Original Article

Full endoscopic percutaneous stenoscopic lumbar decompression and discectomy: An outcome and efficacy analysis on 606 lumbar stenosis patients

ABSTRACT

Introduction: Laminectomy has long been a "gold standard" to treat symptomatic lumbar spinal stenosis (LSS). Minimal invasive spine surgery (MISS) is widely developed to overcome the limitations of conventional laminectomy to achieve a better outcome with minimal complications. Full endoscopic percutaneous stenoscopic lumbar decompression (FE-PSLD) is the newest MISS technique for spinal canal decompression. We aimed to evaluate and analyze the significance of FE-PSLD in reducing pain and its association with age, duration of symptoms, stenosis level, and operative time (OT).

Materials and Methods: A longitudinal cross-sectional study was conducted on 606 LSS patients who underwent FE-PSLD and enrolled from 2020 to 2022. Three-month evaluation of the Visual Analog Scale (VAS) and the modified MacNab criteria were assessed. The significance of changes was analyzed using the Wilcoxon signed-ranks test. Spearman's correlation test was performed to evaluate the significant correlation of several variables (pre-PSLD-VAS, age, symptoms duration, OT, and level of LSS) to post-PSLD-VAS, and multiple regression analysis was conducted.

Results: The reduction of VAS was statistically significant (P 0.005) with an average pre-PSLD-VAS of 6.75 ± 0.63 and post-PSLD-VAS of 2.24 ± 1.04. Pre-PSLD-VAS, age, and stenosis level have a statistically significant correlation with post-PSLD-VAS, while the duration of the symptoms and OT have an insignificant correlation. Multiple regression showed the effect of pre-PSLD-VAS (β =0.4033, P = 0.000) and stenosis level (β =0.0951, P = 0.021) are statistically significant with a positive coefficient.

Conclusions: FE-PSLD is an efficacious strategy with favorable outcomes for managing LSS, shown by a significant reduction of pain level with a relatively short follow-up time after the procedure. Preoperative pain level, age, and stenosis level are significantly correlated with postoperative pain level. Based on this experimental study, PSLD can be considered a good strategy for treating lumbar canal stenosis in all age groups and all LSS levels.

Keywords: Endoscopic surgery, lumbar spinal stenosis, minimal invasive spine surgery, outcome, pain, percutaneous stenoscopic lumbar decompression, visual analog scale

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INTRODUCTION

Percutaneous stenoscopic lumbar decompression/discectomy (PSLD) has been a reliable and newest minimally invasive spine surgery (MISS) technique to treat spinal

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stenosis. Lumbar spinal stenosis (LSS), either a congenital or acquired and relative or absolute LSS, was the most common among other segments.[1,2] The prevalence and incidences were variably among populations and races; however, it was both increased by age and the most typical reason for spinal surgery in a population above 65 years old.[3-6] Persons with LSS are likely had a chance to have a concurrent cervical or thoracic stenosis or combined, with a prevalence of 23.9%, 24.3%, and 12.1%.[7]

LSS leads to compression of nerve roots, which would develop acute to chronic nonradicular pain in the back, buttocks, and lower limbs with intermittent claudication; in more severe conditions, it would cause sensory and motoric disturbance. LSS patients with existing pain tend to have a lower quality of life because of disturbance in daily activities related to work or physical performance and are often associated with depression.[2,8-12] For this reason, LSS management aims to achieve symptomatic relief as much as possible. Even though observation and nonsurgical management have been a reasonable choice because most of the LSS patients reported developed nonsignificant symptomatic changes and recurrent postoperative pain cannot be avoided, with the continued development of medical technology, surgical intervention might be a choice to treat chronic symptomatic LSS that failed in conventional management, a patient that exhibited neurological deterioration, or by the patient's request.[2,13-16]

Laminectomy with preservation of facet has been long to be a "gold standard" to treat symptomatic LSS that failed with conservative treatment; however, this procedure leads to higher complication possibility of intraoperative blood loss, adjacent segment degeneration, and destroyed posterior midline structure inducing instability and chronic pain.[17-21] The study comparing conventional laminectomy with posterior decompression without the midline structures removal concluded a similar or minor significance without clinical impact in differences on functional disability, pain recovery, length of hospital stay, and complications; therefore, further research on better and practical alternative approach is needed.[18,19,21-29] Several better approaches to overcome this limitation have been developed, focusing on MISS using stenoscope to achieve better anatomical marker visualization with less invasiveness (blood loss and tissue/structure damage) and to preserve and stabilize a posterior midline structure, including the vertebral arch, spinous process, interspinous ligaments, and supraspinous ligaments.

Posterior structure preservation potentially minimized the risk of misalignment and iatrogenic degeneration and preserved normal spine motion. Biomechanical analysis showed greater preservation of normal lumbar spine motion and alignment in a MISS than traditional laminectomy.[20] Full endoscopic (FE) PSLD as an interlaminar, uniportal, and unilateral approach is the newest MISS technique for spinal canal decompression and/or diskectomy that might be far better than the conventional posterior open surgery for LSS management with less complication. This study aimed to evaluate and analyze the significance of FE-PSLD in reducing pain and improving the quality of life in patients with LSS and its association with age, duration of symptoms, stenosis level, and operative time (OT).

MATERIALS AND METHODS

The longitudinal cross-sectional study was conducted in all patients with LSS treated with FU and enrolled from 2020 to 2022, with the inclusion criteria are (1) LSS objectively diagnosed with magnetic resonance imaging (MRI), (2) Having mechanical or radicular low back pain (LBP), (3) >17 years old, (4) One-level LSS, and (5) Patient indicated and compatible to be treated with PSLD. Exclusion criteria included patients with no symptoms or incidental findings during MRI medical checkups, disc calcification, severe spondylodiscitis, infected spine, and instability or deformity that required correction. Changes in the Visual Analog Scale (VAS) and the modified MacNab criteria within 3-month evaluation post-PSLD were assessed. The correlation analysis was done between VAS, age, symptom duration, OT, and LSS level. Using the STATA 14 (StataCorp LLC., Texas-USA) statistical analysis, all data are valid with Cronbach's Alpha validity test, and the Levene's test showed $P > 0.05$, indicating homogenous data of pre- and post-PSLD-VAS ($P = 0.698$ and $P = 0.131$) by age-group. Shapiro–Wilk normality test showed the data were not normally distributed, the changes in VAS score analysis were using the Wilcoxon signed-ranks test with a significance level of analysis of ≤ 0.005, while the correlation between other variables was analyzed using Spearman's correlation test. Multiple regression analysis was conducted to analyze the relationship and predict the outcome between the significantly correlated variables with post-PSLD-VAS.

Percutaneous stenoscopic lumbar decompression procedure

PSLD procedure was using the iLESSYS® Delta (joimax®) endoscopic system with 125 mm working length, 6 mm working channel, 10 mm outer diameter (OD), and 15° optical angle, with 15 mm of each irrigation and suction channel. Most of the procedure was performed with the patient under local anesthesia, but some were chosen with general anesthesia, considering the patient's general condition or by patient choice. The patient was placed in a prone position on a radiolucent table. After an aseptic application

and draping, a fluoroscope was used intraoperatively to confirm the precise incision site. Vertical skin incision was made around 7 mm to the confirmed location, and a blunt dilator, which guided the OD working sleeve, was advanced into the lamina of the ipsilateral side beside the spinous process. Over the dilator, a working sleeve was inserted, and a rigid-angle stenoscope was introduced into the lesion by approaching through fatty atrophy between the spinous process and multifidus muscles. This approach was beneficial in decreasing post-PSLD muscle origin LBP. Taylors retractor was used to retract the muscle on the lateral side of the joint. Normal saline continuous irrigation to the operative field was needed during the procedure to provide a clean visualization of epidural anatomy. Every procedure step was done under image intensifier control to confirm the exact entry point.

Laminectomy was done to open an epidural space, and by removing ligamentum flavum and superior articular process using a 4 mm drill and Kerrison punch through a stenoscope, the transverse root was sequentially exposed. Then, laminotomy was performed to expose the uppermost portion of ligamentum flavum to remove it as much as possible to decompress ipsilaterally. The same procedure was performed at a contralateral site to decompress a contralateral transversing nerve root by removing its ligamentum flavum and superior articular process. The top priority in this procedure is facet joint preservation by minimal bone work as much as required. These procedures were vital in gently releasing and mobilizing the dural sac and nerve root to find the herniated disc. The dura mater was gently pushed toward the midline using a dura retractor to expose the compressed nerve visibly. Coagulation of epidural vessels using bipolar forceps was sometimes. Only the ruptured portion of the disc and some of the bone spurs or synovial cysts were removed to decompress the spinal nerve root. The amount of disc excision varies, and in some cases, laminectomy might be extended if the herniated disk is sequestrated downward or upward. Still, the overlying nerve must be checked first before excising the sequestra. After the whole procedure, muscle and skin incision closure was made after reviewing the nerve root freedom, hemostasis, and cerebrospinal fluid leakage.

RESULTS

A total of 606 patients with one-level LSS were treated with FE-PSLD [Table 1], with 68 patients (11.22%) elderly, and 538 are the productive age group. The number of male patients (66.99%) was greater than females (33.01%). The duration of symptoms experienced by patients before therapy varied, with the shortest onset being 1 year experienced by 219 (36.14%) patients and the most extended onset of up to 10 years experienced by 1 (0.17%) patient. The average duration of disease symptoms experienced until the patient was indicated for FE-PSLD or at the patient's decision was 2.29 ± 1.28 years. FE-PSLD was performed on one-level LSS at a total of 14 levels decompressed at L1-L2, 22 levels at L2-L3, 175 levels at L3-L4, 181 levels at L4-L5, and the most common was at L5-S1 with 214 levels decompressed.

One-level LSS FE-PSLD procedure takes up to 34 min–180 min (average OT 89.78 ± 35.82 min), and most of the patients were done in 120 min (35.64%). Subjective clinical outcome 3-month post-PSLD was assessed using modified MacNab criteria showed 57.43% of patients had a good outcome, and 40.75% are excellent, both had a satisfactory outcome with no restriction and return of regular activity and relief of presenting symptoms. A total of 11 (1.82%) patients with fair and poor modified MacNab criteria are in an elderly group with unsatisfied because of residual pain or insufficient improvement in functional capacity and the need for further follow-up with pain interventions and rehabilitation.

The patients have an average VAS for mechanical/radicular LBP of 6.75 ± 0.63, with a maximum score of 8 and a minimum of 5. There was a decrease in VAS after PSLD with an average score of 2.24 ± 1.04 with a maximum score of 4 and a minimum of 1. The reduction of VAS after FE-PSLD was statistically significant [$P \leq 0.005$, Table 2]. The correlation analysis showed that pre-PSLD-VAS has a weak positive correlation but is statistically significant ($P \leq 0.005$) with the post-PSLD-VAS. Age group and stenosis level have a very weak but statistically significant ($P \leq 0.005$) positive correlation with the post-PSLD-VAS. This positive correlation means higher pre-PSLD-VAS, older age group, and lower segments correlated with the higher post-PSLD-VAS (note: our statistical analysis coded L5-S1 as the lowest segment with the highest code number and L1-L2 as the highest segment with the lowest code number). The duration of symptoms has a very weak negative correlation, while OT has a very weak positive correlation with post-PSLD-VAS; both are statistically insignificant. Multiple regression analysis was conducted to analyze the relationship and predict the outcome between the three variables significantly correlated with post-PSLD-VAS [Table 3]. The effect of pre-PSLD-VAS ($\beta = 0.4033$, $P = 0.000$) and stenosis level ($\beta = 0.0951$, $P = 0.021$) is statistically significant, and its coefficient is positive, indicating that the greater the pre-PSLD-VAS and the lower the lumbar stenosis segment toward L5-S1 were related to the greater of post-PSLD-VAS. However, the age group effect is not statistically significant in multiple regression, which means it was unrelated to post-PSLD-VAS in multiple regression analysis.

Table 1: Demographic and clinical status of participants

Variables	Total, *n* (%)	Variables	Total, *n* (%)
Age group (years)		OT (min)	
Adult (>17 and <60)	538 (88.78)	≤34	21 (3.47)
Elderly (≥60)	68 (11.22)	35–45	26 (4.29)
Mean±SD (years)	45.64±12.31	46–50	43 (7.10)
Median (years)	45	51–60	144 (23.76)
Minimum–maximum (years)	27–90	61–65	58 (9.57)
Gender		66–70	13 (2.15)
Male	406 (66.99)	71–80	16 (2.64)
Female	200 (33.01)	81–100	5 (0.83)
Duration of symptoms (years)		101–120	216 (35.64)
1	219 (36.14)	121–130	20 (3.30)
2	132 (21.78)	131–140	21 (3.47)
3	157 (25.91)	141–150	11 (1.98)
4	76 (12.54)	151–180	12 (1.80)
5	13 (2.15)	Mean±SD (min)	89.78±35.82
6	3 (0.50)	Median (min)	70
7	4 (0.66)	Minimum–maximum (min)	34–180
8	1 (0.17)		
9	0	Complications	
10	1 (0.17)	No complications	586 (96.69)
Mean±SD (years)	2.29±1.28	Dural tear	15 (2.48)
Median (years)	2	Transient dysesthesia	5 (0.83)
Minimum–maximum (years)	1–10		
Stenosis level		Modified MacNab criteria	
L1–L2	14 (2.31)	Excellent	247 (40.75)
L2–L3	22 (3.63)	Good	348 (57.43)
L3–L4	175 (28.88)	Fair	9 (1.49)
L4–L5	181 (29.87)	Poor	2 (0.33)
L5–S1	214 (35.31)		

