

Percutaneous endoscopic ventral facetectomy: An innovative substitute of open decompression surgery for lateral recess stenosis surgical treatment?

ABSTRACT

Background: Percutaneous transforaminal endoscopic surgery (PTES) constitutes an innovative method principally recruited for the treatment of lumbar disc herniation. Indication spectrum of PTES is constantly widened in current years. Hence, PTES has been proposed to represent a satisfactory alternative for the treatment of lateral recess stenosis (LRS), being defined as percutaneous endoscopic ventral facetectomy (PEVF) in these cases. The aim of this original study is to determine, for the first time in the literature, the outcomes of PEVF, especially in otherwise healthy nonelderly patients with LRS, alongside with special focus in health-related quality of life (HRQoL) assessment.

Materials and Methods: Eighty-five otherwise healthy individuals from 58 to 64 years were diagnosed with LRS, being subjected to successful PEVF. Patients were prospectively evaluated in 6 weeks, in 3, 6, and 12 months, and in 2 years postoperatively. Visual analog scales (VASs) were separately utilized for leg and low back pain evaluation (VAS-LP and VAS-BP, respectively), whereas Short Form-36 (SF-36) questionnaire was sequentially implemented for HRQoL assessment.

Results: All indexes of SF-36 as well as VAS-LP featured maximal amelioration in 6 weeks postoperatively, with subsequent further enhancement until 3 months and successor stabilization until 2 years. In contrast, VAS-BP presented minimal quantitative amelioration in 6 weeks, featuring no additional alterations. Values of all indexes in all follow-up intervals were demonstrated to be statistically significant in comparison with preoperative values ($P < 0.05$). No remarkable differentiation was observed between distinct parameters of SF-36.

Conclusions: PEVF implementation in nonelderly patients with LRS was displayed to be safe and effective, providing alongside considerable improvement in HRQoL 2 years postoperatively.

Keywords: Lateral recess stenosis, percutaneous endoscopic ventral facetectomy, percutaneous transforaminal endoscopic surgery


INTRODUCTION

Lumbar spinal stenosis (LSS) is defined as the constriction of spinal canal which results into neurovascular impingement.^[1] Various anatomic conditions may be associated with LSS as lumbar disc herniation (LDH) and other degenerative alterations, tumor, spondylolisthesis as well as fractures.^[2] Degenerative LSS is associated with particular pathologic alterations in facet joints, posterior longitudinal ligament, or ligamentum flavum, alongside constituting a frequent disorder and the most banal indication for surgery in older adults.^[3,4] LSS is traditionally classified into three different anatomic types: central stenosis (CS), lateral recess

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stenosis (LRS), or foraminal stenosis (FS), with particular clinical significance.^[3,5,6]

LSS treatment is initially conservative including spine injections, physical therapy, as well as administration of analgesics. However, conservative treatment failure, especially when accompanied by pain and functional limitation, establishes the option of surgery.^[3,7] In these cases, open decompression surgery with laminectomy and foraminotomy is conventionally performed.^[8] Nevertheless, the existence of notable complications limits the safety and effectiveness of these selections.^[3]

Percutaneous transforaminal endoscopic surgery (PTES) is increasingly implemented in current years, fundamentally for LDH surgical treatment. PTES is associated with considerable surgical advantages as preservation of dorsal musculature and spine anatomic elements, lesser intraoperative hemorrhage, more rapid rehabilitation, and diminished perioperative morbidity. These advantages gradually establish PTES in spine surgeon's armamentarium in recent years.^[9-11]

PTES has been proposed as an effective alternative for lateral recess decompression and therefore LRS surgical treatment.^[12] Technique may be renamed in percutaneous endoscopic ventral facetectomy (PEVF) in this situation, actually representing a full-endoscopic surgical technique.^[13] To our best knowledge, there is no study in current literature to report specific results about PTES implementation for LRS, enrolling exclusively nonelderly patients. However, three original studies sought to elucidate the exact role of PTES in LRS, recruiting patients in a large age range, including nonelderly.^[14-16]

The aim of this paper is to report particular outcomes of PEVF for LRS utilizing Transforaminal Endoscopic Surgical System (TESSYS) technique and including only nonelderly patients with the absence of comorbidities. Furthermore and for the first time in the literature, specific data about patients' health-related quality of life (HRQoL) are provided. These traits in conjunction with the considerable sample utilized underline the originality of our study.

MATERIALS AND METHODS

Study population

In this study were only nonelderly individuals enrolled. All patients were under the age of 65 years (58–64 years),^[17] being diagnosed with LRS according to clinical and radiologic criteria. Furthermore, they were otherwise healthy, featuring no comorbidities. All patients fulfilled all the indications for conventional open decompression surgery, being referred

to the same spine surgeon (KS). Patients were thoroughly informed about study's primary aim, deciding to sign a fully informed written consent. Institutional review board of the hospital as well as local ethics committee administrated a special approval. Moreover, all aspects of this study were in absolute conformity with Ethical Principles for Medical Research Involving Human Subjects, as defined in Helsinki Declaration of 1975 and as revised in 2000.

Inclusion and exclusion criteria

Inclusion criteria were as follows: (i) radiculopathy, (ii) neurogenic claudication, (iii) sensory or motor neurologic deficit, (iv) LRS especially due to excessive osseous growth and less due to yellow ligament hypertrophy/ossification, as confirmed by magnetic resonance imaging (MRI) of the lumbar spine, in compliance with clinical findings, and (v) failure of 12-week typical conservative treatment (analgesic administration, spinal injections as well as physical therapy sessions).

Exclusion criteria were as follows: (i) noncontaminated disc hernia exceeding the one-third of the spinal canal on the sagittal MRI scans, (ii) sequestration of the disc, (iii) recurrent herniated disc or previous surgery at the affected level, (iv) segmental instability or spondylolisthesis, (v) vertebral fracture, (vi) spinal tumor or infection, (vii) elderly patients (over the age of 65 years), and (viii) presence of comorbidities as coronary insufficiency, heart failure, diabetes mellitus, and respiratory failure.

Methods

This study was prospectively designed, enrolling eighty-five individuals. All patients were subjected to PEVF through transforaminal route in 2015–2016. Patients were assessed preoperatively as well as in 6 weeks, in 3, 6, and 12 months, and in 2 years postoperatively. Especial clinical scales were utilized for patients' health objective assessment. Visual analog scale (VAS) was utilized for leg and low back pain (VAS for leg pain, VAS-LP, and VAS for back pain, VAS-BP, respectively). Moreover, Short Form 36 Health Survey (SF-36) Questionnaire was recruited for HRQoL evaluation.

Surgical technique

All patients enrolled in this study underwent full-endoscopic ventral facetectomy with TESSYS method by the same spine surgeon. Technique was performed under local anesthesia and mild sedation. Preoperative position of patients was lateral decubitus, lying down on the opposite side, in order to accomplish optimal amplification of foraminal space. Surgical field disinfection in conjunction with injection of local anesthetic at the point of needle introduction (in a lateral position 11 cm from midline) was conducted. Needle was gradually forwarded under constant fluoroscopic

guidance, in order to verify its precise position [Figure 1]. Implemented angulation was more cranial in comparison with endoscopic discectomy procedure. Transit corridor led in Kambin's triangle (safe zone).^[18] After fluoroscopic verification of correct position, three distinct reamers with gradually increasing diameters (5.5, 6.5, and 7.5 mm, respectively, joimax® system) were sequentially applied, achieving therefore adequate foramintomy [Figure 2]. Introduction of reamers was accompanied by analgesia (fentanyl ampule) and mild sedation administration by the anesthesiologist. Cannula and endoscope were finally inserted. Hence, osseous decompression of the lateral recess by conducting ventral facetectomy was achieved [Figure 3]. All patients were discharged on the first postoperative day. Nevertheless, two of them (2.4%) featured temporary postoperative dysesthesia in distribution of exiting nerve root (L5), being entirely retreated in 6 weeks with conservative treatment.

Visual analog scale utilization

VAS constitutes a facile and accurate method for the evaluation of pain intensity.^[19] In our study, a unipolar horizontal line of 100 mm was recruited. Patients were asked to demonstrate the level of realized pain with a point. VAS was distinctly for leg and low back pain (VAS-LP and VAS-BP, respectively) acquired in each interval assessment. All scores were estimated in millimeters (mm), recruiting a one-decimal place approach. 9 mm was defined as the level of lower clinically significant alteration. Concomitant parameters as pain etiology, age, and gender were not separately investigated.^[20]

Short Form 36 Questionnaire

SF-36 Medical Health Survey Questionnaire is thoroughly implemented for the evaluation of HRQoL in spine surgery.^[21] SF-36 is composed by 36 different objects, evaluating totally 8 parameters in regard to patients' generic health and daily life conditions; physical function, role-physical, bodily pain, general health, energy, fatigue, and vitality, social function, role-emotional, and mental health. The appropriately formed questionnaire was completed from all patients in every follow-up interval. Results were subsequently collected and edited, in order to be represented by a percentage. In all studied indexes, higher score is associated with auspicious HRQoL. Questionnaires were considered invalid if less than half of form entries were checked.

Statistical analysis

Statistical processing of compiled data was performed with statistical package SPSS, version 23.00 (SPSS Inc., Chicago, IL, USA). Continuous variables were calculated as mean \pm standard deviation. In contrast, categorical variables were represented by specific percentages.

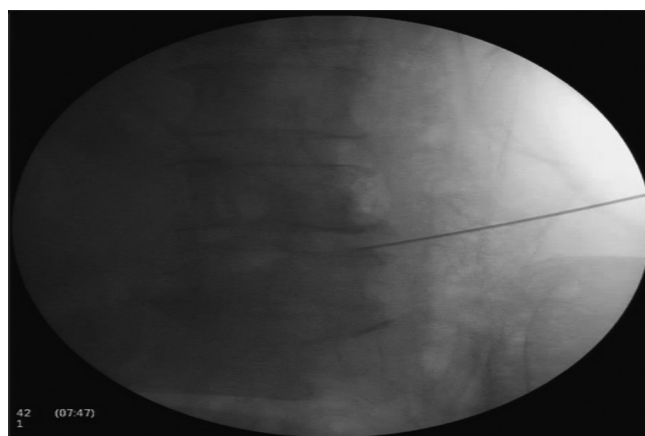


Figure 1: Anteroposterior fluoroscopic view of gradual needle promotion

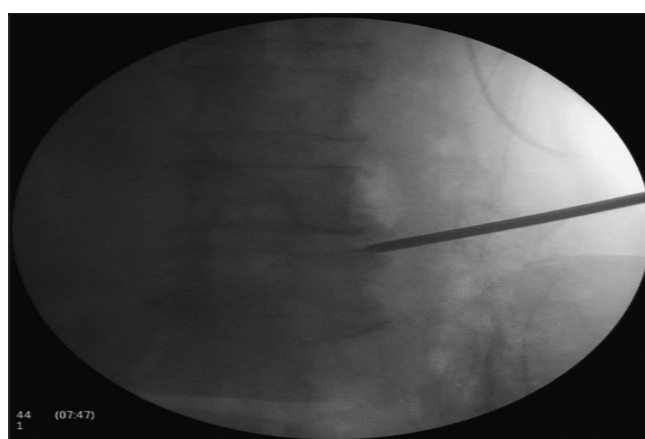


Figure 2: Successive passage of different size of reamers and foramintomy

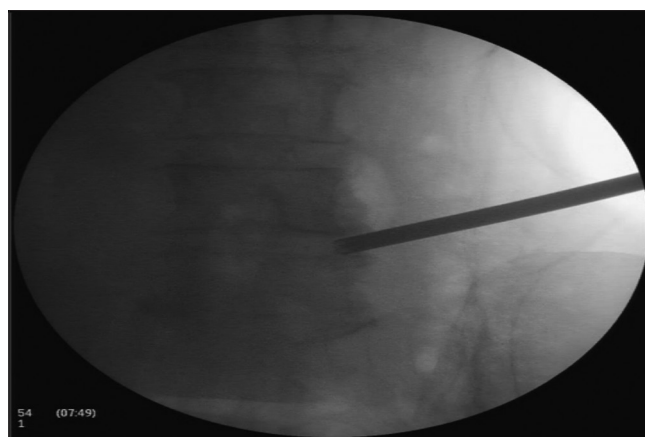


Figure 3: Introduction of cannula and endoscope with ventral facetectomy conduction

Statistical correlation of continuous indexes was achieved with Student's *t*-test, in the case of normal distribution presence. Otherwise, Mann–Whitney test was employed. $P = 0.05$ instituted the level of statistical significance. All utilized scores were evaluated preoperatively and regularly in all intervals of follow-up.

RESULTS

All patients successfully completed the end of follow-up. Demographic features of recruited patients are provided in Table 1. Preoperative values of all indexes are presented in Table 2.

The overwhelming majority of indexes featured a similar amelioration pattern. Major improvement was recorded in 6 weeks, with a subsequent enhancement until 3 months.

Table 1: Demographic data of enrolled patients

Evaluated parameter	Value (%)
Population size	85 (100)
Gender	
Males	41 (48.2)
Females	44 (51.8)
Age	61.3±2.0
Level of operation	
L3-L4	4 (4.7)
L4-L5	57 (67.1)
L5-S1	24 (28.2)

Table 2: Presentation of preoperative values of all parameters

Parameter	Preoperative value
PF	52.1±3.4
RP	43.6±8.4
BP	43.5±9.5
GH	45.0±7.3
V	48.4±10.1
SF	47.9±10.1
RE	44.5±10.6
MH	46.5±8.7
VAS-LP (mm)	87.4±9.7
VAS-BP (mm)	89.4±7.3

*PF - Physical function; RP - Role-physical; BP - Bodily pain; GH - General health; V - Energy, fatigue, and vitality; SF - Social function; RE - Role-emotional; MH - Mental health; VAS-LP - VAS for leg pain; VAS-BP - VAS for back pain; VAS - Visual analog scale

