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Improvement of lumbar spine function in patients with lumbar spinal stenosis by spinal endoscopic bilateral decompression of the spinal canal with unilateral interlaminar approach

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Abstract: Objective To analyze the effect of spinal endoscopic unilateral interlaminar approach with bilateral decompression of the spinal canal to improve lumbar spine function in patients with lumbar spinal stenosis (LSS). **Methods** A total of 82 patients with LSS admitted in Shanghai Jiao Tong University Affiliated Songjiang Hospital from August 2021 to August 2023 were selected and divided using the randomized numerical table method, in which 41 patients were treated with spinal endoscopic percutaneous interlaminar approach decompression of the spinal canal (control group), and 41 patients were treated with spinal endoscopic unilateral interlaminar approach bilateral decompression of the spinal canal (study group). The surgical indexes, lumbar spine function, pain level, imaging indexes, microinflammatory factors of the spinal canal, oxidative stress indexes, therapeutic effects and complications were compared between the two groups. **Results** Compared with the control group, the study group had a shorter operation time and bedtime, less intraoperative bleeding, lower herniation encroachment ratio and higher spinal canal area (P<0.05). At 24 h after surgery, in study group, monocyte chemotactic protein-1 (MCP-1) , interleukin (IL)-1β, IL-1α, serum malondialdehyde (MDA) were lower than those of the control group (P<0.05), while the levels of superoxide dismutase (SOD) and glutathione peroxidase (GSH Px) were higher than those of the control group (P<0.05). The excellent rate of MacNab in the study group was higher than that in the control group (92.68% vs 75.61%, χ^2=4.479, P<0.05), and the total incidence of complications was lower than that in the control group (4.88% vs 19.51%, χ^2=4.100, P<0.05). **Conclusion** SPercutaneous intervertebral foraminal approach and unilateral interlaminar approach are the commonly used approaches to perform spinal decompression in LSS patients, and both achieved good results, but spinal endoscopic unilateral interlaminar approach with bilateral decompression of the spinal canal is better, which is conducive to the improvement of lumbar spine function, reduce the degree of lumbar pain, spinal canal microinflammatory injury and oxidative stress injury, and reduce complications, and the clinic can be further popularized and applied.

Keywords: Lumbar spinal stenosis; Lpinal endoscopic bilateral decompression of the spinal canal with unilateral interlaminar approach; Lumbar spine function; Lpinal canal microinflammatory factor

Lumbar spinal stenosis (LSS) mainly affects middle-aged and elderly individuals, with the degree of spinal canal narrowing increasing with age [1]. Conservative treatment is often advocated clinically for LSS, which can effectively alleviate patients' symptoms in the short term. However, the long-term efficacy is not satisfactory, necessitating decompression surgery. Decompression surgeries of the spinal canal are common surgical approaches for treating LSS, which can effectively alleviate spinal cord compression, restore normal load capacity of the intervertebral joints, and improve lumbar spine function. However, these procedures are associated with significant trauma to the patient's body and a high incidence of postoperative complications, limiting their clinical effectiveness [2].

Minimally invasive spinal canal decompression surgery has been gradually used in the treatment of LSS, with promising clinical applications. Common surgical approaches include the percutaneous interlaminar endoscopic approach and the unilateral laminar approach, with differences in efficacy between different approaches [3]. Therefore, this study primarily analyzed the effectiveness of minimally invasive unilateral laminar decompression surgery for LSS patients.

1 Material and methods

1.1 General data

From August 2021 to August 2023, 82 patients with LSS from Shanghai Jiao Tong University Affiliated Songjiang Hospital were selected for the study. They were divided into study group and control group using a random number table, with 41 patients in each group. There were

24 males and 17 females in the study group, aged 40-72 (58.64±10.39) years old, with an average course of (3.12±0.48) years. There were 23 males and 18 females in the control group, aged 41-72 (58.73±10.42) years old, with an average course of (3.14±0.49) years. There was no statistically significant differences in general data between the two groups ($P > 0.05$).

Inclusion criteria: (1) based on the "Expert consensus on diagnosis and treatment for degenerative lumbar spinal stenosis", patients diagnosed with LSS by X-ray and CT examination; (2) single-segment stenosis; (3) with high surgical tolerance, and agree to received spinal canal decompression surgery; (4) informed consent from patients and their families to participate in the study.

Exclusion criteria: (1) diagnosis of multi-segmental LSS; (2) with history of lumbar spine surgery; (3) concurrent cancer, autoimmune diseases, or coagulation disorders; (4) with contraindications, inability to undergo surgery; (5) presence of other lumbar spine diseases such as vertebral canal deformities, lumbar vertebral fractures, discitis; (6) presence of psychiatric disorders, or sensory impairments.