SD - Standard deviation; OT - Operative time

Table 2: Statistical analysis of Visual Analogue Scale changes before and after percutaneous stenoscopic lumbar decompression and discectomy, and correlation of demographic and clinical status toward postpercutaneous stenoscopic lumbar decompression and discectomy Visual Analog Scale

Variable	Mean±SD (95% CI)	P50 (minimum–maximum)	*P*
Comparative analysis*			
Pre-PSLD VAS	6.75±0.63 (6.69–6.79)	7 (5–8)	0.000
Post-PSLD VAS	2.24±1.04 (2.15–2.32)	2 (1–4)	
Variables	**Spearman's rho**		***P***
Correlation analysis**			
Pre-PSLD VAS	0.2128		0.000
Age group	0.1120		0.005
Duration of symptoms	−0.0516		0.204
Stenosis level	0.1242		0.002
OT	0.0540		0.184

*Wilcoxon signed-rank test between pre- and post-PSLD VAS; **Spearman correlation test of all variables toward post-PSLD VAS. Strength of correlation based on Spearman's rho: Very strong (0.80–1.00), strong (0.60–0.79), moderate (0.40–0.59), weak (0.20–0.39), very weak (0.01–0.19). VAS - Visual Analog Scale; PSLD - Percutaneous stenoscopic lumbar decompression and discectomy; CI - Confidence interval; SD - Standard deviation; OT - Operative time

Table 3: Multiple regression analysis of variables relationship with postpercutaneous stenoscopic lumbar decompression and discectomy Visual Analog Scale

Post-PSLD VAS	β (coefficient)	SE	*t*	*P*	95% CI
Pre-PSLD VAS	0.4033	0.0644	6.26	0.000	0.2769–0.5298
Age group	−0.0017	0.0033	−0.51	0.609	−0.0083–0.0049
Stenosis level	0.0951	0.0411	2.31	0.021	0.0143–0.1760
Constant	−0.7810	0.4952	−1.57	0.118	−1.7600–0.1980

Number of observations=606, F (5,60)=9.74, $P>F$ = 0.000, R^2=0.0751, adjusted R^2=0.0674, root MSE=1.0005. SE - Standard error; VAS - Visual Analogue Scale; PSLD - Percutaneous stenoscopic lumbar decompression and discectomy; CI - Confidence interval

DISCUSSION

The development of the MISS technology era for spine surgery nowadays provides a lower risk and complication than what was faced in the prior traditional open-surgery period, and conventional management or observation for LSS might not be a better choice anymore.[13,15,16,30,31] FE-PSLD was chosen in this study in a person with symptomatic LSS because it is

prone to have greater walking restriction and less functional mobility compared to other degenerative musculoskeletal disorders, and when symptoms developed severely, it tends to be associated with poorer physical ability.[4,32,33] FE-PSLD with uniportal approach is less invasive than biportal unilateral laminotomy for bilateral decompression (ULBD), even though the use of biportal ULBD was rapidly progressed due to its greater familiarity.[34-37] FE-PSLD can be argued to be superior to conventional surgery with several considerations: (1) Minimal blood loss and damaged anatomical structure, leading to less spinal instability complication and the need of future spinal fusion; (2) Ability to decompress single to multiple levels of LSS concurrently with single skin incision using uniportal access; and (3) Ability to decompress central and lateral recess LSS and excised herniated disc concomitantly with stenoscope by translaminar approach.[34,38,39] The feasibility of PSLD as effective management to replaced conventional open surgery for lumbar stenosis was also proven by Lim *et al*., study on LSS patients which shown a significant increase of spinal canal volume, less soft-tissue damage by MRI, less hospital stay, and pain improvement with a mean score of 4.[34,35]

