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Biportal endoscopic lumbar discectomy surgery in patients with cauda equina syndrome caused by lumbar herniated intervertebral disc: a retrospective multi-center cohort study

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Abstract

Background Cauda equina syndrome (CES) is a severe neurological condition caused by significant compression of the cauda equina nerve roots. This study evaluates the efficacy of biportal endoscopic (BE) lumbar discectomy in treating CES caused by lumbar herniated intervertebral discs.

Methods This retrospective case series includes 32 CES patients treated with BE lumbar discectomy from March 2017 to July 2022. Patient demographics, surgical details, and outcomes were analyzed. Clinical outcomes were assessed using the Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and EQ-5D scores at baseline, and at 3, 6, and 12 months postoperatively.

Results The mean age was 44.44 ± 13.70 years. The average duration from symptom onset to surgery was 44.81 ± 32.69 h. Significant improvements at 12 months were observed in VAS for back pain (5.00 ± 2.82 to 1.28 ± 1.63, $p < 0.01$) and leg pain (7.44 ± 1.79 to 1.16 ± 1.55, $p < 0.01$), ODI (58.25 ± 20.15 to 10.13 ± 14.54, $p < 0.01$), and EQ-5D (0.414 ± 0.175 to 0.859 ± 0.163, $p < 0.01$). Bladder and bowel symptom recovery rates were 86.7% and 85.0%, respectively. Mean operation time was 42.50 ± 17.91 min, with a hospital stay of 3.34 ± 2.59 days. Complications included incidental durotomy (6.3%) and facet joint injury (6.3%).

Conclusion Biportal endoscopic spine surgery is a feasible and effective option for CES, providing significant decompression with minimal tissue damage and a low complication rate.

Keywords Biportal endoscopic spinal surgery, Cauda Equina syndrome, Discectomy, Lumbar herniated disc, Minimally invasive spine surgery

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Background

Cauda equina syndrome (CES) is a complex neurological condition characterized by a combination of symptoms, including lower back pain, radiating leg pain, weakness in the lower limbs, sensory loss in the perineum and anus, loss of function in internal organs, and disturbances in urinary and bowel function [1, 2]. It results from severe compression of the cauda equina nerve roots within the lumbar spine. CES is considered a relatively rare condition, with reported incidence rates ranging from 0.3 to 7.0 per 100,000 population [3–5], and it accounts for approximately 2% of lumbar herniated intervertebral disc cases. Despite its rarity, CES can lead to serious complications such as lower limb paralysis, neurogenic bladder, and sexual dysfunction [6, 7]. Emergency decompression surgery may be necessary if CES due to lumbar disc herniation occurs, as delayed treatment can result in permanent disability [8, 9]. Traditionally, laminectomy for CES has been performed using open surgery, with minimally invasive surgery being relatively contraindicated due to concerns about incomplete decompression and iatrogenic damage to the neural elements. However, lumbar wide decompression and discectomy using uniportal endoscopy has recently been developed and has been reported to be used in CES [10]. Nevertheless, uniportal endoscopic surgery is performed through a narrow working channel, making it difficult to control bleeding and increasing the risk of nerve damage.

However, minimally invasive spine surgery using the biportal endoscopic (BE) technique has emerged as a promising alternative. This technique allows for more precise decompression and discectomy procedures while minimizing damage to surrounding tissues and reducing postoperative pain [11–17]. The main difference between the BE technique and the uniportal endoscopic technique is the independent existence of the camera and instrument portals. This configuration allows for a wider surgical field of view and greater freedom of instrument movement. Based on these advantages, several randomized controlled studies have shown that the clinical outcomes of the BE technique are not inferior to those achieved with microscopy [16–19]. Additionally, revision discectomy and high-grade migrated intervertebral disc herniation, which were previously considered relative contraindications for endoscopic surgery, have shown comparable results to open surgery [19, 20]. In other words, biportal endoscopic spine surgery can have almost the same indications as open spine surgery, making it a viable option for treating cauda equina syndrome.

Despite these advantages, the application of biportal endoscopic spine surgery in CES patients has not been extensively studied. Therefore, this study aims to analyze patients undergoing laminectomy and discectomy using biportal endoscopy in CES and evaluate the surgical outcomes.

Methods

Study design and patient demographics

The design and protocol of this retrospective case series study were approved by the institutional review board at our hospital (B-2309-853-103). Between March 2017 and July 2022, three orthopedic spine surgeons (SMP, HJP, and HJL.) treated patients with cauda equina syndrome (CES) caused by lumbar herniated intervertebral discs at three tertiary educational hospitals, following Fraser's criteria [7].

The inclusion criteria were as follows: cauda equina syndrome, diagnosed according to Fraser criteria, caused by a lumbar herniated intervertebral disc confirmed on magnetic resonance imaging with severe canal compromise and underwent single-level biportal endoscopic lumbar discectomy. The exclusion criteria were as follows: (1) previous lumbar surgery history, (2) traumatic lumbar disc herniation with fracture, (3) severe spondylolisthesis which requires fusion surgery, (4) combined infectious spondylitis, (5) combined tumorous condition, (6) less than 12-month follow-up, and (7) incomplete medical records and clinical evaluation during the follow-up period.

We reviewed the medical records of 46 patients diagnosed with CES. Of these, 14 patients were excluded: four due to previous lumbar surgery history, one due to combined fracture, two due to severe spondylolisthesis, one due to combined infectious condition, one due to combined tumorous condition, two due to loss of follow-up, and three due to insufficient radiographic and clinical evaluation. Thus, 32 patients were included in our study, and the demographic information is detailed in Table 1.

Upon reviewing the medical records, data on age, sex, body mass index (BMI), past medical history using the Charlson Comorbidity Index (CCI), American Society of Anesthesiologists (ASA) physical status classification, level of operation, presence of bladder and/or bowel symptoms, saddle anesthesia, neurological status, and time to surgery were collected. Based on etiopathogenesis and clinical features, Shi et al. [21] divided CES into pre-clinical, early, intermediate, and late stages (Table 2).

Surgical procedures

Biportal endoscopic lumbar discectomy, a technique well-described in previous studies [17, 19, 22], shares similar surgical procedures with microscopic discectomy but distinguishes itself by utilizing two portals. The key aspect of this technique is the establishment of a viewing portal for the endoscopic camera and a working portal for the surgical instruments, facilitating an effective workspace. The procedure was carried out under general

Table 1 Demographic and clinical Patient Data

Characteristic	Data
No. of patients	32
Male / Female (No.)	20/12
Mean Age, year (range)	44.4 (23–76)
Body mass index (range)	26.7 (20.1–38.0)
CCI score	1.75 (0–5)
ASA score	1.59 (1–2)
Shi classification (No., %)	
Early	1 (3%)
Intermediate	27 (84%)
Late	4 (13%)
Bladder symptom (No., %)	30 (94%)
Bowel symptom (No., %)	20 (63%)
Saddle anesthesia (No., %)	32 (100%)
Lower extremities weakness (No., %)	23 (72%)
Time interval between symptom to surgery (hours, range)	44.8 (12–164)
Location (No. of levels)	
L2-3	1
L3-4	2
L4-5	8
L5-S1	21
Dominant side (No., %)	
Left	14 (44%)
Central	7 (22%)
Right	11 (34%)

CCI, Charlson Comorbidity Index; ASA, American Society of Anesthesiologists

or spinal anesthesia with the patient in a prone position on a radiolucent operating table, with the spine maintained in slight flexion using a Wilson frame.

The selection of the approach side was based on the dominance of disc extrusion. If the extrusion was equally dominant on both sides, the left side was chosen, due to the surgeon's preference. The incision was made approximately 1 cm lateral to the spinous process. For right-handed surgeons, the viewing portal was placed 1 cm to the left of the working portal, requiring a 7 mm incision. After the two portals were created, a narrow Cobb elevator was used through the working portal to detach the paraspinal muscles from the spinous process and lamina, establishing a working space.

A 4 mm, 30° arthroscope was introduced through the viewing portal with saline irrigation maintained at a pressure of 30–40 mmHg. The surgery was performed via the working portal using standard spinal instruments like a burr, Kerrison punches, and pituitary rongeurs, excluding the use of bipolar radiofrequency electrocautery. After preparing the working space, the discectomy was conducted in a manner similar to a microscopic discectomy.

Partial hemilaminectomy was executed using a burr and the Kerrison punches until the upper edge of the deep portion of the ligamentum flavum (LF) was exposed. The LF was meticulously dissected and either partially or entirely removed depending on the severity of stenosis; completely removed in moderate to severe cases and partially in mild cases. Care was taken to avoid any unintentional retraction of the nerve root. Following LF removal, the disc fragments compressing the nerves were visible in all cases. For cases that contained large, herniated discs, an incision was made on the annulus, and a discectomy was performed using pituitary forceps and curettes to remove the disc fragments. Larger fragments were carefully extracted under endoscopic vision without vigorous movements.

The procedure concluded after confirming decompression and ensuring the nerve root moved freely with a ball-tip probe. Utilizing a 30° arthroscope provided a broader view of the surgical field and direct visualization of the disc fragments. Pulsating nerve roots were observed after disc removal. A Hemovac drain was placed in all patients through the working portal to prevent hematoma formation (Figs. 1 and 2).

Outcome assessment

Patient-reported outcome measures (PROMs) were evaluated at four time points: pre-operative (baseline), and at 3, 6, and 12 months post-surgery. Clinical assessments included the visual analog scale (VAS) for low back pain and radiating pain in the lower extremities, the Oswestry Disability Index (ODI), and the European Quality of Life-5 Dimensions (EQ-5D) score. The VAS pain score ranges from 0 (no pain) to 10 (severe pain). The ODI provides a subjective percentage score reflecting the level of disability in daily activities for those recovering from low back pain [23]. The EQ-5D score, which assesses quality of life (QOL), is converted to a value ranging from – 0.066 to 1.000, with 1 indicating the best QOL [24]. Recovery of bladder and bowel function, saddle anesthesia, and lower extremity neurological function were also assessed. The degree of bladder and bowel function recovery was classified according to previous studies (Table 3) [10]. To

Table 2 Shi's classification of cauda equina syndrome

Stage	The main clinical manifestations
Preclinical	Low back pain with only bulbocavernosus reflex and ischiocavernosus reflex abnormalities
Early	Saddle sensory disturbance and bilateral sciatica
Intermediate	Saddle sensory disturbance, bowel or bladder dysfunction, motor weakness of the lower extremity, and reduced sexual function
Late	Absence of saddle sensation and sexual function in addition to uncontrolled bowel function

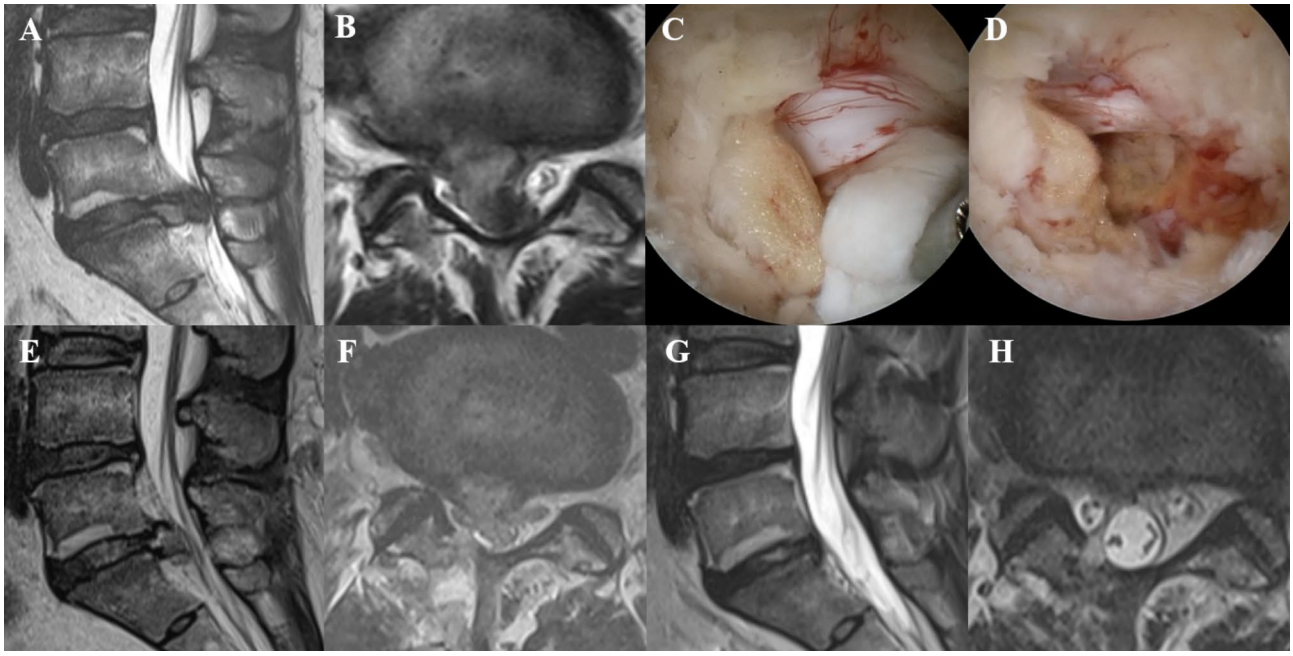

Fig. 1 Biportal endoscopic discectomy in a 34-year-old woman (Case 11). (**a**, **b**) Severely herniated intervertebral disc at L5-S1 was showed in MRI. (**c**, **d**) Intraoperative endoscopic images showed partial ligamentum flavectomy and disc resection using pituitary rongeur. (**e**, **f**) Postoperative MRI showed removed herniated disc with minimally damaged paraspinal muscle. (**g**, **h**) Postoperative 1 year MRI showed minimally damaged paraspinal muscle and ligamentum flavum without recurrence

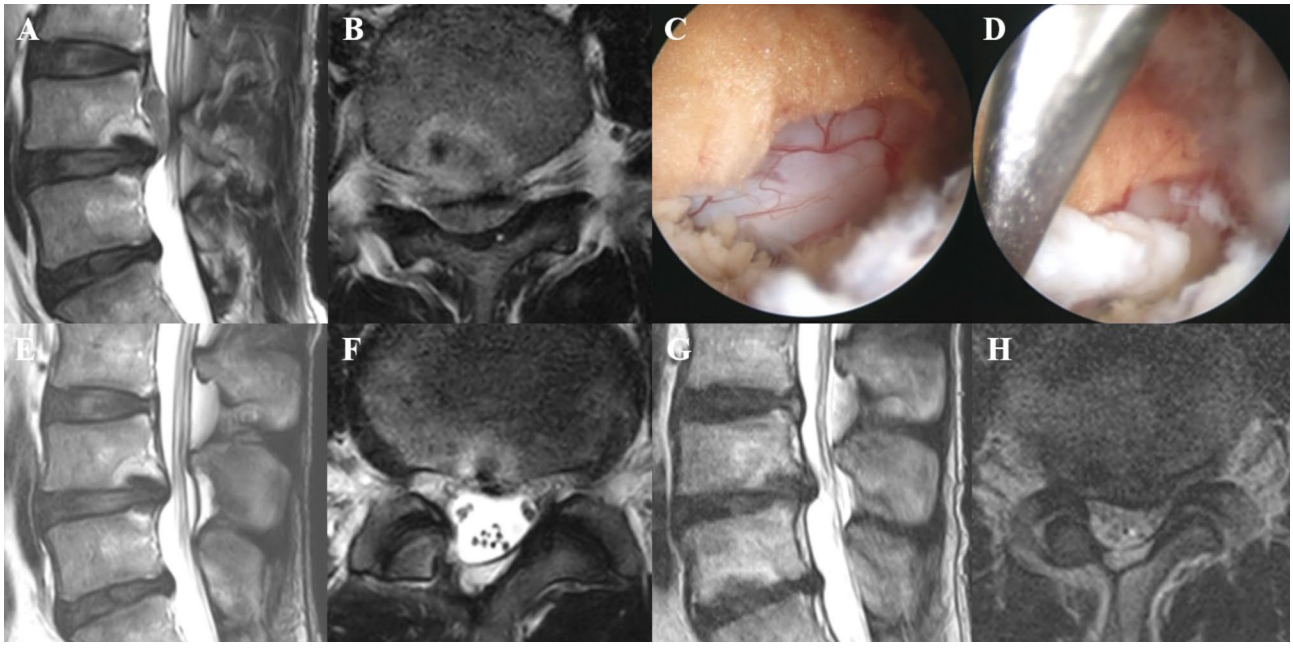

Fig. 2 Biportal endoscopic discectomy in a 34-year-old man (Case 13). (**a**, **b**) Severely herniated intervertebral disc at L4-5 with highly migration to superiorly was showed in MRI. (**c**, **d**) Intraoperative endoscopic images showed partial ligamentum flavectomy and disc resection usisng pituitary rongeur. (**e**, **f**) Postoperative MRI showed fully removed herniated disc with minimally damaged paraspinal muscle. (**g**, **h**) Postoperative 3-year MRI showed minimally damaged paraspinal muscle and ligamentum flavum with partial disc recurrence at L4-5

Table 3 Bladder and bowel recovery score

Recovery score	The main clinical manifestations
No	Requires use of a diaper, Indwelling catheter or Intermittent catheter 4 hourly
Poor	No diaper needed, Needs manual evacuation, Intermittent catheter 8 hourly
Fair	Occasional manual evacuation, Intermittent catheter 12 hourly
Full	Full recovery of bladder and bowel

evaluate clinical outcomes during follow-up, we analyzed serial changes in VAS pain scores for the lower back and lower extremities, ODI scores, and EQ-5D values from preoperative to postoperative periods up to the final follow-up.

Surgery-related outcomes such as total postoperative drainage (mL), operation duration (minutes), postoperative hospital stay (days), and intra- and postoperative complications were analyzed. Total postoperative drainage was measured as the amount collected in the Hemovac drain system until the second postoperative day. Operation duration was recorded from the time of skin incision to skin closure, as noted in the anesthesia record. MRI or computed tomography (CT) scans were performed on all participants immediately after surgery. If disc recurrence was suspected due to worsening pain during the follow-up period, the MRI was repeated. Facet joint injury was defined as damage involving more than one-third of the facet joint. Recurrence of herniated disc was defined as a case in which lumbosacral radicular pain recurred after a pain-free period for more than 6 months after surgery, and a re-herniation in the same direction as in the past was observed on MRI [20].

Statistical analysis

All variables were summarized using descriptive statistics. Continuous variables are expressed as means and standard deviations, while categorical variables are summarized as frequencies and percentages. Repeated measures analysis of variance (RMANOVA) was conducted to evaluate changes in clinical outcomes over time. This method was chosen to account for the correlations between repeated measurements within the same subjects. Prior to conducting RMANOVA, the assumptions of normality and sphericity were checked. The Normality of the data was assessed using the Shapiro-Wilk test, and Mauchly's test was used to assess the assumption of sphericity. In cases where the assumption of sphericity was violated, the Greenhouse-Geisser correction was applied to adjust the degrees of freedom for the F-tests. The RMANOVA model included one within-subject factor (time with four levels: pre-operative, 3, 6, and 12 months after surgery). Post hoc analyses were conducted using Bonferroni corrections to account for multiple comparisons, ensuring the control of Type I error rates. Stata/MP 17.1 (StataCorp LLC, College Station, Texas, USA) was used for all analyses. All statistical tests were two-tailed, and results were considered statistically significant if $p < 0.05$.

Results

Demographic data

Between March 2017 and July 2022, we retrospectively reviewed 46 patients who were diagnosed with cauda equina syndrome. Of these patients, 14 patients were excluded, and 32 patients were included in our study. Thirty-two patients with a mean age of 44.44 ± 13.70 years (range 23–76 years). The duration of symptoms to surgery ranged from 12 to 164 h, with an average of 44.81 ± 32.69 h. The distribution of patients according to the Cauda Equina Syndrome Classification (Shi Classification) was as follows: Early (3.1%), intermediate (84.4%), and late (12.5%). Detailed information on each patient is described in Table 4.

Clinical outcomes

At the final follow-up, bladder symptoms were present in 93.8% of patients, with a recovery rate of 86.7%. Bowel symptoms were reported by 62.5% of patients, with a recovery rate of 85.0%. Lower extremities weakness was reported by 72% of patients, with fully recovered in 50.0% of patients, partially recovered in 21.9%, and no recovery in 28.1%. The recovery scores indicated that 3.1% of patients required ongoing assistance (no recovery), 12.5% had poor recovery, 9.4% had fair recovery, and 75.0% achieved full recovery. Notably, there was a case of no recovery in a patient who underwent surgery 48 h after symptom onset. Among the 13 patients who had surgery later than 48 h after symptom onset, 9 fully recovered, 3 had poor outcomes, and 1 did not recover.

The mean VAS for lower back pain (VAS-LBP) score significantly improved from pre-operation to 12 months after operation. The VAS-LBP scores decreased from a mean of 5.00 ± 2.82 preoperatively to 1.28 ± 1.63 at 12 months postoperatively ($p < 0.01$). The greatest reduction was observed within the first 3 months, with a mean score of 1.69 ± 2.05. Similarly, the VAS scores for leg pain (VAS-LE) showed a significant reduction from pre-surgery to 12 months post-surgery. The mean scores dropped from 7.44 ± 1.79 preoperatively to 1.16 ± 1.55 at 12 months postoperatively ($p < 0.01$). The most substantial improvement was noted within the first 3 months, where the mean score decreased to 1.66 ± 1.36. The ODI scores also demonstrated significant improvements over

Table 4 Details of 32 patients with biportal endoscopic discectomy

Case	Sex/Age	Level	Side	STS (hr)	BMI	Shi	ReS	Bladder Recovery	Bowel Recovery	SA Recover	NE recovery	Complication
1	F/45	L4-5	Left	48	25.7	I	Full	Yes	N/A	Complete	Complete	
2	F/29	L4-5	Left	30	24.5	I	Full	Yes	N/A	Partial	Complete	Facet injury / Recurrence & Revision PLIF
3	M/52	L5-S1	Left	50	28.0	I	Full	Yes	N/A	Complete	Complete	
4	M/66	L4-5	Right	26	23.0	I	Full	Yes	N/A	Complete	Complete	
5	F/50	L4-5	Central	45	20.3	I	Full	Yes	N/A	Complete	Complete	
6	M/54	L4-5	Right	48	24.3	I	Full	Yes	N/A	Partial	Complete	Incidental durotomy
7	M/23	L4-5	Left	26	37.0	I	Full	Yes	Yes	Partial	Partial	
8	F/29	L5-S1	Right	17	22.1	I	Full	Yes	N/A	Complete	Complete	
9	M/28	L4-5	Left	33	24.7	I	Fair	Yes	Yes	Complete	Partial	
10	M/41	L5-S1	Central	30	30.6	L	Full	Yes	Yes	Partial	N/A	Incidental durotomy / Asymptomatic hematoma
11	F/34	L5-S1	Right	30	34.4	I	Full	Yes	Yes	Partial	N/A	
12	F/59	L4-5	Central	50	24.6	I	Full	Yes	Yes	Complete	Complete	Facet injury
13	M/34	L4-5	Right	30	22.6	L	Fair	Yes	Yes	Partial	Partial	Recurrence / No revision surgery
14	F/34	L4-5	Right	60	20.1	I	Full	Yes	Yes	Partial	Complete	
15	M/37	L4-5	Central	24	23.2	I	Full	Yes	Yes	Complete	Complete	
16	F/37	L5-S1	Left	50	25.1	I	Full	Yes	Yes	Partial	Complete	
17	M/37	L3-4	Left	48	25.8	I	No	No	No	Partial	Partial	
18	F/51	L4-5	Central	15	23.8	I	Full	Yes	Yes	Partial	Partial	Asymptomatic hematoma
19	M/44	L4-5	Left	100	24.7	I	Full	Yes	N/A	Partial	N/A	Recurrence / No revision surgery
20	F/48	L4-5	Right	60	27.9	I	Poor	No	Yes	Partial	Complete	Asymptomatic hematoma
21	M/31	L3-4	Right	24	37.6	L	Poor	No	No	No	Complete	Recurrence / Revision discectomy
22	F/34	L4-5	Left	40	27.4	L	Full	Yes	Yes	Partial	Complete	
23	M/73	L4-5	Right	48	25.6	I	Poor	No	Yes	Partial	Partial	Recurrence / Revision discectomy
24	M/47	L4-5	Left	40	29.4	I	Full	Yes	Yes	Partial	N/A	Asymptomatic hematoma
25	M/39	L5-S1	Left	30	25.5	I	Full	Yes	Yes	Partial	N/A	Recurrence / No revision surgery
26	M/38	L5-S1	Central	30	31.3	I	Full	Yes	Yes	Partial	Complete	
27	M/31	L4-5	Left	12	31.6	I	Full	Yes	Yes	Complete	N/A	
28	M/69	L4-5	Left	24	23.1	E	Full	N/A	N/A	Complete	Partial	
29	M/76	L4-5	Left	136	28.7	I	Full	Yes	Yes	Complete	N/A	Asymptomatic hematoma
30	M/58	L4-5	Right	164	28.3	I	Full	Yes	Yes	Partial	N/A	
31	M/51	L2-3	Central	18	28.4	I	Fair	Yes	N/A	Partial	Complete	
32	F/43	L5-S1	Right	48	24.2	I	Poor	N/A	No	Partial	N/A	Asymptomatic hematoma

STS (hr) symptom to surgery time (hour), Shi Shi classification, ReS recovery score, BMI body mass index, SA saddle anesthesia, NE neurologic weakness, E early, I intermediate, L late, N/A not available

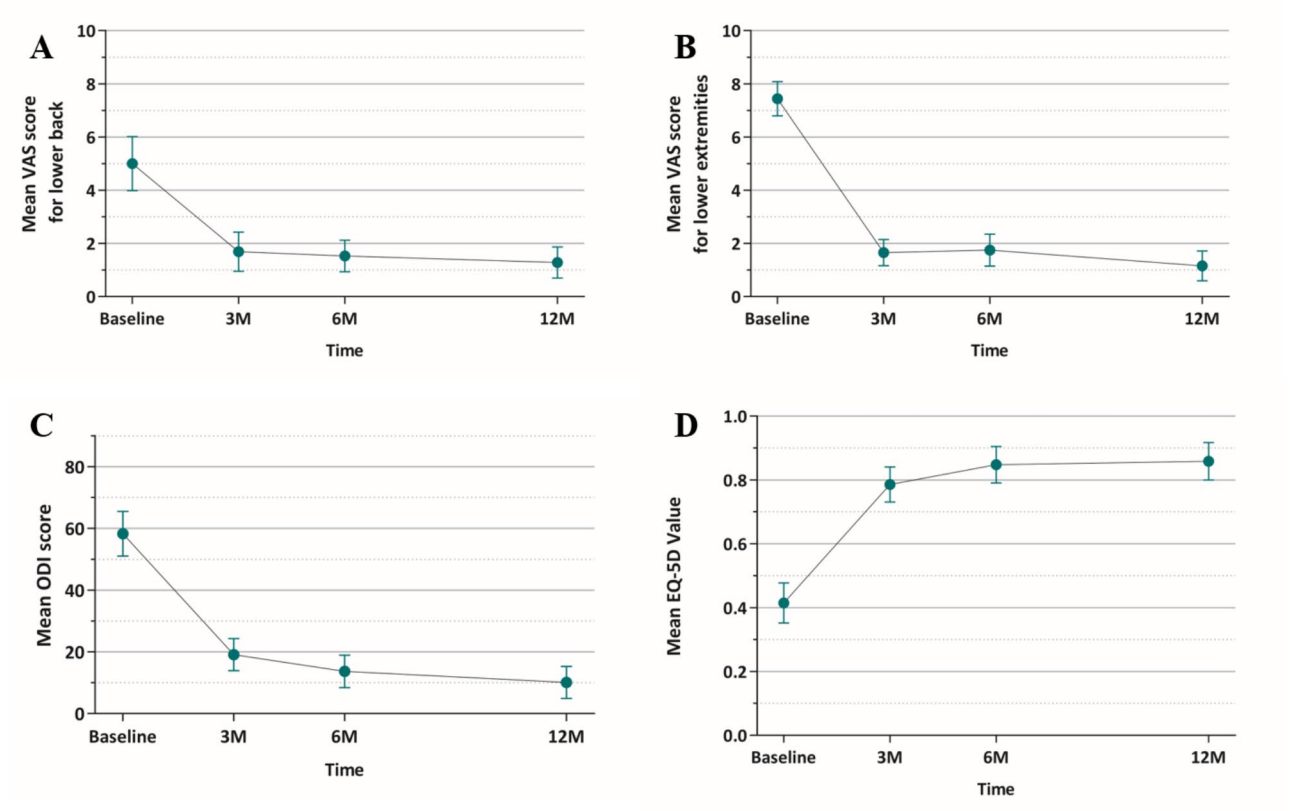

Fig. 3 (**a**) Changes in mean VAS score for low back pain, ranging from 0 (no pain) to 10 (worst pain). (**b**) Changes in mean VAS score for lower extremity. (**c**) Changes in mean ODI score, ranging from 0 (no disability) to 100 (high disability). (**d**) Changes in mean EQ-5D value, ranging from 0 (worst quality of life) to 100 (best quality of life). VAS, visual analog scale; ODI, Oswestry disability index; EQ-5D, European Quality of Life-5 Dimensions

the 12-month period. Preoperatively, the mean ODI score was 58.25 ± 20.15, which reduced to 10.13 ± 14.54 at 12 months post-surgery ($p < 0.01$). Notably, the mean score at 3 months post-surgery was 19.13 ± 14.54, indicating an early and significant improvement in disability. The EQ-5D value improved from a mean of 0.414 ± 0.175 preoperatively to 0.859 ± 0.163 at 12 months postoperatively ($p < 0.01$). The greatest improvement was observed within the first 3 months, with a mean score of 0.786 ± 0.152 (Fig. 3).

Surgery related outcomes

The mean operation time was 42.50 ± 17.91 min, with postoperative drainage averaging 23.72 ± 34.47 ml. The average hospital stay was 3.34 ± 2.59 days. The incidence of complications was as follows: incidental durotomy (6.3%), facet joint injury (6.3%), and asymptomatic (radiographic) hematoma (21.9%). Open repair was performed for the incidental durotomy patients. Although there were 7 cases of radiographic hematoma observed on postoperative MRI, none of these cases resulted in symptom exacerbation. During follow-up, 6 patients experienced herniated disc recurrence, with 1 undergoing revision fusion surgery, 2 undergoing revision discectomy, and 3 receiving conservative treatment.

Discussion

CES is one of the spinal conditions that require emergency surgery, and if it is not treated quickly or if sufficient decompression is not achieved during surgery, permanent neurological sequelae can result. Traditionally, CES is treated with open discectomy, and in some cases, lumbar fusion is recommended [25, 26]. According to a meta-analysis comparing minimally invasive surgery and open surgery at CES, it was reported that minimally invasive decompression showed similar good clinical outcomes compared to open surgery [2]. Meanwhile, Byvaltsev et al. compared microscopic discectomy alone and transforaminal lumbar interbody fusion (TLIF) in acute lumbar disc herniation combined with incomplete CES and reported better clinical outcomes and lower reoperation rate in the TLIF group in the long-term follow-up [27]. As such, there are still several options regarding the most suitable surgical technique for CES. However, microscopic discectomy and TLIF are also a kind of surgical procedures that have concerns regarding paraspinal muscle damages due to retraction during surgery [28, 29].

Recently, the trend of minimally invasive surgery in the spine field has been changing from using a microscope to an endoscopic technique.

Conventional uniportal endoscopic surgery has relative contraindications in some cases. Because the camera and instrument have to work together in one channel, the operation is difficult to familiarize with and is known to have a long learning curve [30, 31]. In addition, the limited field of view makes it difficult to have a large working space. For these reasons, in the case of intervertebral disc herniation with CES, there is a possibility of incomplete decompression or nerve injury during endoscopic discectomy; it is safer to open completely and remove enough lamina to create a space before removing the disc. Therefore, there is an opinion that the endoscopic technique is not appropriate for the treatment of CES. However, recently, the development of endoscopic surgery techniques and instrumentation has overcome this concern. Choi et al. reported that percutaneous endoscopic lumbar discectomy (PELD) showed similar good clinical outcomes compared to open microdiscectomy for large lumbar disc herniation [32]. Also, PELD reported some better results in terms of rapid recovery and improvements in back pain. Additionally, previous studies reported that sufficient decompression was performed on CES through PELD, and a satisfactory outcome was obtained [9, 33]. Although it is difficult to have a high level of evidence due to small sample sizes in these articles, attempts to apply endoscopic spine surgery to CES have been increasing in many recent studies.

BE is an emerging technique that has recently developed into the mainstream of endoscopic spine surgery. Park et al. conducted a randomized controlled trial (RCT) comparing biportal endoscopic discectomy and conventional open surgery [17]. According to the study, biportal endoscopic discectomy showed non-inferiority compared to open microscopic discectomy in postoperative 1-year VAS and ODI, early postoperative VAS for back pain, and showed lower creatinine phosphokinase level. Based on these results, it is considered that BE causes less back muscle damage and allows for early recovery compared to open microscopic discectomy. Some other retrospective studies reported similar clinical outcomes [34–36].

In this study, we performed biportal endoscopic discectomy in CES and achieved good results. Most clinical outcomes were improved, and postoperative MRI showed significant removal of the herniated intervertebral disc and a well-decompressed neural structure. In contrast to traditional microscopic and uniportal endoscopic discectomy, which requires a wide laminectomy before performing a discectomy, biportal endoscopy allows for discectomy without the need for extensive laminectomy. In uniportal endoscopy, the narrow working channel necessitates wide laminectomy to create enough space for discectomy, and in microscopic discectomy, the limited surgical field of view compared to biportal endoscopy demands wider decompression to ensure adequate visualization. Biportal endoscopy, with its independent camera and instrument portals, provides a broader surgical field and greater instrument maneuverability, enabling direct discectomy with minimal tissue disruption. There were minor complications, such as incidental durotomy and facet joint injury, but no neurological damage or other major complications occurred. In a meta-analysis comparing endoscopic discectomy and open microscopic discectomy, percutaneous full-endoscopic discectomy reported a complication rate of 5.5%, and microscopic discectomy reported 10.4% [37]. In the case of BE, a complication rate of about 7.8% was reported in a meta-analysis with a large sample size of 3673 patients, and the details included durotomies of 2.2%, inadequate decompression of 1.2%, and epidural hematoma of 3.7% [38]. We believe that due to the advantages of BE, a low complication rate was achieved at CES as well.

This study has some limitations. First, it is a case series without a control group, which limits the ability to draw definitive conclusions about the efficacy of biportal endoscopic spine surgery compared to other surgical techniques. The absence of a control group makes it challenging to attribute improvements in clinical outcomes solely to the BE technique. Second, the sample size is relatively small, which may affect the generalizability of the findings. However, CES is a rare spinal condition, making it difficult to collect a large number of cases. To address this issue, we collaborated with three institutions to gather sufficient patient data. Despite these efforts, the rarity of CES poses challenges in conducting randomized controlled trials or studies with larger sample sizes. Future research should aim to overcome these limitations by designing well-controlled studies with larger cohorts to provide more robust evidence. Additionally, prospective multicenter studies could help validate the findings and further elucidate the benefits and potential risks of BE technique in the treatment of CES.

Conclusions

Biportal endoscopic spine surgery is a feasible option for treating cauda equina syndrome. It maintains the advantages of existing endoscopic spine surgery while allowing for more flexible handling of surgical instruments through two independent portals. This approach reduces the need for wide laminectomy and enables direct discectomy, potentially decreasing complications associated with traditional methods. Therefore, biportal endoscopy represents a promising advancement in the surgical management of CES, offering effective decompression with minimal tissue damage and a low complication rate.

Abbreviations

ASA	American Society of Anesthesiologists
BE	Biportal endoscopic
BMI	Body mass index
CCI	Comorbidity Index
CES	Cauda equina syndrome
CT	Computed tomography
EQ-5D	European Quality of Life-5 Dimensions
LF	Ligamentum flavum
ODI	Oswestry Disability Index
PELD	Percutaneous endoscopic lumbar discectomy
PROMs	Patient-reported outcome measures
QOL	Quality of life
RCT	Randomized controlled trial
RMANOVA	Repeated measures analysis of variance
TLIF	Transforaminal lumbar interbody fusion
VAS	Visual analog scale
VAS-LBP	Visual analog scale for lower back pain
VAS-LE	Visual analog scale scores for leg pain

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Author contributions
SMP, HJP: Writing- Original draft preparation. HJL, HJP: Conceptualisation, Methodology, Supervision, Writing - Review & Editing KHY: Visualisation, KHY: Data curation, JHJ: Methodology, Software SKC, HJK, JSY: Writing - Review & Editing.

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Data availability
The datasets used and analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The design and protocol of this retrospective case series study were approved by the institutional review board at our hospital (B-2309-853-103). The requirement for informed consent was waived due to the retrospective nature of the design of the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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