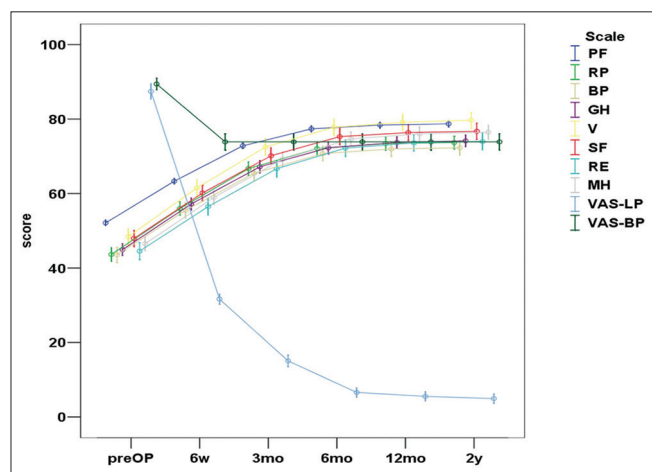


Figure 4: Illustrative ostentation of studied parameter alteration during sections of follow-up

Minimal improvement of parameters was thereafter until 6 months observed, with further stabilization until 2 years [Figure 4 and Table 3].

All parameters of SF-36 featured a quantitatively equal enhancement with no notable differentiation among the different sections of follow-up. Improvement was observed to be major at 6 weeks and almost equal afterward until 3 months. Minimal amelioration until 6 months with subsequent stabilization in 2 years was recorded [Figures 4-7 and Table 3]. Comparatively speaking, all parameters presented a statistically significant improvement in all follow-up sections [Table 3].

VAS score assessment revealed though a remarkable differentiation. VAS-LP index featured maximal enhancement at 6 weeks, with relatively less amelioration after 3 months. Sequent minimal improvement at 6 months with further stabilization was observed [Figures 4, 8 and Table 3]. Statistical significance was recorded for value alteration in all follow-up intervals [Table 3]. In contrast, VAS-BP index was associated with statistically significant betterment at 6 weeks, presenting no alterations thereafter [Figures 4, 9 and Table 3].

DISCUSSION

LSS constitutes an especial clinicoradiologic syndrome.^[22] Typical clinical manifestations include neurogenic claudication and radiculopathy, being classically associated with CS and LRS/FS respectively.^[3] Nevertheless, accompanying symptoms as low back pain, paresthesias, and/or gait limitations may be present.^[1-4] The conjunction of open decompression with fusion has been proposed as an efficient solution for surgery-related low back pain recession, in order to accomplish a more favorable postoperative clinical course.^[23]

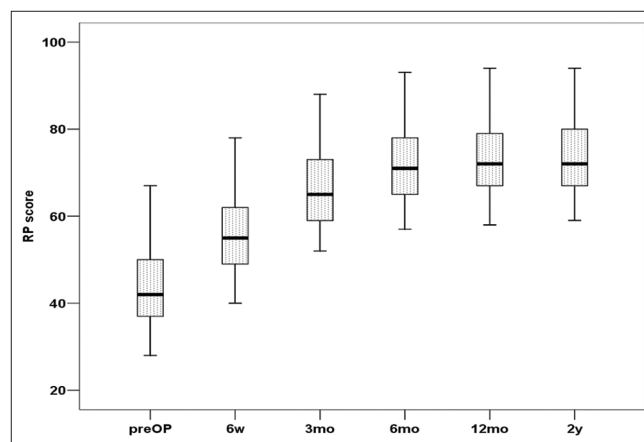


Figure 5: Schematic representation of role-physical score alteration in follow-up

Table 3: Parameters of quantitative amelioration during various follow-up intervals

Parameter	Follow-up interval				
	Preoperative-6 weeks (P)	6 weeks-3 months (P)	3 months-6 months (P)	6 months-12 months (P)	12 months-2 years (P)
PF	11.2±0.9 (<0.001)	9.5±0.9 (<0.001)	4.6±0.6 (<0.001)	1.0±0.7 (<0.001)	0.4±0.5 (<0.001)
RP	12.3±0.9 (<0.001)	10.7±0.8 (<0.001)	5.4±0.5 (<0.001)	1.4±0.5 (<0.001)	0.3±0.5 (<0.001)
BP	11.9±0.8 (<0.001)	10.0±0.8 (<0.001)	5.3±0.6 (<0.001)	1.2±0.6 (<0.001)	0.3±0.5 (<0.001)
GH	12.2±0.8 (<0.001)	10.0±0.8 (<0.001)	5.1±0.8 (<0.001)	1.4±0.7 (<0.001)	0.4±0.5 (<0.001)
V	13.1±0.8 (<0.001)	11.0±0.9 (<0.001)	5.3±0.9 (<0.001)	1.4±0.7 (<0.001)	0.5±0.5 (<0.001)
SF	12.2±1.0 (<0.001)	10.0±0.8 (<0.001)	5.1±0.8 (<0.001)	1.1±0.7 (<0.001)	0.4±0.5 (<0.001)
RE	12.0±1.0 (<0.001)	10.2±1.0 (<0.001)	5.5±0.6 (<0.001)	1.4±0.7 (<0.001)	0.4±0.5 (<0.001)
MH	12.4±1.2 (<0.001)	10.2±1.3 (<0.001)	5.5±0.7 (<0.001)	1.4±0.7 (<0.001)	0.4±0.5 (<0.001)
VAS-LP (mm)	55.8±8.8 (<0.001)	16.6±6.3 (<0.001)	8.5±5.9 (<0.001)	1.1±3.1 (0.003)	0.6±2.4 (0.025)
VAS-BP (mm)	15.5±6.1 (<0.001)	0.0±0.0 (1.000)	0.0±0.0 (1.000)	0.0±0.0 (1.000)	0.0±0.0 (1.000)

*Statistically significant P values are indicated in **boldface**. Level of significance was determined at $P=0.05$. †Amelioration of VAS scores was demonstrated with value diminution, featuring a negative sign. However, absolute improvement with positive sign is presented here, ‡PF - Physical function; RP - Role-physical; BP - Bodily pain; GH - General health; V - Energy, fatigue, and vitality; SF - Social function; RE - Role-emotional; MH - Mental health; VAS-LP - VAS for leg pain; VAS-BP - VAS for back pain; VAS - Visual analog scale

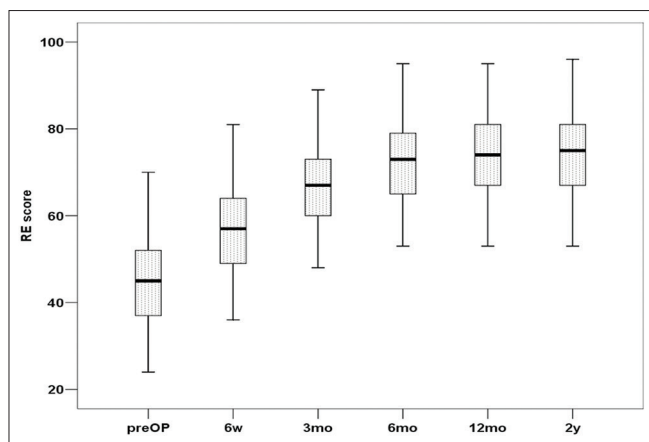


Figure 6: Role-emotional value change during follow-up intervals

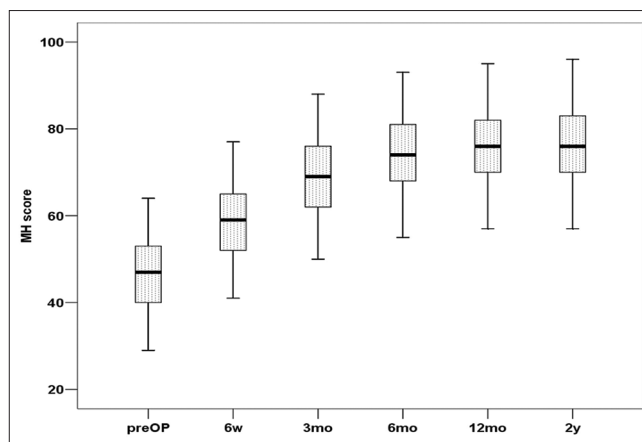


Figure 7: Mental health score amelioration in follow-up examination

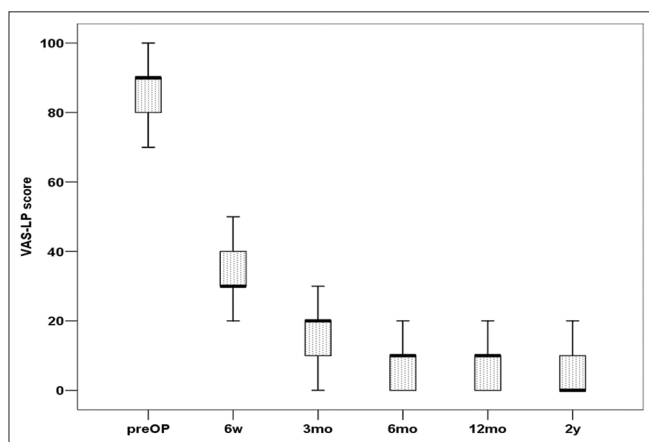


Figure 8: Visual analog scale for leg pain value improvement in regular follow-up sections

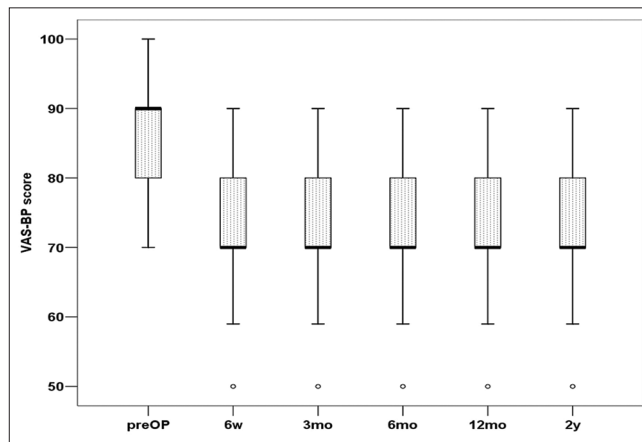


Figure 9: Presentation of Visual analog scale for back pain value alteration

LSS diagnosis is currently ratified by radiologic assessment with MRI.^[24] However, severity of imaginary findings is not always consistent with clinical manifestation intensity. Andrasinova *et al.* performed an observational radiological

study, enrolling 84 patients with CS. The radiologically defined degree of stenosis was not concluded to be correlated to pain intensity or functional disability, demonstrating thus the complexity of the syndrome.^[22] This mismatch of clinical with radiologic data may be an outcome of the routine conventional

conduction of MRI examination in the supine position. Upright MRI may be alternatively implemented in order to attain a more realistic evaluation of neural compression.^[24]

PTES constitutes a constantly evolving surgical technique. It is related to minimal surgical trauma, shorter hospitalization times, and postoperative pain, alongside with minimization of scarring in epidural space. The utilization of local anesthesia with mild sedation in conjunction with the conduction of a small 8-mm incision consolidates the minimally invasive character of this technique, posing it in advantageous position over the conventional open methods, which always require general anesthesia administration.^[9-11,13]

PTES may be recruited instead of open decompression procedures for LSS surgical management. Yeung was the first to introduce PTES for LRS surgical decompression.^[12] Nevertheless, endoscopic approaches for LSS treatment are not limited to transforaminal route; interlaminar approaches may be also efficiently implemented, particularly for cases of CS.^[8,25]

After the first introduction of Yeung in 2007, further studies were conducted in order to delineate the precise importance of PTES in LRS surgical management.^[14-16] In all these studies were patients in a large age range, including nonelderly, recruited.

Lewandrowski performed a wide retrospective study, enrolling 220 patients with age range 35–85 years. The aim of this study was to illustrate the precise role of PTES in lateral spinal stenosis with or without the concomitant presence of LDH. It was concluded that PTES utilizing the outside-in technique was incompetent to achieve adequate decompression in the lateral recess. Patients with stenosis in the entry foraminal zone (which was defined to be in absolute concordance with LRS) featured clinical failure.^[14]

Results of Lewandrowski's study were determined to be opposed to these of next studies. Li *et al.* prospectively studied 85 patients with the age range from 46 to 78 years (mean: 56.7 years). All recruited patients were diagnosed with LRS, whereas attendant LDH was present in 56 cases. Percutaneous endoscopic lumbar foraminoplasty with subsequent decompression was conducted in all cases, whereas patients were followed up for 2 years. VAS for low back and lower limb pain and Oswestry Disability Indexes (ODIs) were found to be significantly improved in all follow-up intervals. Furthermore, the overwhelming majority of evaluated patients (77 patients, 90.6%) featured favorable outcomes (“excellent”/“good”)

according to MacNab criteria assessment. Hence, PTES with foraminoplasty and decompression was advocated to represent a safe and effective alternative for LRS surgical management.^[15]

Singh *et al.* also investigated the role of PTES in the surgical treatment of LSS. Sixty-seven patients with age over 60 years (mean: 68.3 years) were retrospectively evaluated; 22 of them were operated for LSS, while the other 45 for LDH. VAS for lower limb and low back pain as well as ODI scores were statistically significantly postoperatively improved. Moreover, 76.1% of patients featured “excellent”/“good” outcomes according to MacNab score assessment. PTES was concluded to constitute an effective technique for LSS treatment, as results after implementation of PTES for LSS were not significantly differentiated from the cases where PTES was utilized for LDH.^[16] However, anatomic type of LSS in recruited patients was not determined.

Outcomes of these studies are in general concordance with our data. We prospectively studied 85 patients subjected to PEV with TESSYS technique for LRS. VAS-LP and VAS-BP were statistically significantly enhanced 6 weeks postoperatively. However, VAS-LP continued to feature less quantitative improvement at 3 months and 6 months, presenting a subsequent stabilization. In contrast, no alterations after 6 weeks were observed for VAS-BP index. A minimal only recession of back pain was after PTES recorded, theorizing the comparatively with VAS-LP minimal improvement of VAS-BP in 6 weeks.

This considerable differentiation of VAS score amelioration may be related to the existing degenerative lumbar spine disease. All patients enrolled in our study presented LRS, primarily due to the abnormal and extensive osseous growth. Degenerative alterations were though diffusely present in lumbar spine radiologic evaluation. PEV sought to decompress dorsal root ganglia and nerve roots in only one level, where nerve impingement was clinically and radiologically identified. Restoration of spinal elements' physiological anatomy was impossible to be conducted. Hence, satisfactory osseous decompression of nerve elements in lateral recess was clinically associated with momentous amelioration of lower limb pain. On the contrary, the presence of diffusely distributed degenerative pathologic alterations constituted, to our point of view, the primary etiology for the low decline of low back pain.

Furthermore, SF-36 questionnaire was recruited in order to assess HRQoL of our patients. We advocate that pain

constitutes a fundamental parameter with considerable impact in daily routine. However, individual calculation of pain is more likely unable to represent the favorability or not of the daily routine circumstances. Therefore, SF-36 was decided to be included in our assessment armamentarium. All parameters of SF-36 were statistically significantly improved in all follow-up intervals. Absolute quantitative amelioration of values was maximal at 6 weeks, being almost equal until 3 months and less until 6 months. Subsequent stabilization until the end of follow-up was observed for all parameters. Comparative evaluation of individual parameter enhancement did not reveal any noteworthy differentiation. Hence, PEVF achieved statistically and clinically significant amelioration of all parameters of HRQoL in patients with LRS.

Selection of enrolled patients in conjunction with HRQoL evaluation and sample size delineates the originality of our study. All evaluated patients were nonelderly, featuring no comorbidities. No other study focused on this age range, in order to clarify the role of PTES in LRS surgical management. We have conducted this differentiation, in order to acquire safer and more accurate conclusions about PTES usefulness. Co-existing diseases are more frequently in elderly individuals encountered; these conditions are associated with significant effects in patients' HRQoL. Moreover, comorbidities are often severe, automatically excluding these patients from the potentiality of general anesthesia administration and open decompression surgery conduction. PEVF may then represent a potential alternative for LRS surgical treatment.

In our study, nonetheless, enrolled nonelderly patients featured no comorbidities. Open decompression surgery with laminectomy and foraminotomy would represent the currently appropriate surgical selection. Nevertheless, experience in PTES conduction, outcomes of relevant studies in recent literature, thorough deliberation with the radiologists focusing on the precise anatomy and primary etiology of LRS in each case as well as the categorical denial of patients to be subjected to open decompression surgery under general anesthesia allowed us to perform PEVF. To our point of view, the absence of comorbidities in these otherwise healthy individuals verifies the reliability of our results. Enhancement of all parameters of SF-36 instituted a pure demonstration of PEVF favorable outcomes in HRQoL, which was affected from no other factors, as the involving comorbidities.

To the best of our knowledge, this is the first study in recent literature to evaluate the outcomes of full-endoscopic ventral facetectomy recruiting only nonelderly otherwise healthy

individuals with LRS, adding alongside HRQoL assessment. PEVF was centrally displayed to constitute a promising alternative over conventional laminectomy and foraminotomy for LRS surgical management. VAS scores (especially VAS-LP) and all parameters of HRQoL were recorded to be statistically and clinically notably ameliorated in the end of follow-up at 2 years.

To our point of view, the relatively limited follow-up evaluation constituted the primary limitation of our study. Nevertheless, no studies in the current literature have reported particular outcomes for transforaminal full-endoscopic surgery in nonelderly patients. Hence, further multicenter studies with larger samples and more extended follow-up evaluation are required, in order to delineate the precise role of full-endoscopic ventral facetectomy in LRS surgical treatment in nonelderly otherwise healthy individuals.

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Conflicts of interest

Dr. Kapetanakis is a reference doctor for joimax® GmbH and receives payments for teaching.

The other authors have no conflicts of interest to declare.

REFERENCES

1. Maeda T, Hashizume H, Yoshimura N, Oka H, Ishimoto Y, Nagata K, *et al.* Factors associated with lumbar spinal stenosis in a large-scale, population-based cohort: The Wakayama spine study. *PLoS One* 2018;13:e0200208.
2. Lafian AM, Torralba KD. Lumbar spinal stenosis in older adults. *Rheum Dis Clin North Am* 2018;44:501-12.
3. Poetscher AW, Gentil AF, Ferretti M, Lenza M. Interspinous process devices for treatment of degenerative lumbar spine stenosis: A systematic review and meta-analysis. *PLoS One* 2018;13:e0199623.
4. Thornes E, Robinson HS, Vøllestad NK. Dynamic balance in patients with degenerative lumbar spinal stenosis; a cross-sectional study. *BMC Musculoskelet Disord* 2018;19:192.
5. Ahn Y. Percutaneous endoscopic decompression for lumbar spinal stenosis. *Expert Rev Med Devices* 2014;11:605-16.
6. Doualla-Bija M, Takang MA, Mankaa E, Moutchia J, Ongolo-Zogo P, Luma-Namme H, *et al.* Characteristics and determinants of clinical symptoms in radiographic lumbar spinal stenosis in a tertiary health care centre in sub-Saharan Africa. *BMC Musculoskelet Disord* 2017;18:494.
7. Maugeri R, Basile L, Guli C, Banco A, Giordano G, Giugno A, *et al.* Percutaneous pedicle-lengthening osteotomy in minimal invasive spinal surgery to treat degenerative lumbar spinal stenosis: A Single-center preliminary experience. *J Neurol Surg A Cent Eur Neurosurg* 2018;79:365-71.
8. Tacconi L, Spinelli R. Lumbar canal stenosis: Can we treat it endoscopically? Our experience. *J Neurosurg Sci* 2018. [Ahead of print].
9. Kapetanakis S, Giovannopoulou E, Charitoudis G, Kazakos K. Transforaminal percutaneous endoscopic discectomy for lumbar disc herniation in Parkinson's disease: A Case-control study. *Asian Spine J* 2016;10:671-7.

