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Research article

Outcomes of FETD versus UBE in the treatment of L5S1 foraminal stenosis: A comparative study

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A R T I C L E I N F O

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A B S T R A C T

Background: The L5S1 level exhibits unique anatomical features compared with other levels. This makes minimally invasive surgery for L5S1 foraminal stenosis (FS) challenging. This study compared the surgical outcomes of full endoscopic transforaminal decompression (FETD) and unilateral biportal endoscopy with the far-lateral approach (UBEFLA) in patients with L5S1FS.
Methods: In this retrospective study, 49 patients with L5S1FS were divided into two groups. Of these, 24 patients underwent FETD, 25 patients underwent UBEFLA. The study assessed demographic data, leg pain visual analog scale (VAS) score, back pain VAS score, Oswestry Disability Index (ODI), modified MacNab outcome scale, and radiographic parameters including postoperative lateral facet preservation (POLFP).
Results: The Mann-Whitney *U* test revealed that the UBEFLA group exhibited a higher VAS score for back pain at one week after the operation, whereas the FETD group exhibited a higher leg pain VAS score 6 weeks after the operation. All four undesired MacNab outcomes in the FETD group were attributed to residual leg pain, whereas all five undesired MacNab outcomes in the UBEFLA group were due to recurrent symptoms. Radiographically, the FETD group exhibited greater POLFP.
Conclusions: When L5S1FS is performed, there may be challenges in adequately clearing the foraminal space in FETD. On the other hand, UBEFLA allowed for a more comprehensive clearance. However, this advantage of UBEFLA was associated with spinal instability as a future outcome.

1. Introduction

Lumbar foraminal stenosis (FS) has a prevalence rate of 8%–11% [1]. It can lead to radiculopathy and is a common cause of lower back and leg pain [2]. Among all levels, FS at the L5S1 level (L5S1FS) has the highest incidence rate, primarily due to the unique anatomical features of this level [3]. These features include large diameter, frequently located in the dorsal root ganglion of the foramen region, and limited space in the cranio-cephalad direction [4,5]. Notably, the load of the trunk is transmitted to the pelvis at this

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Abbreviations

BMI body mass index
DRG dorsal root ganglion
FS foraminal stenosis
L5S1FS foraminal stenosis at the L5S1 level
MD microendoscopic discectomy
MRI magnetic resonance imaging
ODI Oswestry Disability Index
FETD full endoscopic transforaminal decompression
SAP superior articular process
TP transverse process
UBEFLA unilateral biportal endoscopy with the far-lateral approach
VAS visual analog scale
POLFP postoperative lateral facet preservation.

level, rendering the foramen susceptible to significant loading from trunk-to-trunk movement [5]. L5S1FS can result in nerve root compression, leading to radicular pain and functional impairment [3].

Various techniques have been introduced to treat lumbar FS, such as transforaminal lumbar interbody fusion, microendoscopic discectomy (MD). Other minimally invasive techniques such as full endoscopic transforaminal decompression (FETD) [6] and unilateral biportal endoscopy with the far-lateral approach (UBEFLA) have also been used to treat lumbar FS.

Previous studies have demonstrated that both FETD [7–10] and UBEFLA [11–13] produce similar or even superior outcomes relative to MD. With advancements in surgical techniques and outcomes, FETD and UBEFLA have been widely applied for treating lumbar FS. However, our personal experience of using these techniques, shows that these are associated with specific challenges, such as a high iliac crest and high sensitivity to loading changes, and pose difficulties during decompression-only procedures.

To the best of our knowledge, no study has directly compared the surgical outcomes of uniportal and biportal techniques for the treatment of L5S1FS. This retrospective study compared surgical and radiographic outcomes between FETD and UBEFLA, addressing the potential differences and limitations associated with each technique when applied to L5S1FS.

2. Materials and methods

We retrospectively reviewed all patients diagnosed with L5S1FS who were treated with either FETD or UBEFLA at a hospital in Taiwan between May 2017 and May 2022. All patients were followed up for at least 1 year after surgery. All the operations were performed by the same experienced operator.

This study was approved by the Institutional Review Board of the Research Ethics Committee of the Buddhist Dalin Tzu Chi Hospital (approval number B11103012) on May 12, 2023.

The inclusion criteria were as follows.

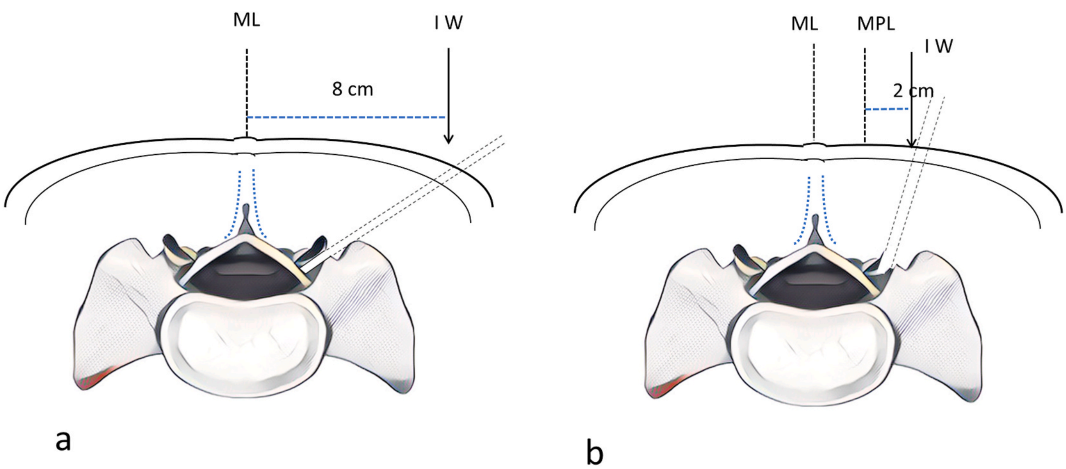

Fig. 1. Axial view of surgery model at the L5S1 disc level, IW: incision wound, a: The FETD incision wounds were 8 cm lateral to the midline, which resulted in a more horizontal orientation of the protective working channel., b: The UBEFLA incision wounds were at 2.5 cm lateral to the medial pedicle line, which made the working portal more vertical. Excessive destruction of the lateral facet could occur with access to the medial portion of SAP.

1. Persistent radicular pain along the L5 dermatome for more than 6 weeks.
2. Magnetic resonance imaging (MRI) suggesting L5S1FS, characterized by the presence of the hypertrophic facet, ligamentum flavum or disc herniation, or hypertrophic ala.
3. Positive results of the L5S1 foraminal nerve block test, with immediate symptom relief following the injection of 1 mL of 0.5% xylocaine and 2 mg of betamethasone to the L5S1 foraminal region under fluoroscopy.

Patients were excluded from the study if they had Bertolotti's syndrome, a history of spine infection or malignancy, had undergone previous fusion surgery involving the L5S1 level, and those with pure herniation of the intervertebral disc characterized by L5S1 disc sequestration.

2.1. Operation methods

For both procedures, patients were prepared in the prone position over a radiolucent frame under general anesthesia. The operator stood on the ipsilateral side of the pathology site.

2.2. FETD

An approximately 1-cm skin incision was made 8 cm lateral to the central line of the spine at the level of the iliac crest (Fig. 1(a)). An 18-gauge spinal needle, guided by fluoroscopy, was inserted through the wound into the lateral L5S1 facet joint surface. Once the target was confirmed, an endoscopic working channel was established by replacing the needle with a guidewire, followed by a 7.0-mm-diameter dilator and a bevel-ended working cannula. Initial foraminal unroofing was conducted under fluoroscopic guidance by using a trephine or reamer. Subsequently, a 30° spinal endoscope (SPINENDOS GmbH, Munchen, Germany) was introduced.

During the operation, periodic confirmation of the working cannula was performed using fluoroscopy. Root decompression was achieved by removing osteophytes and the roof of the L5S1 foramen by using an endoscopic burr, as well as ligamentum flavum surrounding the root by using an endoscopic Rongeur.

The L5 exiting nerve root was assessed by moving the bevel-ended cannula under endoscopic visualization from the infrapedicle region to the lumbosacral tunnel. The endpoint of decompression was the free mobilization of the exiting nerve root.

After the removal of the endoscope and working channel, the wound was closed with 3-0 Nylon. After the surgery, all patients remained in the hospital for up to two days before discharge.

2.3. UBEFLA

A proximal portal was established 2 cm away from the L5 pedicle (Fig. 1(b)) guided by C-arm fluoroscopy. Similarly, a distal portal was established 2.5 cm from the proximal wound. A left-side incision was made for the viewing portal, housing a 30° 4 mm arthroscope, and a right-side incision was made for the working portal.

Serial dilators and radiofrequency coagulators were used through both portals with constant saline irrigation. The inferior aspect of the transverse process (TP) of L5, the supramedial part of the sacral ala, and the lateral aspect of the superior articular process (SAP) of S1 were identified as landmarks. Stepwise removal of the inferior aspect of the TP of L5 and the lateral aspect of the SAP of S1 was performed using a high-speed burr and Kerrison Rongeur. Subsequently, the iliolumbar ligament was released medially with a Kerrison Rongeur and curettage, allowing the identification of the L5 exiting nerve root.

Complete decompression of the root was achieved by removing the bulging disc, osteophytes, and ligamentum flavum surrounding the root throughout the foraminal region. The extraforaminal region was assessed by releasing or removing the thickened lumbosacral and extraforaminal ligaments.

The endpoint of the surgery was confirmed by the free mobilization of the L5 root through endoscopic examination. The surgical wound was closed with 3-0 Nylon after removing the arthroscope.

2.4. Data collection

All patients underwent plain radiography and MRI before surgery. Demographic data including age, sex, body weight, body mass index (BMI), and history of spinal fusion, were collected. The operation time and the number of fluoroscopy images captured during the operation were recorded. Data on patients' Oswestry Disability Index (ODI) and leg pain and back pain visual analog scale (VAS) scores before surgery were collected. Additionally, leg pain and back pain VAS scores and ODI scores at 1 week, 6 weeks, 12 weeks, 6 months, and 12 months were obtained after surgery. A modified MacNab outcome scale was used to assess the treatment outcome, and patients were asked to report their outcomes 12 months after surgery. The medical records of patients with undesired MacNab outcomes (fair/poor) were reviewed to identify the underlying causes. Patients with sustained leg pain VAS score >3 at 1 week after surgery were classified as undesired outcomes due to residual symptoms, and patients with improved leg pain VAS scores but worsened symptoms at 12-weeks after surgery were classified as undesired outcomes due to recurrent symptoms. For the evaluation of radiographic parameters, preoperative plain lumbosacral radiographs with dynamic views were obtained. The segmental lordotic angle (SLA) at the L5S1 level and the global lumbar lordotic angle (GLA) were calculated (Fig. 2a and b). Iliac crest height (ICH) was calculated as the distance between the lines drawn through the superior endplates of S1 and the iliac crest (Fig. 2(c)). Foraminal stenosis grading was done preoperation using Lee's classification[14]. Subsequently, postoperative computed tomography (CT) images with coronal and sagittal reconstruction were reviewed. The assessment of lateral facet preservation at L5S1 was conducted using the coronal reconstruction view. The S1 lateral portion of the SAP was divided into four equal parts, with each part representing 25% of the facet joint. Postoperative lateral facet preservation (POLFP) was recorded as 25%, 50%, 75%, and 100% preservation of the facet joint (Fig. 3). Operation time and intraoperative hemorrhage were also collected and analyzed. All radiographs were stored in the digital imaging and communications in medicine file format and reviewed using a picture archiving and communication system (v.3.0.11.4, BN2; Infinitt, Phillipsburg, NJ, USA).

The normality of continuous data was tested using the Shapiro–Wilk test. Independent *t*-test was used to compare the data with a normal distribution, i.e., age, body weight, BMI, and operation time. Mann-Whitney *U* test was used to analyze the non-normally distributed variables, i.e., leg pain and back pain VAS scores, and ODI scores. The chi-squared test was used to assess categorical variables, including sex, spinal fusion history, MacNab scale score, cause of undesired MacNab outcomes, pre-operation foraminal stenosis grading, and POLFP. All statistical analyses were performed using IBM SPSS Statistics 2019. $P < 0.05$ was considered significant.

3. Results

A total of 59 patients were screened for the study, of whom, 4 (6.7%) patients with equivocal selective nerve block test results, and (10%) other patients were excluded based on the exclusion criteria (Fig. 4). Of the remaining 49 patients, 24 (49%) underwent FETD, and 25 patients (51%) underwent UBEFLA. The two groups did not exhibit significant differences in age, sex, body weight, BMI, preoperative VAS score (leg pain and back pain), or ODI **(Table 1).** Chi-square test revealed no difference between the spinal fusion history and foraminal stenosis grading between the two groups **(Table 2)**. Additionally, no significant differences were found in the operation time between the two groups (FETD:UBEFLA = 102.7min:104.1min, P = 0.830). Blood loss in both groups were minimal.

Radiographically, the FETD group exhibited different POLFP than the UBEFLA group ($P < 0.001$)**(Table 3)**. Both groups exhibited significant improvements in VAS and ODI scores. The ODI scores did not differ significantly between the two groups at 1 week, 6 weeks, 12 weeks, 6 months, or 12 months after surgery. Notably, the UBEFLA group exhibited higher back pain VAS scores than the FETD group (FETD:UBEFLA = 2.1:2.9, $P = 0.020$) at 1 week after surgery. However, the FETD group exhibited higher leg pain VAS scores than the UBEFLA group at 6 weeks **(Table 4)** (FETD:UBEFLA = 2.83:1.72, $P < 0.001$). VAS scores did not differ significantly between the two groups at 12 weeks, 6 months, and 12 months (Figs. 5 and 6).

None of the patients reported a “poor” outcome on the modified MacNab scale. Among the patients, 20 (83.3%) in the FETD group and 20 (80%) in the UBEFLA group reported “good” or “excellent” outcomes on the modified MacNab scale, and no significant

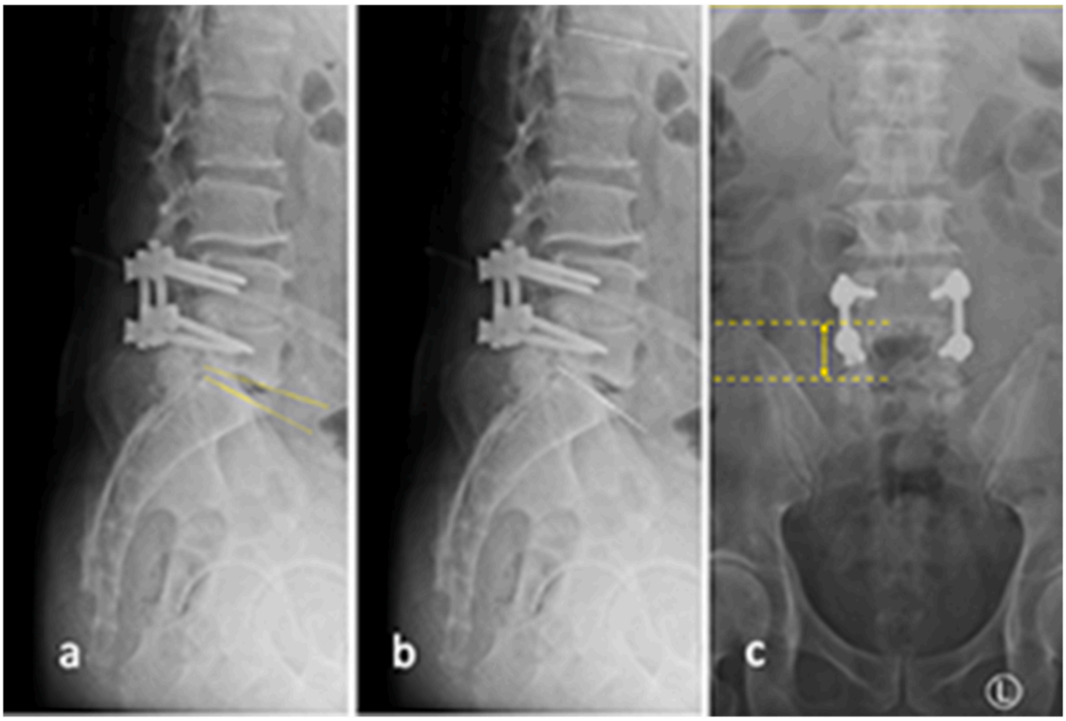

Fig. 2. Segmental lordotic angles, For radiographic evaluation (a) Segmental lordotic angles (SLA) at the L5S1 level were calculated between the upper endplate of S1 and lower endplate of L5 (yellow short dotted line) at the lateral view and (b) global lumbar lordotic angles (GLA) were calculated between the upper endplate of L1 and upper endplate of S11 (white short dotted line) at the lateral view. Iliac crest height (ICH) was calculated as the distance between the lines drawn through the superior endplates of S1 and iliac crest (yellow long dotted line) on AP view.

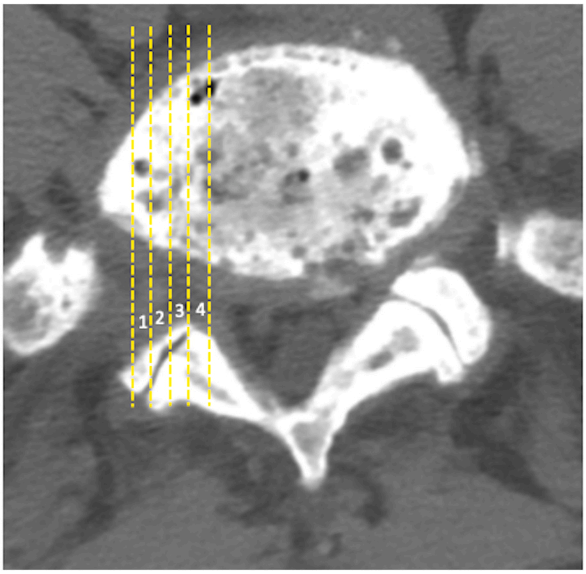

Fig. 3. Postoperative lateral facet preservation, The proportion of lateral facet preservation at L5S1 was evaluated using the coronal reconstruction view. The S1 lateral portion of the superior articular process was divided into four equal parts, with each part representing 25% of the facet joint. Postoperative lateral facet preservation (POLFP) was recorded as 25%, 50%, 75%, and 100% preservation., 1 = 25% Postoperative lateral facet preservation, 1 + 2 = 50% Postoperative lateral facet preservation, 1 + 2 + 3 = 75% Postoperative lateral facet preservation, 1 + 2 + 3 + 4 = 100% Postoperative lateral facet preservation.

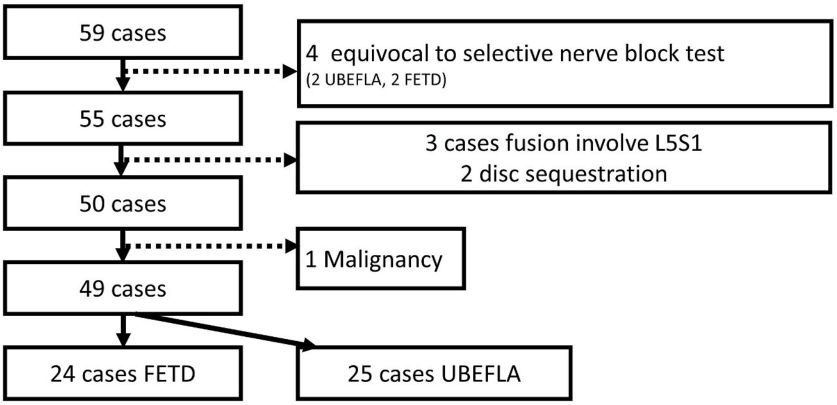

Fig. 4. Flowchart of our study.

Table 1
Demographic characteristics of patients with L5S1FS.

		FETD (n = 24)	UBEFLA (n = 25)	p value
Independent *t*-test	**Sex (male: female)**	7:17	8:17	0.830
	Age (year)	66.08 ± 7.9	71.36 ± 11.3	0.066
	BMI	24.6 ± 4.9	23.9 ± 4.2	0.753
	Body weight (kg)	66.93 ± 11.37	66.48 ± 15.84	0.910
Mann-Whitney	**SLA (degree)**	9.6 ± 5.61	10.6 ± 5.57	0.247
***U* test**	**GLA (degree)**	19.08 ± 13.1	20.22 ± 11.1	0.204
	ICH (mm)	24.2 ± 6.9	25.7 ± 5.59	0.570

FETD: full endoscopic transforaminal decompression; UBEFLA: unilateral biportal endoscopy-far lateral approach; BMD: Bone Mineral Density; BMI: body mass index; SLA: segmental lordotic angle at the L5S1 level; GLA: global lumbar lordotic angle; ICH: iliac crest height.

Table 2
Chi-square analysis of pre-operative data of patients with L5S1FS.

	FETD (n = 24)	UBEFLA (n = 25)	p value
Previous spinal fusion history (cases with: cases without)	13:11	13:12	0.870
Foraminal stenosis grading (grade1:grade2:grade3)	12:3:9	13:7:7	0.423

FETD: full endoscopic transforaminal decompression; UBEFLA: unilateral biportal endoscopy-far lateral approach.

Table 3
Postoperative lateral facet preservation in FETD and UBEFLA.

	FETD (n = 24)	UBEFLA (n = 25)	p value
POLFP (0%:25%:50%:75%)	19:3:1:1	5:14:6:2	<0.001

FETD: full endoscopic transforaminal decompression; UBEFLA: unilateral biportal endoscopy-far lateral approach; POLFP: postoperative lateral facet preservation.

Table 4
Clinical and Radiologic comparisons between the groups.

		FETD (n = 24)	UBEFLA (n = 25)	p value
Leg pain VAS	PreOP	7.4 ± 0.7	7.5 ± 0.8	0.960
	1 week	2.5 ± 0.8	2.4 ± 0.7	0.755
	6 weeks	2.8 ± 0.5	1.7 ± 1.0	<0.001
	12 weeks	1.2 ± 1.3	1.1 ± 1.2	0.374
	6 months	1.1 ± 1.4	1.3 ± 1.5	0.759
	12 months	1.3 ± 1.5	1.2 ± 1.8	0.225
Back pain VAS	preOP	7.2 ± 0.7	7.4 ± 0.7	0.731
	1 week	2.1 ± 0.1	2.9 ± 0.7	0.020
	6 weeks	1.7 ± 1.0	2.0 ± 1.2	0.960
	12 weeks	1.2 ± 1.2	1.6 ± 1.6	0.855
	6 months	1.2 ± 1.3	1.8 ± 1.8	0.827
	12 months	1.3 ± 1.6	1.4 ± 1.6	0.619
ODI	PreOP	60.9 ± 8.4	65.8 ± 10.5	0.629
	6 weeks	20.2 ± 13.1	22.0 ± 5.3	0.575
	6 months	11.1 ± 14.2	14.6 ± 14.2	0.067
	12 months	13.3 ± 18.2	17.4 ± 19.6	0.149

FETD: full endoscopic transforaminal decompression; UBEFLA: unilateral biportal endoscopy-far lateral approach; VAS: visual analog scale; ODI: Oswestry Disability Index; OP: operation.

differences were observed between the two groups (Table 5).

