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ORIGINAL PAPER

Percutaneous endoscopic decompression via transforaminal approach for lumbar lateral recess stenosis in geriatric patients

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Abstract

Purpose We aimed to investigate the surgical strategy, safety, and efficacy of percutaneous endoscopic decompression via transforaminal approach for lumbar lateral recess stenosis in geriatric patients.

Methods From January 2012 to June 2014, 25 elderly patients (18 males and 7 females) with symptomatic lumbar lateral recess stenosis were performed percutaneous endoscopic transforaminal decompression. The ages of patients ranged from 70 to 93 years (mean 79.6 years). Clinical outcomes were assessed mainly by leg pain visual analogue scale (VAS), Oswestry disability index (ODI) score, MacNab criteria, and post-operative computerized tomographic (CT) scanning.

Results The surgery was successfully completed in all patients with an average operation time of 75 minutes (range, 50–110 min). The lumbar CT images at two days after the operation demonstrated distinct enlargement of the foramen intervertebrale as well as satisfactory decompression of the lumbar lateral recess. And 24 patients of the group were followed up for a mean duration of 29 ± six months (range, 12–44 months). The leg pain VAS score decreased from 8.52 ± 1.11 pre-operatively to 1.80 ± 0.63, 1.33 ± 0.89, 1.05 ± 0.69, and 0.71 ± 0.50 at one, three, six and 12 months after the operation, respectively. Besides, the ODI score also dropped from 59.43 ± 10.04 pre-operatively to 29.42 ± 10.33, 20.13 ± 8.18, 13.98 ± 6.16, and 9.86 ± 5.03 at one, three, six and 12 months during the post-operative follow-up period. Statistically significant differences existed in both VAS score and ODI score at each follow-up time point when compared with the pre-operative scores ($P < 0.05$). The mean reciprocal angulation change of the operated segment in dynamic lumbar lateral view was 3.2° ± 1.6° at the last follow-up. And there were 18 excellent cases, three good cases, and three fair cases according to the MacNab criteria, and the excellent and good rate was 87.5% at 12 months after the operation. There was no aggravation of the coexisting medical conditions after operation in this group. Only 1 case was found complicated with lower extremity numbness, which was recovered by conservative treatment for two weeks. No persistent neurological deficit or soft tissue infection occurred in all patients post-operatively.

Conclusions We considered that percutaneous endoscopic transforaminal decompression achieved satisfactory results and provided a safe, effective, and less invasive alternative for treating lumbar lateral recess stenosis in geriatric patients.

Keywords Lumbar lateral recess stenosis · Percutaneous endoscopic decompression · Transforaminal approach · Geriatric

Introduction

Lumbar spinal stenosis is considered as a degenerative disease in geriatric people. Based on anatomical types, stenosis can happen at the central spinal canal, lateral recess, or intervertebral foramina site, while lateral recess stenosis is most common. It may be caused by hyperostosis, discal, or ligamentous structures, and classic clinical symptom is neurogenic claudication with radicular signs [1]. The number of geriatric patients with degenerative lumbar lateral recess stenosis has been increasing along with the deepening of aging process worldwide. And conservative treatments usually have no significant effects. These patients usually have long-term

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courses of disease, severe symptoms, and poor general conditions. It is an issue worth considering how simple, effective, and safe treatments can be performed to relieve their pain and discomfort and to improve their quality of life. Percutaneous endoscopic technology has been a minimally invasive treatment for disc herniation [2–4]. It has comparative efficacy with classical microdiscectomy, but with less trauma and faster recovery after operation [5–7]. However, with the improvement of surgical skills and advancement of optical equipment systems and operative instrument, indications of percutaneous endoscopic surgery have been gradually expanding [8].

In this study, we describe the clinical efficacy of percutaneous endoscopic transforaminal decompression in the treatment of geriatric patients with symptomatic lumbar lateral recess stenosis.

Materials and methods

Patients

After the institutional review board approval, we enrolled a total of 25 geriatric patients (18 male and 7 female) with lower extremity radiculopathy due to lumbar lateral recess stenosis who performed percutaneous endoscopic transforaminal decompression under local anesthesia in our department from January 2012 to June 2014. The mean age of patients at the time of surgical treatment was 79.6 years (range, 70–93 years). The duration of clinical symptoms ranged from three to 76 months (mean 18 months). After undergoing computed tomography (CT) and magnetic resonance imaging (MRI), all enrolled patients were diagnosed with single lumbar lateral recess stenosis, including four in segments L3–L4, 12 in segments L4–L5, and nine in segments L5–S1. Magnetic resonance imaging (MRI) in 25 patients was obtained with two grade 1, six grade 2, and 17 grade 3 according to the Bartynski [9] classification system. Besides, internal medical histories of all patients were asked in detail before the operation. And necessary pre-operative examination was performed on all the patients. Baseline characteristics of all the patients were shown in Table 1. One male patient was lost to follow-up after discharged from hospital. And the remaining 24 patients (17 male and 7 female) all had more than one year follow-up.

Inclusive and exclusive criteria

Inclusive criteria (1) The age of patient was equal or more than 70 years old; (2) the main symptom was intermittent claudication with lower extremity pain and numbness; (3) for computed tomography (CT), magnetic resonance imaging (MRI), etc., imaging characteristics were in accordance with clinical symptoms; (4) no efficacy after more than three month conservative therapy, or recurrent attacks of the symptom; and (5) clinical data of the patients were sufficient, with more than one year follow-up.

Exclusive criteria (1) The patient was below 70 years in age; (2) patient was performed with open surgical procedures (fenestration, hemilaminectomy, etc.); (3) patient with central spinal canal stenosis; (4) patient combined with lumbar spondylolisthesis or instability; (5) the intervertebral foramen of the responsible segment (L5–S1) was completely blocked by the transverse process or iliac crest; (6) combined with infected lesions on the puncture path; and (7) patient with abnormal blood coagulation function and serious mental disorder.

Surgical procedure

Patients were prone to arch cushions by bending their hips and knees, with their abdomen vacant and without discomfort. The puncture site was decided based on patients' figure and CT or MR cross-sectional imaging before operation. Lidocaine (0.5%) was used to conduct local layered anaesthesia through an 18-G puncturing needle. The puncturing needle perforated toward the targeted point under the guidance of C-arm imaging. The needle inner core was then taken out and the guide wire was put into the disc. The next step was to take out the needle, and an 8-mm incision was made by an 11# blade at the needle entering point. A 2-mm expansion guiding rod was inserted along the guide wire, and the catheter was inserted successively along the rod step by step to expand the soft tissues. Trepans were used for the foraminoplasty step by step from small to large diameters to abrade articular osteophytes and a part of the anterolateral portion of the superior facet joint. The trepan was taken out after reaming, and a working sheath was placed in. Under fluoroscopy, the sheath ramp was positioned between the inner edge of the pedicle and spinous process in the anteroposterior view, while the sheath tip was positioned at the posterior upper edge of the inferior vertebral body in the lateral view.

The endoscope was placed inside the sheath, and the ligamentum flavum that was hypertrophied or even calcified was first seen. Straight and angled forceps and a bipolar radiofrequency system were used to cut and ablate the ligamentum flavum, expose the underlying nerve root, and remove herniated lumbar disc when patients combined with lumbar disc herniation. A radiofrequency system was further used to ablate the outer annulus fibrosus that caused the nerve root compression. Endoscopic tools like osteotome, trepan, abrasive drill, etc. were used to remove hyperplasia superior facet, vertebral posterior edge, and osteophytes that existed at the nerve root shoulder. The sheath was rotated from cephalic to caudal along the nerve root to confirm that its dorsal and ventral sides had been fully decompressed. Nerve roots pulsed obviously and their surface vessels were well filled under the

Table 1 Baseline characteristics of the included patients

No.	Sex	Age (years)	Level	Duration of symptoms (months)	Grade of lateral recess stenosis (0–3)	Pre-operative comorbidities	Duration of follow-up (months)	MacNab efficacy
1	Male	84	L4–L5	12	2	Diabetes	22	Excellent
2	Male	70	L4–L5	10	3	Hypertension, diabetes	20	Excellent
3	Male	79	L3–L4	21	3	Hypertension, coronary heart disease	26	Good
4	Female	76	L4–L5	7	3	–	44	Excellent
5	Male	83	L5–S1	16	2	Hypertension	29	Excellent
6	Male	90	L4–L5	6	3	Hypertension, coronary heart disease	30	Excellent
7	Female	76	L5–S1	12	2	–	32	Excellent
8	Male	81	L4–L5	76	3	Hypertension	28	Fair
9	Female	73	L5–S1	19	3	Hypertension	27	Excellent
10	Male	88	L3–L4	26	3	–	Lost to follow-up	–
11	Male	93	L4–L5	15	3	–	39	Excellent
12	Female	78	L5–S1	12	3	Hypertension, coronary heart disease	24	Excellent
13	Male	81	L5–S1	9	2	Hypertension, diabetes, cerebral thrombosis without sequelae	27	Excellent
14	Male	70	L5–S1	38	2	Hypertension, coronary heart disease	37	Fair
15	Male	84	L4–L5	14	3	Diabetes, sinus bradycardia	30	Excellent
16	Female	77	L5–S1	16	3	Hypertension, atrial fibrillation	26	Good
17	Male	78	L4–L5	3	3	Arrhythmia with permanent pacemaker implanted	36	Excellent
18	Female	75	L4–L5	9	1	Diabetes	24	Excellent
19	Male	79	L5–S1	20	3	–	28	Excellent
20	Male	80	L3–L4	23	3	Hypertension, coronary heart disease	12	Good
21	Female	74	L4–L5	14	2	–	27	Excellent
22	Male	82	L5–S1	8	1	Cerebral thrombosis without sequelae	34	Excellent
23	Male	78	L4–L5	42	3	–	30	Fair
24	Male	85	L3–L4	6	3	Diabetes	28	Excellent
25	Male	75	L4–L5	16	3	Sinus bradycardia, diabetes	24	Excellent

endoscopic field. The endoscope and working sheath were taken out, and the incision was sutured with one stitch. Figure 1 shows the specific operation process.

Efficacy evaluation

Clinical efficacy was assessed mainly by leg pain visual analogue scale (VAS) score; the Oswestry disability index (ODI) score at one, three, six and 12 months after the surgery, respectively; and the excellent and good rate according to the MacNab criteria [10]. And clinical evaluation also included post-operative computerized tomographic scanning (CT), complications with subsequent remedy, recurrence of symptoms, and duration of hospitalization.

Statistical analysis

Statistical analysis was performed by SPSS software, version 20.0 (SPSS Inc., Chicago, IL, USA). Results were presented as mean ± standard deviation. The one-way ANOVA Dunnett *t* test was used for comparison of leg pain VAS and ODI scores respectively. And Spearman's coefficient was used for evaluating the correlation of MacNab efficacy and grade of lateral recess stenosis. P value < 0.05 was considered statistically significant.

Results

All the 25 patients underwent the operation successfully. The operation time was 50–110 minute, with an average of 75 ± 40 minutes. Patients could stand on their feet with a lumbar brace after two to four hours lying on bed after operation. The mean hospital stay was 2.3 ± 0.8 days (range, 1-3 days). They needed to wear a lumbar brace within six weeks and to avoid actions like bending or twisting the waist. Only one male patient was lost to follow-up after discharged from hospital. And the remaining 24 patients were followed up for a mean duration of 29 ± six months (range, 12-44 months). Both the leg pain VAS scores and the ODI scores were significantly

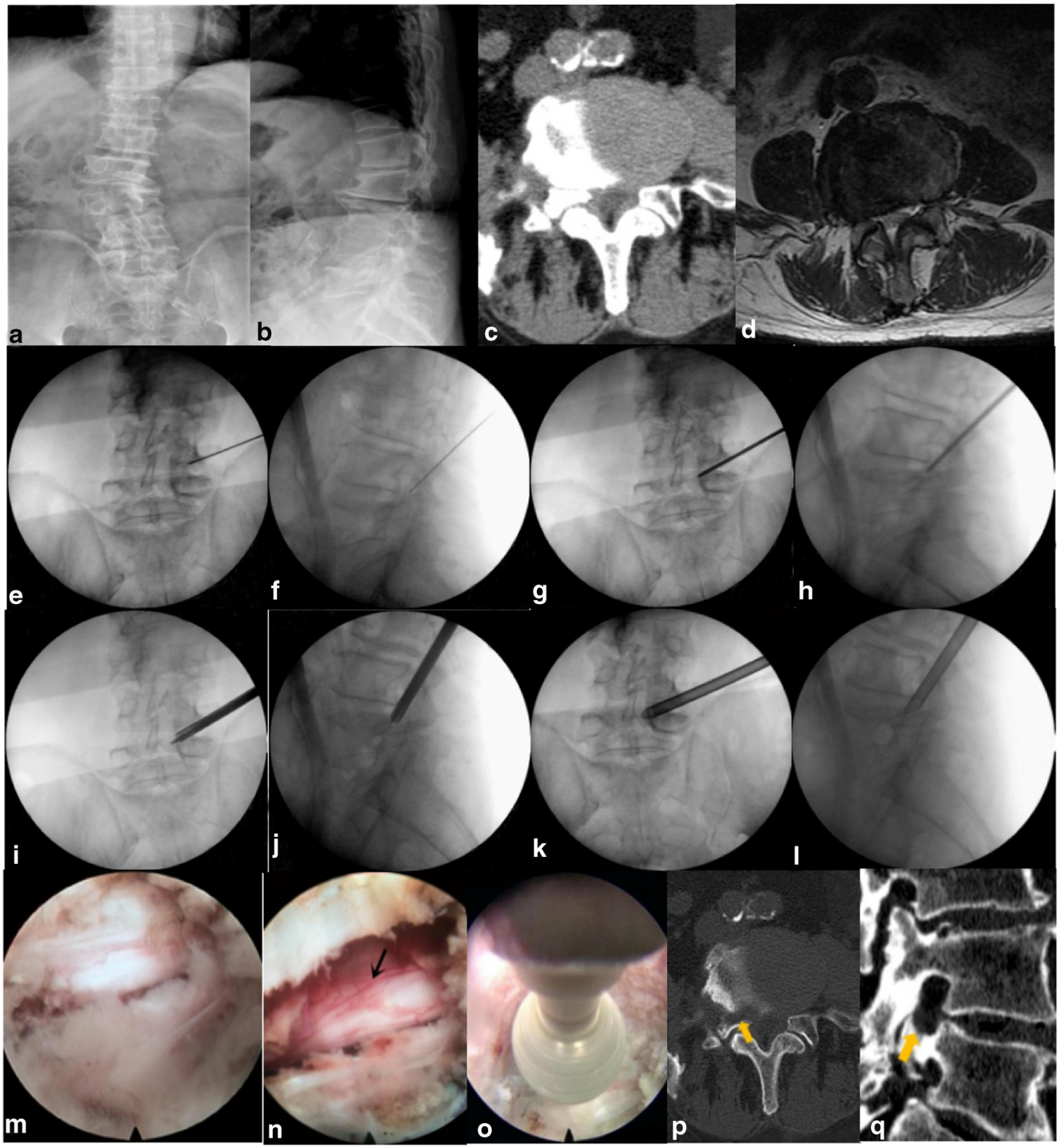

Fig. 1 A 90-year-old male patient suffered from right leg extremity pain and numbness for half a year, with intermittent claudication and the walking distance less than 50 metres. Straight-leg raising test was negative, hallux extensus strength was grade III, and there was hypoalgesia on the lateral side of right calf. **a**-**b** Pre-operative X-ray showed degenerative lumbar scoliosis. **c**-**d** Pre-operative CT (**c**) and MRI (**d**) showed L4/5 lateral recess stenosis (right side). **e**-**f** The puncturing needle perforated toward the targeted point under the guidance of C-arm imaging. **g**-**h** A 2-mm expansion guiding rod was inserted along the guide wire. **i**-**j** Trepans were used for the foraminoplasty step by step from small to large diameters. **k**-**l** The trepan was taken out after reaming, and a working sheath was placed in. **m** The nerve root was compressed. **n** Bony compression was relieved by endoscopic burr drill. **o** Revascularization was shown on the nerve root surface after decompression (black arrow). **p**-**q** Postoperative CT showed distinct enlargement of the foramen and satisfactory decompression of the lateral recess (yellow arrow)

lower at all post-operative time points than those before the operation. The leg pain VAS score was decreased from 8.52 ± 1.11 pre-operatively to 1.80 ± 0.63, 1.33 ± 0.89, 1.05 ± 0.69, and 0.71 ± 0.50 at one, three, six and 12 months after the

operation, respectively. Besides, the ODI score was also dropped from 59.43 ± 10.04 pre-operatively to 29.42 ± 10.33, 20.13 ± 8.18, 13.98 ± 6.16, and 9.86 ± 5.03 at one, three, six and 12 months during the post-operative follow-up period (Fig 2). Statistically significant differences existed in both VAS and ODI scores at each follow-up time point when compared with the pre-operative scores ($P < 0.05$). The MacNab efficacy was excellent for 18 (75%) patients, good for three (12.5%) patients, and fair for three (12.5%) patients with an excellent and good rate of 87.5%. And we sorted the rank data of MacNab efficacy from 1 to 4 (excellent 4; good 3; fair 2; poor 1). No significant correlation was observed between MacNab efficacy and grade of lateral recess stenosis (Spearman's rho 0.193, $P = 0.367 > 0.05$). The post-operative CT examination showed that the vertebral foramen had expanded obviously, and lateral recess stenosis had been fully decompressed (Fig 1p-q). The mean reciprocal angulation change of the operated segment in dynamic lumbar lateral view was 3.2° ± 1.6° at the last follow-up. And all patients showed no exacerbation for internal medical comorbidities. Only one patient felt lower limb numbness after operation and completely recovered after four week conservative treatment. No permanent nerve damage, dural tear, CSF leakage, infection, or other surgical complications were observed.

Discussion

Surgical treatment was necessary for symptomatic lateral recess stenosis, to which the conservative therapy was usually ineffective. The traditional surgical treatment, including various decompression methods by laminectomy and facet joint resection, usually strips the paravertebral muscle termination through the central path at the low back. To relieve the nerve root compression, a wide excision of the facet joints is needed, which unavoidably impairs the stable structure of the posterior spine column. Moreover, lumbar fusion and internal fixation are usually needed at the mean time for reconstruction of spinal stability. Under these circumstances, operation time is surely to be extended, resulting in an increase in surgical trauma and operative risk, especially for elderly patients with pre-operatively various internal medical comorbidities. Besides, the incidence of pathological changes of adjacent segments will obviously increase after lumbar fusion and fixation [11]. Ong KL's study showed that 16.9% of the elderly patients (71.4 ± 7.9 years) treated with posterolateral spinal fusion for lumbar spinal stenosis or spondylolisthesis underwent re-operation on the spine within two years of surgery, and nearly 25% of the patients were readmitted for a surgery-related complication [12].

With the prevalence of minimal invasion concept, innovations of instrument design, and appearance of various channel expansion technologies, paraspinal muscle iatrogenic injury has been decreased. A cold light microscope is used at the same time during decompression, which can improve lighting and enlarge the field of vision. By using these methods, surgeons can clearly identify the neural structures and their induced compression range. In this case, the outer portion of the facet joint can be preserved as much as possible when guaranteeing full decompression, which can reduce the incidence of iatrogenic instability. This method has comparable clinical efficacy with the traditional open surgery and has advantages as less surgical trauma, fast post-operative recovery, etc. [13]. Ruetten and his colleagues innovatively used percutaneous endoscopic interlaminar decompression for the treatment of lumbar lateral recess stenosis, with an excellent rate reaching 89–92%, and the prevalence of comorbidities and reoperation rate were both lower than the lateral recess decompression technique under microscope [1, 14]. However, this method should be conducted under general anaesthesia, which may largely increase the operative risk for geriatric patients, especially for those with various internal medical comorbidities. It was indicated by some researches that recession and lesions of organ functionality of elderly patients would cause the decrease of compensatory ability, increase of sensitivity to anaesthetics, and slow down the metabolic rate, which may further lead to problems like delayed extubation, post-operative delirium, and short-term cognitive dysfunction [15].

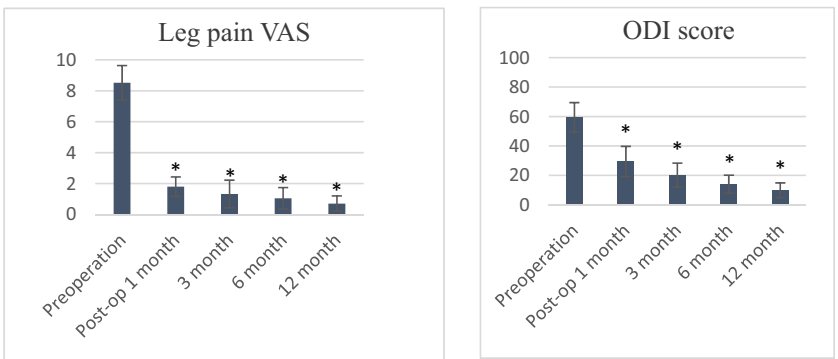

Fig. 2 Histograms for VAS and ODI scores ($n = 24$, $^*P < 0.05$)

Percutaneous transforaminal has its unique advantages compared with interlaminar approach for the treatment of lateral recess stenosis in geriatric patients. The surgical procedure is conducted under local anesthesia, which avoids a number of risks resulted from general anaesthesia. Note that patients at 70 years are considered relatively young and most of them (even patients older than 70 years) are able to undergo traditional microsurgical or open approach under the precondition of patients' good general condition and principle of informed consent. Especially for 70-75-year-old patients with no severe comorbidities, this procedure is just one of the surgical treatments, but not the first choice. The final surgical procedure is determined by both patients and surgeons. And this minimally invasive intervention is an alternative for patients who are unwilling to receive traditional microsurgical decompression or open surgery. