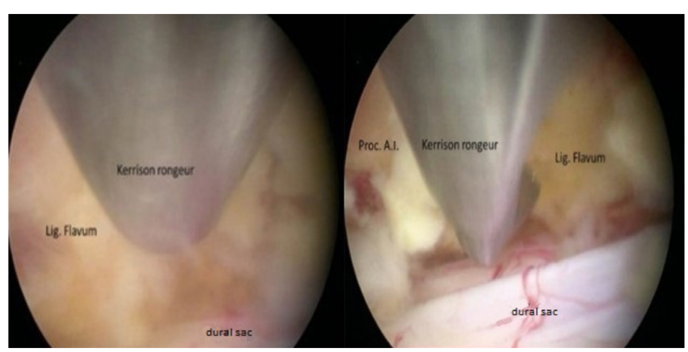

Figure 8. Contralateral bone and ligament resection. (Lig. Flavum: Ligamentum flavum, Proc. A. I.: Inferior articulating process)

163 min for the patient treated at three levels. No complication or neurological deterioration was observed after surgery. In one of the four patients with preoperative paresis, the neurological status improved during the early postoperative period. One patient who underwent a single-level surgery and another subjected to a multi-level intervention reported pain in both legs of the same severity as before surgery. No evidence of spinal instability was detected during the postoperative assessments. The comparison between pre- and postoperative pain scores revealed a significant decrease in pain levels after treatment of patients with endoscopic interlaminar decompression at single or multiple spinal levels. In patients subjected to a single-level intervention, the preoperative mean VAS score was 9, and the postoperative score was 2.5. Their mean ODI was 43.5 and decreased to 11 in the postoperative evaluation. The difference between both scores was statistically significant (p=0.001). Before surgery, the mean VAS score was 8.5, and the mean ODI score was 40 for patients subjected to a multilevel resection. Both scores were significantly decreased to 3.5 and 14.5, respectively (p=0.002), after surgery. At an individual level, the pain scores of two patients who did not report any postoperative improvement remained similar to those before surgery. After clinical and radiological evaluation, we proposed to perform a second operation, but both patients declined an additional intervention.

DISCUSSION

Although the most common surgical treatment for LSS is laminectomy, frequently accompanied by stabilization, less invasive surgical options have become popular recently. Classical decompression surgeries require extensive soft tissue dissection and bone removal. Because excessive bone and facet removal leads to instability, even in cases without preoperative instability, stabilization usually complements classical decompression procedures. This may cause additional morbidity and chronic persistent low back pain in patients with LSS, particularly older ones. Low patient satisfaction has been reported after these surgeries due to persistent or recurrent pain[19-32]. For example, Amundsen et al.[19] evidenced the positive outcomes of the surgical management of lumbar stenosis and mentioned a certain dissatisfaction of some patients during the early postoperative period. Another study found that surgical intervention was more effective than conservative treatment, but the relative benefit faded with time[20]. Iguchi et al.[23] suggested spinal fusion after adequate decompression by laminectomy to avoid long-term deterioration in neurological status. Mayer et al.[32] proposed that paravertebral muscle dissection and retraction cause atrophy in traditional decompression procedures. Electromyographical anomalies and chronic denervation can also be observed after extreme decompressing operations[33]. Young et al.[6] were among the first surgical teams to perform bilateral microscopic laminotomy. They treated 32 patients and aimed to cause as little damage as possible while preserving stability by protecting the spinous process and interspinous and supraspinous ligaments[6]. However, a study by Thomas et al.[26] showed that laminotomy was insufficient to decompress the spinal canal, as spondylolisthesis rates were similar to those of laminectomy. On the other hand, Aryanpur and Ducker[5] observed no complications after laminotomy in their lateral stenosis study. Additionally, a few reports on less invasive procedures indicated that these procedures also caused instability despite the minimal tissue damage and bone removal[34,35]. However, most studies on bilateral laminectomy and unilateral or bilateral decompression have not described any instability[16,36-41].

Weiner et al.[16] suggested bilateral microdecompression using a unilateral route to successfully treat lower back pain by causing minimal tissue damage. Orpen et al.[42] published a similar study in 2010. Four patients developed symptomatic instabilities in their two-year follow-up of 100 patients with "grade 1" spondylolisthesis and no instability symptoms. Thomé et al.[35] compared bilateral decompression using bilateral laminotomy, unilateral laminotomy, and laminectomy in patients without disc herniation and instability symptoms. Although all three methods effectively treated symptoms and resulted in greater distances walked by patients, the bilateral laminotomy seemed superior to the other methods. Instability symptoms were reported in three out of 40 patients treated with laminectomy and two out of 40 patients treated with unilateral laminotomy and bilateral decompression[35].

In 2005, Ikuta et al.[18] compared microendoscopic and traditional microscopic laminectomy methods. Short-term analysis showed that the microendoscopic approach was better at treating lower back pain and restoring functionality. Additionally, the microendoscopic method prevented blood loss and the excessive administration of painkillers. Ikuta et al.[18] reported a longer operation time for the microendoscopic method than that of the traditional method; however, they attributed this difference to the novelty and lack of mastery of the approach. Wada used a single tubular retractor to perform bilateral decompression. Although they stated that this method achieved adequate decompression, working through a narrow tube is disadvantageous. Moreover, in his study, they reported only one surgical field hematoma as a complication[43].