Also, 4 patients in the FETD group and 5 in the UBEFLA group reported a “fair” outcome at 1 year (Table 6). The cause of the “fair” MacNab outcomes was significantly different between the two groups ($P = 0.01$). Notably, all four cases of “fair” outcomes in the FETD group were caused by residual symptoms and those in the UBEFLA group were due to recurrent symptoms, 3 patients had ipsilateral leg pain and 2 with contralateral leg pain.

4. Discussion

Both FETD and UBEFLA are successful techniques for the treatment of L5S1FS. FETD is associated with less soft tissue trauma, whereas UBEFLA provides a wider surgical field [15] similar to MD and has a short learning curve.

This study compared surgical outcomes following FETD and UBEFLA for the treatment of L5S1FS, and the results revealed significant differences between the two treatment options.

The FETD group exhibited higher leg pain VAS scores than the UBEFLA group at 6 weeks postoperatively. Additionally, the incidence of residual symptoms was higher in the FETD group than in the UBEFLA group. These findings indicate that there are challenges in adequately clearing the L5S1 foraminal space in FETD, which is consistent with the findings of previous studies [16,17].

Conversely, the UBEFLA group exhibited higher back pain VAS scores at 1 week after the operation. This finding could be attributed to the wider operative view and clearer field in UBEFLA, which requires more soft tissue manipulation in the back, a partial removal of the iliolumbar ligament, and excessive removal of the lateral portion of the SAP. Furthermore, in the present study, the UBEFLA group exhibited a higher incidence of recurrent symptoms. This could be due to the higher risk of spinal instability caused by increased bony destruction in UBEFLA [18,19].

FETD, one of the most popular minimally invasive spinal surgeries, employs precise decompression with a narrow operative view and relies on fluoroscopic guidance. Although previous studies have demonstrated a high success rate for this technique [7–9], Choi et al. reported that an incomplete removal of herniated discs as a complication of FETD, accounted for 64.9% of unsuccessful cases

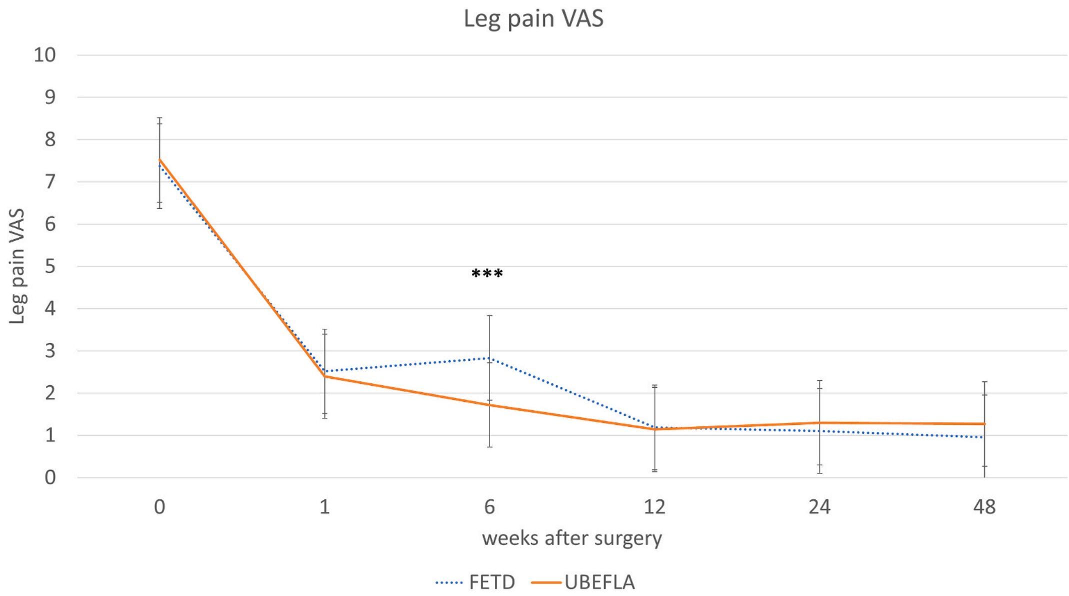

Fig. 5. Changes in mean leg pain VAS score in both groups, The FETD group exhibited higher leg pain VAS scores 6 weeks after surgery upon Mann-Whitney *U* test., FETD: Full Endoscopic Transforaminal Decompression; UBEFLA: Unilateral Biportal Endoscopy-Far Lateral Approach; VAS: Visual Analog Scale. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, Error lines show 1 standard error.

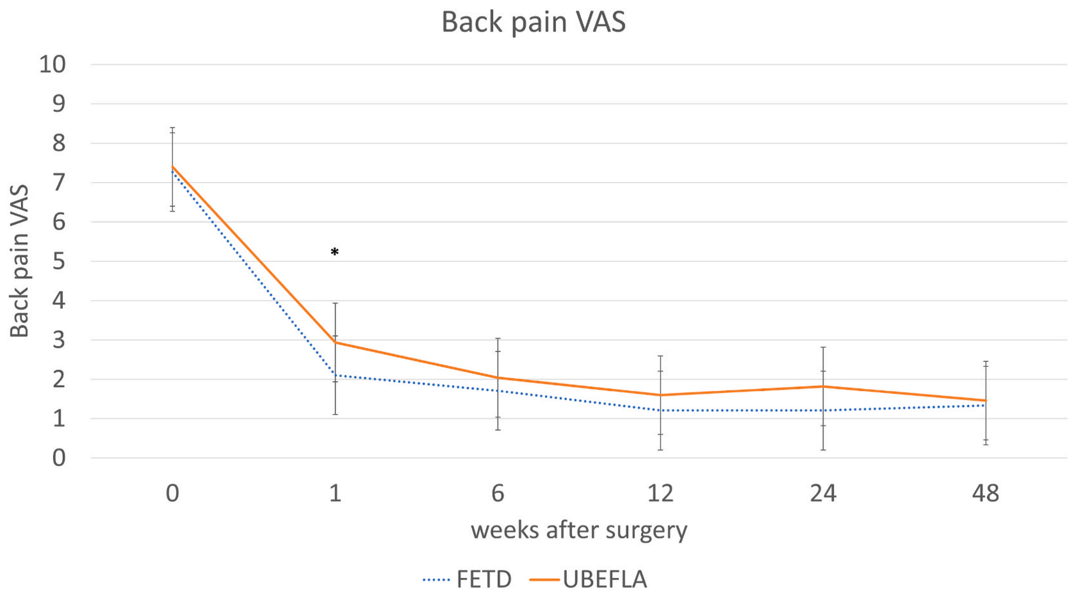

Fig. 6. Changes in mean back pain VAS score in both groups, The UBEFLA group exhibited higher back pain VAS scores 1 week after surgery upon Mann-Whitney *U* test., FETD: Full Endoscopic Transforaminal Decompression; UBEFLA: Unilateral Biportal Endoscopy-Far Lateral Approach; VAS: Visual Analog Scale. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, Error lines show 1 standard error.

[20]. In a review article, Pan et al. also reported that incomplete disc removal was one of the complications of FETD [17]. Other case series have reported residual symptoms as a complication of FETD [21]. Several variations of FETD have been developed Kim et al. developed a contralateral approach for L5S1 lateral recess and foraminal and extraforaminal stenosis, which has shown good clinical outcomes, particularly for combined stenosis [22]. However, these variations have a steeper learning curve and a higher risk of dural tears.

The unique anatomical features of the L5S1 space present challenges for the traditional FETD technique. Choi et al. demonstrated that the L5S1 space poses anatomical challenges for FETD, including a narrower foramen, larger facet joint, and a high iliac crest that potentially conceals the L5S1 foramen [16]. We hypothesized that the technical limitations of FETD along with the anatomic

Table 5
MacNab clinical outcome in FETD and UBEFLA.

	FETD	UBEFLA
Total Number	24	25
Excellent	11	8
Good	9	12
Fair	4	5
Poor	0	0

FETD: full endoscopic transforaminal decompression; UBEFLA: unilateral biportal endoscopy-far lateral approach.

Table 6
Demographic characteristics of cases of fair outcomes.

OM	Age	BMI	SEX	FH	ICH	Leg pain VAS					cause (P = 0.01)
						Pre-OP	1 WK	6 WK	6 M	12 M	
FETD	59	31.9	male	L2~5	42.14	8.5	3.0	3.0	4.5	6.0	Residual
FETD	57	30.0	female	L2~5	19.64	7.0	3.0	3.0	4.0	1.5	Residual
FETD	74	24.0	male	L45	30.49	7.0	3.5	3.5	4.0	4.0	Residual
UBEFLA	69	26.0	male	L2~5	26.26	7.0	2.5	2.5	3.5	6.5	Recurrent
UBEFLA	70	31.8	female	L345	25.14	7.5	1.0	2.0	4.0	4.0	Recurrent
UBEFLA	69	27.7	male	L345	26.76	10.0	2.5	2.0	6.0	Fused	Contralateral Recurrent
UBEFLA	80	29.8	female	L345	26.61	8.0	2.5	2.0	5.0	5.0	Contralateral Recurrent
FETD	56	24.7	male	Non	26.01	6.5	3.4	3.5	4.0	4.0	Residual
UBEFLA	54	24.7	male	Non	26.01	6.5	1.5	2.0	5.0	5.0	Recurrent

OM: operation methods; FH: fusion history; ICH: iliac crest height; VAS: visual analog scale; OP: operation; WK: week (s); M: months.

challenges of the L5S1 foramen could have contributed to a higher incidence of residual symptoms and higher leg pain VAS scores at 6 weeks postoperatively in the FETD group. FETD technique and a high iliac crest makes it challenging for surgeons to adequately clear the foraminal space, especially at the medial portion of the SAP (Fig. 7(a–f)). Consequently, residual FS is associated with a higher incidence of residual symptoms.

The UBEFLA technique is another minimally invasive surgical technique, and it has been demonstrated to successfully treat FS [11–13]. In this report, we focused on the far-lateral approach. UBEFLA features the "landing" process, in which a working space is created and filled with fluid, providing a wider operative view and a clearer visual field. However, this process also leads to more soft tissue trauma and requires the complete or partial removal of the iliolumbar ligament. In our study, the UBEFLA group exhibited higher back pain VAS scores within 1 week after the operation. This finding may be attributed to soft tissue disturbance caused by the UBEFLA technique.

UBEFLA might lead to spinal instability. In this study, the incision wounds in UBEFLA were approximately 2 cm lateral to the pedicle. Thus, the trajectory of the working portal was significantly more vertical than that of FETD. For ensuring a wider surgical field, the surgeon might remove an excessive amount of the lateral portion of the facet joint (Fig. 8(a–f)). In this study, the FETD group exhibited greater POLFP than the UBEFLA group. It is well-established that the excessive clearance of facet joints can induce instability in the spine segments [18] and may lead to recurrent leg pain on the ipsilateral or even contralateral side, especially in patients with previous fusion just above the L5 level [23].

In a study on cadavers, Enyo et al. observed that as the facet joint was removed, the relative stiffness of each motion segment decreased. However, the UBEFLA approach unavoidably caused a certain degree of facet joint destruction [18]. Therefore, the excessive removal of facet joints destabilized the spine segments, increasing the risk of future degenerative changes and recurrence [24]. This conclusion aligned with the findings of our study, where all patients with unfavorable results in the UBEFLA group exhibited recurrent symptoms. The trajectory of UBEFLA is similar to that of the microscopic decompression procedure. The findings are consistent with that presented by Chang et al. That study reviewed the risk factors for unfavorable outcomes after microscopic decompression, and showed that 75% of the patients with L5S1 lesions and without distinctive preoperative features reported persistent pain or FS and required revision surgery [25]. However, due to the clearer operative view in UBEFLA compared with microscopic decompression and improvements in the technique, enhanced preservation of the lateral facet may contribute to improved long-term results after UBEFLA (Fig. 9(a–e)).

In this study, the overall VAS and ODI scores in both the FETD and UBEFLA groups significantly improved. More than 80% of patients in both groups reported favorable MacNab outcomes, and no complications were reported other than "fair" MacNab results. There were significant differences in the cause of undesirable outcomes between the two groups. Notably, when selecting between the two minimally invasive techniques, patient-specific factors, anatomical variations, and surgeon expertise must be considered. Treatment plans should be individualized based on specific patient characteristics, preferences, and risks.

This study has some limitations. The sample size was limited, and this study was of a retrospective design. The outcomes of minimally invasive surgery considerably depended on the surgeon's technique. Therefore, a learning curve may alter the surgical outcomes including accessing the medial portion of the SAP in the FETD technique and preserving the lateral facet in the UBEFLA

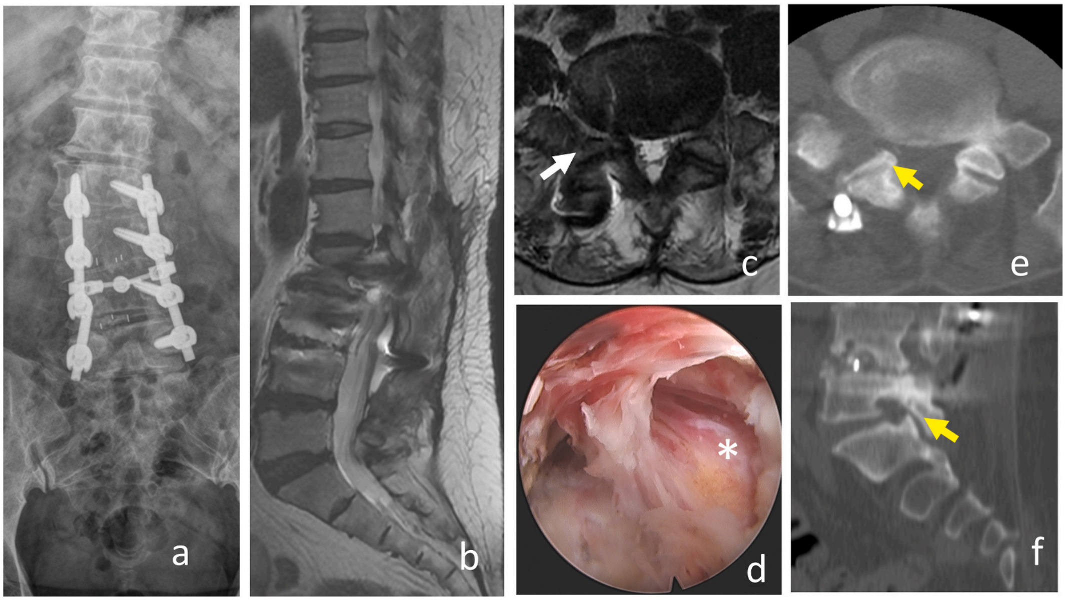

Fig. 7. FETD case with residual symptoms, (a) A 60-year-old woman with a history of L2 to L5 fusion complained of right sciatica for years. (b) (c) Magnetic resonance imaging (MRI) indicated well-decompressed L45 recess and L5S1 foraminal stenosis (white arrow). (d) She received FETD for L5S1. The L5 nerve was decompressed (star) and symptoms were relieved for only 1 month. (e) (f) Postoperative computed tomography (CT) revealed a well-preserved lateral portion of the L5S1 facet joint but residual stenosis over the medial portion of the superior articular process (SAP) (yellow arrow).

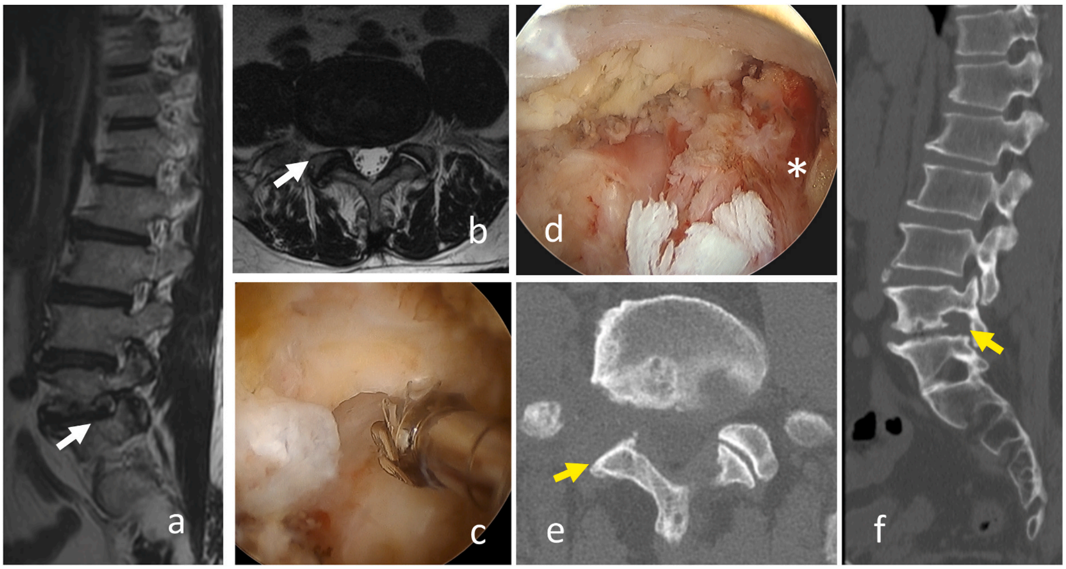

Fig. 8. UBEFLA case with recurrence, A 55-year-old man sustained right sciatica. (a) (b) MRI revealed right L5S1 foraminal stenosis (white arrow). (c) (d) Intraoperative picture revealed a well-decompressed L5 nerve root (star). His leg pain improved soon after the operation. (e) (f) Postoperative CT indicated widened L5S1 foramen but extensive destruction of the lateral portion of the right L5S1 facet (yellow arrow). Recurrent leg pain was identified at 6 weeks and the patient rated the surgical outcome as fair at 1-year follow-up.

technique. Lastly, patient-specific factors such as previous spinal fusion above L5 and ICH may negatively affect surgical outcomes. However, we could not discuss these factors separately. Further prospective studies with larger sample sizes and longer follow-up periods are required to validate these findings and address any confounding factors. The FETD and UBEFLA techniques, when applied to the L5S1 space, can be modified to overcome the challenges identified in this study.

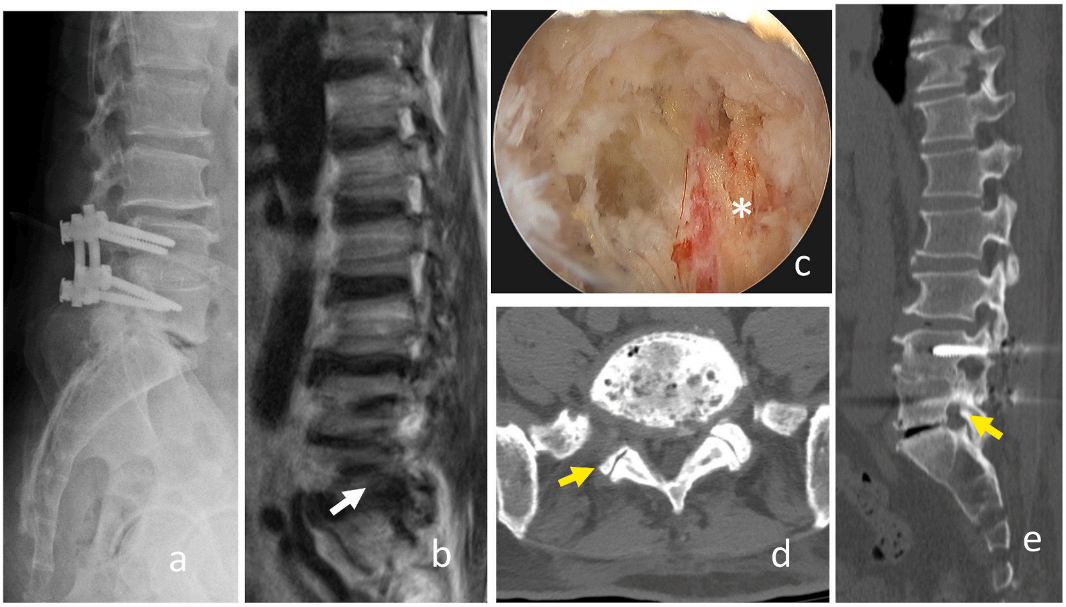

Fig. 9. UBEFLA case, (a) A 61-year-old woman with a history of L4L5 fusion sustained from right sciatica and numbness along the L5 dermatome. (b) The pathology could not be well identified by a blurred MRI due to severe pain. Positive selective nerve block led to a diagnosis of L5S1 foraminal stenosis. (c) He received UBEFLA and the L5 nerve root was well-decompressed (star) intraoperatively. He had good leg pain relief which lasted for 1 year. (d) (e) Postoperative CT revealed a well-preserved lateral portion of the L5S1 facet joint and good removal of medial SAP.

Conclusions

Our findings indicate that patients who underwent FETD for L5S1FS treatment could experience more residual symptom because of incomplete decompression associated with the iliac crest. By contrast, the UBEFLA group exhibited more recurrent symptoms, possibly due to spinal instability caused by increased bony destruction. These conclusions have potential clinical implications, providing surgeons with valuable insights when choosing an adequate technique based on clinical factors and thereby improving patient care and optimizing treatment decisions.

Ethics statement

This study was approved by the Institutional Review Board of the Research Ethics Committee of the Buddhist Dalin Tzu Chi Hospital (approval number B11103012) on May 12, 2023. Consent for treatment, data collection, and data analysis was obtained from all participants.

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Yao-Chun Yang: Writing – review & editing, Writing – original draft, Software. **Min-Hong Hsieh:** Conceptualization. **Jui-Teng Chien:** Data curation. **Keng-Chang Liu:** Data curation, Conceptualization. **Chang-Chen Yang:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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