Several studies have shown that females prone to had a higher risk of LSS and even higher with an older age and had a lower tolerance toward pain due to LSS; however, it was debatable, a study by Kim *et al*. showed even there was a difference in the symptoms by age, but there was no difference on LSS grade and no variety of radiographic LSS prevalence between gender.[4,40-44] Our study participants were primarily men under 60 years old. Differences in the prevalence of LSS in the participant group are possible because Indonesia, as a developing country, has a population of productive age of 15–64 years old that is still larger (68.62%) than the elderly group, in contrast to research in developed countries, which are epidemiologically heading toward an aging population, and Indonesia has a larger male population (50.08%) based on data from the Indonesia Central Bureau of Statistics in 2023.[45]

LSS usually affected the lower lumbar segments, typically L3-L5, in line with our study with the most LSS in L5-S1, followed by L4-L5 and L3-L4.[46,47] Lower lumbar that prone to degenerative canal stenosis due to biomechanical forces that are greater in the lumbosacral region with higher mobility during flexion and torsion and with higher weight bearing and axial compression load.[48-51] Our study also found that age and stenosis level had a statistically significant correlation with the outcome resolved post-PSLD, with older ages, and the lower LSS segment correlated with higher post-PSLD-VAS. OT in LSS depends on the complexity of cases and procedures. Our study takes 34–180 min with an average of 89.78 ± 35.82 min. This finding was similar to the study by Kaminski and Banse in 438 patients having LSS surgery with an operation time of 60–194 min; They also recommended the additional OT of 35 min for each segment and 29 min for elderly patients to reduce complication rates with improving surgical technique efficiently and patient selection especially in identifying the presence of dural tears and epidural hematoma that need the additional OT.[52] Lee *et al*. also presented an average OT of FE lumbar decompression of 84.51 ± 31 min for one segment, with the finding of higher complication rates in participants with longer OT.[53]

FE use in MISS for LSS has been one of the best approaches, as it has the better advantage in terms of minimal anatomical resection than open surgery, microscopic, and tubular technique, and it has a wide focused operative field that overcomes a limitation of invisible structure that faced during open surgery.[54-56] FE-PSLD might be a possible gold standard in the future for LSS management. Our study presented a statistically significant reduced post-PSLD-VAS and pain severity pre-PSLD significantly correlated with the outcome, suggesting that early intervention for indicated LSS patients might be needed to achieve a more favorable outcome postprocedure. Lim *et al*. also concluded that PSLD in 450 LSS patients achieved a better clinical outcome, shorter hospitalization, and lower complication rates post-PSLD (2.9%) compared to microendoscopic decompression or open laminectomy (7.9%), including incidental dural tear or root herniation, epidural hematoma, and wound infection.[34] Eleven (1.82%) of our patients with fair and poor modified MacNab criteria does not experiencing those complications, but residual pain or insufficient improvement resulting in an unsatisfied outcome should be investigated further during follow-up sessions, especially in the elderly patients with the risk of facet joints osteoarthritis and further degenerative changes.

We consider some limitations in this study that might influence the results and conclusion of this study: (1) Did not compare directly between FE-PSLD with conventional surgery; and (2) Pain as an outcome is very subjective, other bio-psychosocial factors that could affect the outcomes are not accessed and might become the response-or cognitive-bias of this research. Further study in a serial follow-up might needed to investigate the long-term PSLD efficacy and a potential complication related with PSLD. The addition of other symptomatic LSS psychometric scoring might be better to evaluate PSLD efficacy comprehensively and more objective.[2,57-62] A comparison between FE-PSLD and other management options is needed to define the best strategy. MRI changes comparison before and after PSLD

during serial follow-up might be considered, even though Sirvanci *et al*. showed that the degree of stenosis radiologically was not significantly correlated with the severity of ODI.[12,63]

CONCLUSIONS

FE-PSLD as the newest spine decompression technique is an efficacious strategy with favorable outcomes for the management of LSS, shown by a significant reduction of mechanical/radicular LBP level scored with VAS with a relative short follow-up time in 1–3-month post-PSLD. Pre-PSLD pain level, age, and stenosis level are significantly correlated with postoperative pain level achieved post-PSLD, while its correlation with duration of symptoms and OT is insignificant. Based on this experimental study, PSLD can be considered a good strategy for treating LSS in all lumbar segments and age groups.

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Conflicts of interest

There are no conflicts of interest.

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