Here, we treated all patients using a full-endoscopic percutaneous interlaminar approach. This method was first described by Ruetten in 2006 and modified for spinal stenosis in 2009. The comparison of full-endoscopic and microscopic decompression methods in 161 patients with unilateral single-level lateral recess stenosis revealed that the full-endoscopic approach resulted in an increased walking distance and less pain. Moreover, the full-endoscopic approach allowed better surgical field vision, shorter operation time, and faster rehabilitation. Because of minimal tissue damage, there was less scar tissue and a lower need for blood transfusion. The only reported disadvantage of the full-endoscopic method is the long and arduous learning process[1]. In a study by Komp et al.[17], 74 patients, including those with radicular pain and single-level stenosis, underwent unilateral full-endoscopic surgery. The authors reported an average operation time of 44 min (35-61 min) and no significant blood loss. They listed transient dysesthesia, transient urinary retention, dural injury, and motor deficit as possible complications. They also observed an increased kyphotic angle at the operated level in three patients (4.2%) and decreased intervertebral disc space height in eight patients (11.1%). Additionally, grade 1 spondylolisthesis progressed to grade 2 in one patient. No additional instability findings were reported[17]. Siepe et al.[44] used the endoscopic interlaminar over-the-top technique for bilateral decompression of both nerve roots.

McGrath et al.[45] compared the outcomes of minimally invasive and endoscopic unilateral laminotomies for bilateral decompression. They showed that the operation time was significantly longer for the endoscopic group, but the hospital stay was shorter. At the first-year follow-up, the VAS scores for leg pain and back pain disability index scores were significantly lower in the endoscopic group. The endoscopic technique was the first to introduce a tubular retractor and replace the trocar with an endoscope[45]. A similar study by Chen et al.[46] compared full-endoscopic and microscopic unilateral laminotomies for bilateral decompression of LSS at the L4-L5 level. A 9-mm endoscope with a 5.7-mm working channel was used (Vertebris stenosis, RIWOSpine, GmbH, Knittlingen, Germany). There were no significant differences in postoperative disc height, translational motion, or facet preservation rate. No findings of instability were reported for both groups. The use of analgesics, blood loss, and hospitalization time were significantly lower in the endoscopic group. Furthermore, the endoscopic group had a lower VAS score for back pain, whereas there was no significant difference in leg pain and ODI[46]. A study by Lee et al.[47] on 213 patients (232 lumbar levels) subjected to decompression for treating spinal canal and lateral recess stenoses reported significantly lower VAS scores for leg and back pain and mean ODIs. Kim et al.[48] included 48 patients in their study, showing that full-endoscopic bilateral decompression for LSS decreased the VAS score and ODI. Macnab outcome grade was good to excellent in 96% of patients. Kim et al.[48] used an iLESSYS Delta Endoscopic System (Joimax GmbH, Karlsruhe, Germany). This system has a working cannula with a 13.7-mm outer diameter and a 10.2-mm inner diameter. The endoscope has a 10-mm outer diameter and a 6-mm working channel. Dural tear occurred in 3 patients (6.25%), and 2 patients (4.17%) required a transforaminal interbody fusion procedure. There were no findings of instability during the follow-up period[48]. In another study, 450 patients with single- and multiple-level lumbar stenosis were operated on using a full-endoscopic approach with a single-entry point. No evidence of instability was found in the postoperative dynamic imaging modalities[49]. However, most of the aforementioned studies involved patients with single-level pathologies. In our study, all patients had neurological claudication, and none presented spinal instability, even those subjected to a multilevel resection. Postoperative decreases in the ODI and VAS scores were statistically significant. There was a poor outcome for two patients, one undergoing a two-level intervention and one undergoing a single-level resection. One of these patients had previously undergone surgery after a diagnosis of acromegaly. Postoperative evaluation of both patients suggested insufficient decompression, and the patients were offered a second intervention that they declined.

In the present study, four patients had neurological deficits before surgery. The neurological deficit improved in one of these patients, whereas the condition of the other three patients remained unchanged during the early postoperative period. No additional neurological deficits or complications were encountered. Contrary to many other studies[19-31,35], no spinal instability was detected in patients after a one-year follow-up. The mean operation time was 62 min in cases of single-level intervention, which was longer than that reported by Komp et al.[17]. Because of constant irrigation, the actual bleeding could not be quantified, but the hemoglobin levels of patients were not significantly decreased.

Study Limitations

The retrospective nature of the study, limited patient population, and inability to compare microscopic spinal decompression and endoscopic technique of the same surgeon were some of the study's limitations.

CONCLUSION

Endoscopic procedures are increasingly used for spinal surgery, and the application areas of endoscopy are also expanding. Endoscopic treatment of LSS is relatively new, but its advantages are increasingly reported. Persistent pain and instability are severe problems occurring after decompression surgeries, and endoscopic approaches might allow for avoiding the complications encountered after traditional interventions. Lesser tissue damage and lower blood loss seem to be definite advantages of endoscopic surgeries, and operation time shortens as experience increases. Moreover, the endoscopic approach enables better preservation of the spine's stability, even in patients operated on at multiple spinal levels.

Ethics

Ethics Committee Approval: The study was approved by İstanbul University, İstanbul Faculty of Medicine, and the Ethics Committee for Clinical Trials (reference no: 655, date: 15.04.2014).

Informed Consent: Informed consent was obtained from each patient and their parents.

Peer-review: Internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: İ.D., A.G.Y., A.S., Concept: İ.D., T.C.Ü., A.G.Y., P.A.S., A.A., Y.A., A.S., Design: İ.D., T.C.Ü., A.G.Y., P.A.S., A.A., Y.A., A.S., Data Collection or Processing: İ.D., A.G.Y., Analysis or Interpretation: İ.D., T.C.Ü., A.G.Y., D.D., O.Ö., P.A.S., A.A., Y.A., A.S., Literature Search: İ.D., A.G.Y., D.D., O.Ö., C.İ.G., D.Ş., Writing: İ.D., C.İ.G., D.Ş.

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