1.2 Methods

The study group underwent minimally invasive unilateral laminotomy bilateral decompression (ULBD) surgery under spinal endoscopy. The surgical procedure was as follows: the patient was placed in a prone position with slight flexion at the hip and knee joints. General anesthesia was administered, and the surgical site was prepared and draped. The C-arm X-ray machine was used for positioning and marking of the surgical site, midline, and superior and inferior pedicles. A surgical incision, approximately 12-15 mm in length, was made adjacent to the articular prominence. The lamina and soft tissues were carefully dissected, and a working sleeve was inserted and an endoscope was introduced. After achieving hemostasis, the bone surface was adequately exposed, and the decompression range was assessed and marked. The lesion area was thinned using a burr drill, and the lamina was opened using laminectomy rongeurs until the ligamentum flavum was encountered. The contralateral part of the spinous process was identified and removed, followed by further removal of hypertrophic bone from the upper and lower laminae and the inner edge of the articular process. The intervertebral foramen was carefully expanded, and the ligamentum flavum was identified and excised to relieve pressure on the nerve roots and dura mater. The decompression effect was observed, and electrocoagulation hemostasis was performed. The endoscope and working sleeve were removed, and the surgical incision was sutured. Sterile dressings were applied to cover and dress the incision, and the surgery was completed.

The control group underwent percutaneous endoscopic lumbar decompression (PELD) surgery via the transforaminal approach. The surgical procedure was as follows: the patient was placed in a prone position, and anesthesia was administered at a point 12 cm lateral to the midline of the spine and at the level of the intervertebral space. A puncture needle was inserted into the skin and advanced to the intervertebral foramen, after which the stylet was removed and a guidewire was inserted. A surgical incision of approximately 7 mm in length was made along the puncture point, and the puncture needle was removed. A dilation tube was inserted under the guidance of the C-arm X-ray machine until reaching the articular prominence, after which the endoscope was inserted into the intervertebral foramen. The articular prominence was enlarged using a trephine, and hypertrophic bone was carefully removed to widen the intervertebral foramen. The ligamentum flavum was repaired and excised using a radiofrequency knife, and the nerve roots and protruding intervertebral disc were fully exposed. The protruding intervertebral disc was gently removed, and the outer annulus fibrosus was managed. After confirming the satisfactory decompression effect, electrocoagulation hemostasis was performed. The working channel and endoscope were removed, and the surgical incision was sutured. The surgery was completed with dressing of the incision.

1.3 Observation indicator

(1) Surgical indicators: including surgical time, intraoperative blood loss, and bedridden time.

(2) Lumbar function: evaluation criteria refer to the Oswestry Disability Index (ODI). ODI has a total score of 50 pionts, with lower scores indicating better lumbar function.

(3) Pain intensity: Visual Analog Scale (VAS) was selected as the evaluation tool, with a total score of 10 pionts, with higher scores representing stronger pain sensation.

(4) CT imaging indicators: Spiral CT was used to detect the percentage of protrusions and the area of the vertebral canal occupied by protrusions in both groups.

(5) Vertebral canal inflammatory factors: 6 mL of venous blood was collected before and 24 hours after surgery in a fasting state, centrifuged, and the serum was separated and stored at -20°C for subsequent analysis. Enzyme-linked immunosorbent assay (ELISA) was used to detect the levels of monocyte chemoattractant protein-1 (MCP-1), interleukin-1β (IL-1β), and interleukin-1α (IL-1α) in both groups.

(6) Oxidative stress indicators: Before and 24 hours after surgery, serum malondialdehyde (MDA), superoxide dismutase (SOD), and glutathione peroxidase (GSH-Px) levels were detected using ELISA in both groups.

(7) Treatment effect: The MacNab scoring criteria were used as the basis for judgment, ① Symptoms such as lower back and leg pain and restricted activity basically disappeared after treatment, classified as excellent; ② Symptoms such as lower back and leg pain significantly improved after treatment, with no intermittent pain, classified as good; ③ Symptoms such as lower back and leg pain were relieved to some extent after treatment, but intermittent pain existed, affecting normal life and work,

classified as fair; ④ There was no significant improvement in symptoms after treatment, classified as poor. The excellent and good rate was calculate.

(8) Complications: including nerve root injury, infection, and dural membrane injury.

1.4 Statistical methods

SPSS 25.0 software was used for data analysis. Measurement data were described as $\bar{x}\pm s$, and intergroup comparisons were made using independent sample *t*-tests. Count data were expressed as case (%), and intergroup comparisons were made using the chi-square test. A *P*-value less than 0.05 was considered statistically significant.

2 Results

2.1 Comparison of surgical indicators between two groups

The surgical time and bedridden time were shorter, and the intraoperative blood loss was less in the study group than those in the control group, with statistically significant difference ($P < 0.05$). **See Table 1.**

Tab.1 Comparison of surgical indicators between two groups (n=41, $\bar{x}\pm s$)

Group	Surgical time (min)	Intraoperative blood loss (mL)	Bedridden time (d)
Study group	100.85±10.24	352.78±29.56	6.35±1.47
Control group	109.73±10.46	368.42±33.21	8.96±1.72
t value	3.884	2.252	7.386
P value	< 0.001	0.027	< 0.001

2.2 Comparison of lumbar spine function and pain severity between two groups

Postoperatively, the ODI and VAS scores of the study group were lower than those of the control group, with statistically significant difference ($P < 0.05$). **See Table 2.**

Tab.2 Comparison of lumbar spine function and pain severity between two groups (n=41, $\bar{x}\pm s$)

Group	ODI Score		VAS Score	
	Before surgery	After surgery	Before surgery	After surgery
Study group	37.21±6.45	13.46±2.11	7.23±1.05	1.38±0.24
Control group	37.29±6.31	18.57±4.23	7.21±1.03	1.89±0.35
t value	0.057	6.955	0.087	7.695
P value	0.955	< 0.001	0.931	< 0.001

2.3 Comparison of CT imaging indicators between two groups

Postoperatively, the percentage of protrusions in the study group was lower than that in the control group, while the vertebral canal area was larger than that in the control group ($P < 0.05$). **See Table 3.**

Tab.3 Comparison of CT imaging indicators between two groups (n=41, $\bar{x}\pm s$)

Group	Percentage of protrusions (%)		Vertebral canal area (mm^2)	
	Before surgery	After surgery	Before surgery	After surgery
Study group	0.64±0.13	0.13±0.04	51.39±10.46	172.48±15.34
Control group	0.62±0.12	0.19±0.08	51.82±10.54	156.93±12.41
t value	0.724	4.295	0.185	5.046
P value	0.471	< 0.001	0.853	< 0.001

2.4 Comparison of treatment effect between two groups

The MacNab excellent and good rate in the study group was higher than that in the control group, with statistically significant difference ($P < 0.05$). **See Table 4.**

Tab.4 Comparison of treatment effect between two groups (n=41, case)

Group	Excellent	Good	Fair	Poor	Excellent and good rate (%)
Study group	20	18	2	1	92.68
Control group	17	14	7	3	75.61
χ^2 value					4.479
P value					0.034

2.5 Comparison of vertebral canal inflammatory factors between two groups

At 24 hours postoperatively, the levels of MCP-1, IL-1β, and IL-1α in both groups increased, with the study group being lower than the control group, the difference was statistically significant ($P < 0.05$). **See Table 5.**

2.6 Comparison of oxidative stress indicators between two groups

At 24 hours postoperatively, the level of MDA in the study group was lower than that in the control group, while the levels of SOD and GSH-Px were higher than those in the control group ($P < 0.05$). **See Table 6.**

2.7 Comparison of complication between two groups

There were 2 cases of infection in the study group, 1 case of nerve injury, 6 cases of infection, and 1 case of spinal cord injury in the control group. The total incidence of complications in the study group was lower than that in the control group (P<0.05).

Tab.5 Comparison of vertebral canal inflammatory factors between two groups (n=41, $\bar{x}\pm s$)

Group	MCP-1（pg/mL）		IL-1β（ng/L）		IL-1α（ng/L）	
	Before surgery	After surgery	Before surgery	After surgery	Before surgery	After surgery
Study group	196.38±21.45	285.62±24.97	10.26±1.45	20.93±4.12	9.23±1.08	16.45±2.89
Control group	196.83±21.47	372.56±28.35	10.38±1.47	28.75±6.11	9.26±1.09	21.36±4.82
***t* value**	0.095	14.736	0.372	22.435	0.125	5.594
***P* value**	0.925	＜0.001	0.711	＜0.001	0.901	＜0.001

Tab.6 Comparison of oxidative stress indicators between two groups (n=41, $\bar{x}\pm s$)

Group	MDA（μmol/L）		SOD（U/mL）		GSH-Px（pg/mL）	
	Before surgery	After surgery24 h	Before surgery	After surgery24 h	Before surgery	After surgery24 h
Study group	4.26±1.03	13.46±2.59	349.85±42.73	293.47±38.61	186.54±23.41	146.35±20.09
Control group	4.58±1.24	18.72±4.16	349.68±42.51	238.64±32.56	186.72±23.15	114.83±16.24
***t* value**	1.271	6.873	0.018	6.951	0.035	7.813
***P* value**	0.207	< 0.001	0.986	< 0.001	0.972	< 0.001

3 Discussion

LSS is a degenerative disease with a high incidence rate, second only to lumbar disc herniation. It is typically caused by factors such as lumbar vertebral osteophyte formation, facet joint hypertrophy, and thickening of the ligamentum flavum. Clinically, it manifests as symptoms such as lower back and leg pain, intermittent claudication, and limited lumbar extension [5-6].

For patients with severe conditions and no improvement after conservative treatment for three months, surgical intervention is necessary to rapidly improve clinical symptoms, relieve nerve compression, and control disease progression [7]. With the introduction of minimally invasive concepts and the improvement of minimally invasive techniques, minimally invasive surgery has become a trend in the treatment of LSS. Compared to traditional open surgery, the incision for endoscopic spinal canal decompression is smaller, allowing for maximum preservation of muscle tissue attachment points and reducing the extent of detachment of the deep fascia and multifidus muscles. During the surgery, muscle tissue does not need to be in a prolonged stretched state, promoting normal peripheral blood flow, reducing intraoperative bleeding, and alleviating postoperative pain. Additionally, spinal endoscopy can widen the surgical field of view, accurately locate the lesion, preserve the integrity of the posterior spinal ligaments, maintain the stability of the lumbar spine structure, and accelerate postoperative recovery [8-10].

The results of this study showed that the patients treated with unilateral interlaminar approach under spinal endoscopy for bilateral decompression had better surgical outcomes, CT imaging indicators, treatment efficacy, and lower complication rates compared to the control group. This finding was consistent with the research reported by Li et al [11], confirming the effectiveness and safety of the unilateral interlaminar approach under spinal endoscopy for bilateral decompression in the treatment of LSS. The reason for this can be analyzed as follows. Although the transforaminal percutaneous endoscopic approach can rapidly decompress the intervertebral foramen, relieving the pressure inside the dural sac to release the nerve roots, it has a blind spot in dealing with spinal canal stenosis, increasing surgical difficulty and duration [12]. In contrast, the unilateral interlaminar approach utilizes the interspace between the posterior vertebral plates as the puncture point, enabling direct penetration of the ligamentum flavum to reach the vertebral canal. This approach exposes the posterior aspect of the vertebral canal, allowing sequential decompression of the neural foramens, lateral recesses, and central canal. With endoscopic assistance, this approach simplifies the surgical steps, shortens the duration, reduces the risk of nerve and dural sac injuries associated with the surgical approach, decreases intraoperative bleeding and complications, enhances surgical safety, improves outcomes, and optimizes CT imaging parameters [13].

The study also found that the lumbar spine function scores and pain scores of study group were superior to those of control group, similar to the findings reported by Guo et al. [14]. The analysis attributes this to the fact that the percutaneous transforaminal approach enters the vertebral canal by enlarging the intervertebral foramen and may affect surgical outcomes and delay the recovery of lumbar function by not completing decompression under direct visualization. In contrast, the unilateral interlaminar approach achieves better decompression by clearing hypertrophic bone within the facet joints and the upper and lower vertebral plates while preserving the facet joints. This approach is more effective in relieving pressure within the dural sac, reducing the severity of lumbar pain, and improving lumbar function [15]. Although bilateral vertebral canal decompression via endoscopy is minimally invasive, it still inflicts trauma on the patient's body, causing local tissue damage, inflammation, and stress reactions, which exacerbate postoperative pain. MCP-1, IL-1β, and IL-1α are common clinical inflammatory mediators whose expression levels abnormally increase when the body undergoes an inflammatory response. MDA, SOD, and GSH-Px are oxidative stress indicators; when the body undergoes stress reactions, it produces large amounts of reactive oxygen species, depleting the levels of antioxidant enzymes (SOD and GSH-Px) and generating MDA. The study found that 24 h after surgery, the levels of inflammatory factors and MDA increased in both groups, while SOD and GSH-Px decreased, but the fluctuation amplitude in the study group was lower than that in the control group. The reason for this is that compared to the transforaminal percutaneous endoscopic approach, the unilateral interlaminar approach directly and extensively decompresses, effectively reducing the compression of nerve roots by the working channel, improving patients' surgical tolerance, reducing damage to the body, thereby alleviating inflammatory and oxidative stress responses, and accelerating postoperative recovery.

In summary, for patients with LSS, performing unilateral interlaminar approach under spinal endoscopy for bilateral decompression yields good results. This approach is beneficial for optimizing surgical and CT imaging indicators, improving lumbar spine function, alleviating lumbar spine pain symptoms, reducing inflammation and oxidative stress injuries within the spinal canal, decreasing the occurrence of complications, and increasing the MacNab excellent rate.