10. Kapetanakis S, Charitoudis G, Thomaidis T, Theodosiadis P, Papathanasiou J, Giatroudakis K, *et al.* Health-related quality of life after transforaminal percutaneous endoscopic discectomy: An analysis according to the level of operation. *J Craniovertebr Junction Spine* 2017;8:44-9.
11. Kapetanakis S, Gkantsinikoudis N, Chaniotakis C, Charitoudis G, Givissis P. Percutaneous transforaminal endoscopic discectomy for the treatment of lumbar disc herniation in obese patients: Health-related quality of life assessment in a 2-year follow-up. *World Neurosurg* 2018;113:e638-49.
12. Yeung AT. The evolution and advancement of endoscopic foraminal surgery: One surgeon's experience incorporating adjunctive technologies. *SAS J* 2007;1:108-17.
13. Sairyo K, Chikawa T, Nagamachi A. State-of-the-art transforaminal percutaneous endoscopic lumbar surgery under local anesthesia: Discectomy, foraminoplasty, and ventral facetectomy. *J Orthop Sci* 2018;23:229-36.
14. Lewandrowski KU. "Outside-in" technique, clinical results, and indications with transforaminal lumbar endoscopic surgery: A retrospective study on 220 patients on applied radiographic classification of foraminal spinal stenosis. *Int J Spine Surg* 2014;8:26.
15. Li ZZ, Hou SX, Shang WL, Cao Z, Zhao HL. Percutaneous lumbar foraminoplasty and percutaneous endoscopic lumbar decompression for lateral recess stenosis through transforaminal approach: Technique notes and 2 years follow-up. *Clin Neurol Neurosurg* 2016;143:90-4.
16. Singh R, Zeng Xin G, Hirachan MP, Yu Cheng L. Outcome of percutaneous transforaminal endoscopic lumbar surgery in >60-year-old patients with low back pain. *Asian Spine J* 2018;12:511-7.
17. Powell JB, Gach JE. Phototherapy in the elderly. *Clin Exp Dermatol* 2015;40:605-10.
18. Kambin P, Brager MD. Percutaneous posterolateral discectomy. Anatomy and mechanism. *Clin Orthop Relat Res* 1987;223:145-54.
19. Lee JJ, Lee MK, Kim JE, Kim HZ, Park SH, Tae JH, *et al.* Pain relief scale is more highly correlated with numerical rating scale than with visual analogue scale in chronic pain patients. *Pain Physician* 2015;18:E195-200.
20. Kelly AM. Does the clinically significant difference in visual analog scale pain scores vary with gender, age, or cause of pain? *Acad Emerg Med* 1998;5:1086-90.
21. Zanolli G, Jönsson B, Strömqvist B. SF-36 scores in degenerative lumbar spine disorders: Analysis of prospective data from 451 patients. *Acta Orthop* 2006;77:298-306.
22. Andrasinova T, Adamova B, Buskova J, Kerkovsky M, Jarkovsky J, Bednarik J, *et al.* Is there a correlation between degree of radiologic lumbar spinal stenosis and its clinical manifestation? *Clin Spine Surg* 2018. [Ahead of print].
23. Lønne G, Fritzell P, Hägg O, Nordvall D, Gerdhem P, Lagerbäck T, *et al.* Lumbar spinal stenosis: Comparison of surgical practice variation and clinical outcome in three national spine registries. *Spine J* 2018. pii: S1529-9430(18)30253-5.
24. Lang G, Vicari M, Siller A, Kubosch EJ, Hennig J, Südkamp NP, *et al.* Preoperative assessment of neural elements in lumbar spinal stenosis by upright magnetic resonance imaging: An implication for routine practice? *Cureus* 2018;10:e2440.
25. Lee CH, Choi M, Ryu DS, Choi I, Kim CH, Kim HS, *et al.* Efficacy and safety of full-endoscopic decompression via interlaminar approach for central or lateral recess spinal stenosis of the lumbar spine: A meta-analysis. *Spine (Phila Pa 1976)* 2018. [Ahead of print].