The authors report no conflict of interest

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· 论　著 ·

脊柱内镜下单侧椎板间入路双侧椎管减压术对腰椎管狭窄症患者腰椎功能的改善效果

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摘要：目的　分析脊柱内镜下单侧椎板间入路双侧椎管减压术改善腰椎管狭窄症（LSS）患者腰椎功能的效果。**方法**　选择 2021 年 8 月至 2023 年 8 月到上海交通大学医学院附属松江医院诊治的 LSS 患者 82 例，利用随机数字表法分组，实施脊柱内镜下经皮椎间孔入路椎管减压术治疗的 41 例患者纳入对照组，实施脊柱内镜下单侧椎板间入路双侧椎管减压术治疗的 41 例患者纳入研究组。对比两组的手术指标、腰椎功能、疼痛程度、影像学指标、椎管微炎症因子、氧化应激指标、治疗效果及并发症。**结果**　研究组手术时间、卧床时间短于对照组，术中出血量少于对照组（$P<0.05$）。术后，研究组突出物侵占比低于对照组，椎管面积大于对照组（$P<0.05$）。术后 24 h，研究组单核细胞趋化蛋白-1（MCP-1）、白细胞介素（IL）-1β、IL-1α 及血清丙二醛（MDA）低于对照组（$P<0.05$），超氧化物歧化酶（SOD）及谷胱甘肽过氧化物酶（GSH-Px）水平高于对照组（$P<0.05$）。研究组 MacNab 优良率高于对照组（92.68% *vs* 75.61%，$\chi^2=4.479$，$P<0.05$），并发症总发生率低于对照组（4.88% *vs* 19.51%，$\chi^2=4.100$，$P<0.05$）。**结论**　对于 LSS 患者，经皮椎间孔入路与单侧椎板间入路均取得良好的效果，但脊柱内镜下单侧椎板间入路双侧椎管减压术的效果更佳，有利于改善腰椎功能，减轻腰椎疼痛程度、椎管微炎症损伤和氧化应激损伤，减少并发症的发生。

关键词： 腰椎管狭窄症；脊柱内镜下单侧椎板间入路双侧椎管减压术；腰椎功能；椎管微炎症因子

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Improvement of lumbar spine function in patients with lumbar spinal stenosis by spinal endoscopic bilateral decompression of the spinal canal with unilateral interlaminar approach

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Abstract: Objective　To analyze the effect of spinal endoscopic unilateral interlaminar approach with bilateral decompression of the spinal canal in the improvement of lumbar spine function in patients with lumbar spinal stenosis (LSS). **Methods**　A total of 82 patients with LSS admitted in Songjiang Hospital Affiliated to Shanghai Jiao Tong University School of Medicine from August 2021 to August 2023 were selected and divided using the randomized numerical table method, in which 41 patients were treated with spinal endoscopic percutaneous interlaminar approach decompression of the spinal canal (control group), and 41 patients were treated with spinal endoscopic unilateral interlaminar approach bilateral decompression of the spinal canal (study group). The surgical indexes, lumbar spine function, pain level, imaging indexes, microinflammatory factors of the spinal canal, oxidative stress indexes, therapeutic effects and complications were compared between the two groups. **Results**　Compared with the control group, the study group had a shorter operation time and bedtime, less intraoperative bleeding, lower herniation encroachment ratio and higher spinal canal area ($P<0.05$). At 24 h after surgery, in study group, monocyte chemotactic protein-1

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(MCP-1), interleukin (IL)-1β, IL-1α, serum malondialdehyde (MDA) were lower than those of the control group ($P<0.05$), while the levels of superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) were higher than those of the control group ($P<0.05$). The excellent rate of MacNab in the study group was higher than that in the control group (92.68% *vs* 75.61%, $\chi^2=4.479$, $P<0.05$), and the total incidence of complications was lower than that in the control group (4.88% *vs* 19.51%, $\chi^2=4.100$, $P<0.05$). **Conclusion** Both percutaneous intervertebral foraminal approach and unilateral interlaminar approach have good therapeatic effects in LSS patients, but spinal endoscopic unilateral interlaminar approach with bilateral decompression of the spinal canal is better, which is conducive to the improvement of lumbar spine function, reduce the degree of lumbar pain, spinal canal microinflammatory injury and oxidative stress injury, and reduce complications, and the clinic can be further popularized and applied.

Keywords: Lumbar spinal stenosis; Lpinal endoscopic bilateral decompression of the spinal canal with unilateral interlaminar approach; Lumbar spine function; Lpinal canal microinflammatory factor

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腰椎管狭窄症(lumbar spinal stenosis, LSS)以中老年人为主要患病群体,且椎管狭窄程度随着年龄的增加而加重[1]。临床对 LSS 主张实施保守治疗,虽能有效缓解患者的临床症状,但远期疗效不理想,需采取减压术治疗。椎管减压术是临床治疗 LSS 的常用术式,可有效缓解脊髓压迫情况,推动椎间关节载荷能力恢复正常,改善腰椎功能,但对患者身体造成的创伤较大、术后并发症较多,临床疗效有限[2]。脊柱内镜下椎管减压术逐渐用于 LSS 治疗,且临床应用前景广阔,经皮椎间孔入路与单侧椎板间入路是常见手术入路方式,不同入路方式的疗效存在差异[3]。鉴于此,本研究主要分析脊柱内镜下单侧椎板间入路双侧椎管减压术用于 LSS 患者的效果,报道如下。

1　资料与方法

1.1　*一般资料*　将 2021 年 8 月至 2023 年 8 月上海交通大学医学院附属松江医院 82 例 LSS 患者纳入研究,按随机数字表法分为研究组和对照组,每组 41 例。研究组男 24 例,女 17 例;年龄 40～72 (58.64±10.39)岁;病程(3.12±0.48)年。对照组男 23 例,女 18 例;年龄 41～72(58.73±10.42)岁;病程(3.14±0.49)年。两组一般资料差异无统计学意义($P>0.05$)。纳入标准:(1) 以《退行性腰椎管狭窄症诊疗专家共识》[4] 为基础,X 线及 CT 检查符合 LSS 的诊断;(2) 均为单一节段狭窄;(3) 对手术耐受程度较高,同意择期行椎管减压术治疗;(4) 患者及家属对拟采取的研究方案知情并愿意参加本研究。排除标准:(1) 诊断为多节段 LSS;(2) 存在腰椎手术治疗史;(3) 并发癌症、自身免疫性疾病或凝血功能障碍;(4) 具备手术禁忌证,无法实施手术治疗;(5) 并发椎管畸形、腰椎骨折、椎间盘炎等其他腰椎疾病;(6) 精神病或视听功能障碍。

1.2　*方法*　研究组实施脊柱内镜下单侧椎板间入路双侧椎管减压术治疗,手术流程为:患者采取俯卧姿势,髋关节和膝关节处于轻微屈曲状态,做好全身麻醉和消毒铺巾处理,利用 C 型臂 X 线机定位和标记手术部位、后正中线、上下椎弓根。沿着关节突出部位旁作一长度 12～15 mm 的手术切口,仔细分离关节突表层的椎板、软组织,确定分离后放入工作套管并插入内窥镜;止血后充分暴露骨面,评估和标记病灶的减压范围,使用磨钻打薄病灶部位,利用椎板咬骨钳打开椎管,直至黄韧带止点方可停止;找准对侧部分棘突根部并咬除,再次使用磨钻削磨掉上下椎板 1/2 的增生骨质和关节突内缘处的增生骨质,仔细扩大侧隐窝,找准黄韧带并切除,以减轻神经根和硬膜囊的压力,观察减压情况,确定减压效果良好后电凝止血,取出内窥镜和工作套管,缝合手术切口,使用无菌敷料覆盖包扎切口,手术结束。

对照组开展脊柱内镜下经皮椎间孔入路椎管减压术治疗,手术方法为:患者采取俯卧姿势,在距离间隙水平线和脊柱后中线旁 12 cm 的位置进行麻醉处理,将穿刺针刺入皮肤,刺入椎间孔处后取出针芯、置入导丝,并沿着穿刺点作一长度大约为 7 mm 的手术切口,取出穿刺针。在 C 型臂 X 线机下置入扩张导管,直至关节突部位方可停止,随后在椎间孔插入脊柱内镜,使用环锯扩大关节突,仔细磨除关节突的增生骨质以扩大椎间孔;使用射频刀修理黄韧带并切除,充分暴露神经根和突出椎间盘,轻轻摘掉突出椎间盘,处理外层纤维环;确定减压效果良好后进行电凝止血,取出工作通道和脊柱内镜,缝合手术切口,手术结束。

1.3　观察指标　(1) 手术指标:包括手术时间、术中出血量和卧床时间。(2) 腰椎功能:评估标准参照 Oswestry 功能障碍指数(Oswestry disability index, ODI)ODI 量表总计 50 分,分数越低则腰椎功能越好。(3) 疼痛程度:选择视觉模拟评分法(visual analogue scale, VAS)作为评估工具,总计 10 分,分数越高则代表痛感越强烈。(4) CT影像学指标:使用螺旋 CT 检测两组的突出物侵占比和椎管面积。(5) 椎管微炎症因子:术前与术后 24 h,在空腹状态下抽取 6 mL 静脉血,做好离心处理,分离血清后保存在-20 ℃的冰箱中备用,使用酶联免疫吸附法(enzyme-linked immunosorbent assay, ELISA)检测两组的单核细胞趋化蛋白-1(monocyte chemotactic protein-1, MCP-1)、白细胞介素(interlenkin, IL)-1β 及 IL-1α 水平。(6) 氧化应激指标:术前与术后 24 h,利用 ELISA 检测两组的血清丙二醛(malondialdehyde, MDA)、超氧化物歧化酶(superoxide dismutase, SOD)及谷胱甘肽过氧化物酶(glutathione peroxidase, GSH-Px)水平。(7) 治疗效果:将 MacNab 评分标准作为判断依据。① 治疗后患者腰腿痛、活动受限等症状基本消失,评定为优;② 治疗后患者的腰腿痛等症状明显改善,未出现间歇性疼痛,则视为良;③ 治疗后患者的腰腿痛等症状有所缓解,但存在间歇性疼痛,对正常生活和工作造成影响,评定为可;④ 治疗后病情无明显改善,视为差。计算 MacNab 优良率。(8) 并发症:包括神经根损伤、感染、硬脊膜损伤。

1.4　统计学方法　采用 SPSS 25.0 软件处理数据。计量资料用 $\bar{x}\pm s$ 表示,采用独立样本 t 检验;计数资料以例(%)表示,采用 χ^2 检验。$P<0.05$ 为差异有统计学意义。

2　结　果

2.1　两组手术指标比较　研究组手术时间、卧床时间短于对照组,术中出血量少于对照组($P<0.05$)。见表 1。

2.2　两组腰椎功能和疼痛程度比较　术后 24 h,研究组 ODI 评分及 VAS 评分低于对照组($P<0.05$)。见表 2。

2.3　两组 CT 影像学指标比较　术后研究组突出物侵占比低于对照组,椎管面积大于对照组($P<0.05$)。见表 3。

2.4　两组治疗效果比较　研究组 MacNab 优良率高于对照组($P<0.05$)。见表 4。

2.5　两组椎管微炎症因子水平比较　术后 24 h,两组的 MCP-1、IL-1β 及 IL-1α 水平均升高,且研究组低于对照组($P<0.05$)。见表 5。

2.6　两组氧化应激指标比较　术后 24 h,研究组 MDA 低于对照组,SOD 及 GSH-Px 水平高于对照组($P<0.05$)。见表 6。

2.7　两组并发症发生率比较　研究组发生感染 2 例,对照组发生神经损伤 1 例,感染 6 例,硬脊膜损伤 1 例。研究组并发症总发生率低于对照组(4.88% *vs* 19.51%, $\chi^2=4.100$, $P<0.05$)。

表 1　两组手术指标比较　($n=41$, $\bar{x}\pm s$)

Tab. 1　Comparison of surgical indicators between two groups　($n=41$, $\bar{x}\pm s$)

组别	手术时间(min)	术中出血量(mL)	卧床时间(d)
研究组	100.85±10.24	352.78±29.56	6.35±1.47
对照组	109.73±10.46	368.42±33.21	8.96±1.72
t 值	3.884	2.252	7.386
P 值	<0.001	0.027	<0.001

表 2　两组腰椎功能和疼痛程度比较　($n=41$, 分, $\bar{x}\pm s$)

Tab. 2　Comparison of lumbar spine function and pain severity between two groups　($n=41$, point, $\bar{x}\pm s$)

组别	ODI 评分		VAS 评分	
	术前	术后 24 h	术前	术后 24 h
研究组	37.21±6.45	13.46±2.11	7.23±1.05	1.38±0.24
对照组	37.29±6.31	18.57±4.23	7.21±1.03	1.89±0.35
t 值	0.057	6.955	0.087	7.695
P 值	0.955	<0.001	0.931	<0.001

表 3　两组 CT 影像学指标比较　($n=41$, $\bar{x}\pm s$)

Tab. 3　Comparison of computed tomography imaging indexes between two groups　($n=41$, $\bar{x}\pm s$)

组别	突出物侵占比(%)		椎管面积(mm^2)	
	术前	术后	术前	术后
研究组	0.64±0.13	0.13±0.04	51.39±10.46	172.48±15.34
对照组	0.62±0.12	0.19±0.08	51.82±10.54	156.93±12.41
t 值	0.724	4.295	0.185	5.046
P 值	0.471	<0.001	0.853	<0.001

表 4　两组治疗效果比较　(例)

Tab. 4　Comparison of treatment effects between two groups　(case)

组别	例数	优	良	可	差	MacNab 优良率(%)
研究组	41	20	18	2	1	92.68
对照组	41	17	14	7	3	75.61
χ^2 值						4.479
P 值						0.034

表 5　两组椎管微炎症因子水平比较　($n=41$,$\bar{x}\pm s$)

Tab. 5　Comparison of levels of vertebral canal inflammatory factors between two groups　($n=41$, $\bar{x}\pm s$)

组别	MCP-1(pg/mL)		IL-1β(ng/L)		IL-1α(ng/L)	
	术前	术后 24 h	术前	术后 24 h	术前	术后 24 h
研究组	196.38±21.45	285.62±24.97[a]	10.26±1.45	20.93±4.12[a]	9.23±1.08	16.45±2.89[a]
对照组	196.83±21.47	372.56±28.35[a]	10.38±1.47	28.75±6.11[a]	9.26±1.09	21.36±4.82[a]
t 值	0.095	14.736	0.372	22.435	0.125	5.594
P 值	0.925	<0.001	0.711	<0.001	0.901	<0.001

注:与术前比较,[a]$P<0.05$。

表 6　两组氧化应激指标比较　($n=41$, $\bar{x}\pm s$)

Tab. 6　Comparison of oxidative stress indicators between two groups　($n=41$, $\bar{x}\pm s$)

组别	MDA(μmol/L)		SOD(U/mL)		GSH-Px(pg/mL)	
	术前	术后 24 h	术前	术后 24 h	术前	术后 24 h
研究组	4.26±1.03	13.46±2.59	349.85±42.73	293.47±38.61	186.54±23.41	146.35±20.09
对照组	4.58±1.24	18.72±4.16	349.68±42.51	238.64±32.56	186.72±23.15	114.83±16.24
t 值	1.271	6.873	0.018	6.951	0.035	7.813
P 值	0.207	<0.001	0.986	<0.001	0.972	<0.001

3　讨　论

LSS 发病率高,其患病人数仅次于腰椎间盘突出症,通常是由于腰椎骨质增生、关节突增生肥大、黄韧带增厚等所致,临床上表现为腰腿痛、间歇性跛行、腰部过伸行动受限等症状[5-6]。

对于病情严重、且保守治疗 3 个月后无效的 LSS 患者,需采取手术治疗快速改善临床症状、解除神经压迫、控制病情恶化[7]。随着微创理念的提出、微创技术水平的提升,微创术式成为 LSS 治疗趋势。与传统开放术式相比,脊柱内镜下椎间管减压术的手术切口小,能最大程度上保留肌肉组织的附着点,缩小深筋膜和多裂肌的剥离范围[8];手术过程中,肌肉组织不需要长期处于牵拉状态,促使周围血运维持正常,减少术中出血量,减轻术后痛感[9];此外,脊柱内镜能拓宽手术视野,精准定位病灶部位,实现椎管减压的同时保留脊柱后方韧带的完整性、维持腰椎结构的稳定性,加快术后康复速度[10]。

本研究结果显示,研究组经脊柱内镜下单侧椎板间入路双侧椎管减压术治疗后,其手术指标、CT 影像学指标、治疗效果及并发症发生率均优于对照组,与李鹏等[11]研究报道相似,证实了脊柱内镜下单侧椎板间入路双侧椎管减压术用于 LSS 治疗的有效性和安全性。分析其原因是:经皮椎间孔入路虽能快速降压椎间孔,释放硬膜囊内空间压力以松解神经根,但在处理椎管狭窄时存在视野盲区,增加手术操作难度,延长手术耗时,且实施偏腹侧穿刺容易损伤腹腔内脏器,增加术后并发症发生的风险[12]。而单侧椎间板入路将腰椎后路椎板间隙作为穿刺点,能直接刺穿黄韧带抵达椎管,显露椎管后切开纤维环,依次对神经根管、侧隐窝、中央椎管进行减压处理;单侧椎间板入路在内窥镜辅助下完成穿刺,刺破黄韧带后挑选最优操作点,有利于精简手术操作步骤,缩短手术耗时,减轻手术入路导致的神经损伤、硬膜脊损伤,减少术中出血量和并发症,提高手术安全性,提高手术效果[13]。本研究发现,研究组的腰椎功能评分及疼痛评分优于对照组,与郭泽等[14]研究报道相似。分析其原因是:经皮椎间孔入路通过扩大椎间孔的方式进入椎管,且没有在直视下完成减压操作,可能会影响手术效果,延缓腰椎功能康复速度;而单侧椎间板入路通过清理小关节突内缘增生骨质、上下椎板增生骨质,在保留关节突的基础上进行椎管减压,获取的减压效果更佳,更有利于释放硬膜囊内空间压力,减轻腰椎疼痛程度,改善腰椎功能[15]。虽然脊柱内镜下双侧椎管减压术属于微创术式,但其作为创伤性治疗手段,仍会对患者的身体造成创伤,产生局部组织损伤,引发炎症反应和应激反应,加重术后疼痛。MCP-1、IL-1β 及 IL-1α 是临床常见的炎症介质,当机体出现炎症反应后,其表达水平会异常升高。MDA、SOD 及 GSH-Px 均为氧化应激指标,当机体出现应激反应后产生大量的活性氧,消耗抗氧化酶(SOD 及 GSH-Px)含量,并生成 MDA。本研究发现,术后 24 h,两组的炎症因子及 MDA 均升高,SOD 及 GSH-Px 下降,但研究组的波动幅度低于对照组。分析其原因是:同经皮椎间孔入路相比,单侧椎间板入路的减压方式更直接、减压面积更大,能有效缩小工作通道对神经根造成的挤压,提高患者的手术耐受力,减小对身体造成的损伤,进而减轻炎症反应和氧化应激反应,加快术后康复速度。

综上所述,针对 LSS 患者,实施脊柱内镜下单侧

椎板间入路双侧椎管减压术的效果良好,有利于优化手术指标和 CT 影像学指标,改善腰椎功能,缓解腰椎疼痛症状,减轻椎管内炎症损伤和氧化应激损伤,减少并发症的发生,提高 MacNab 优良率。

利益冲突　无

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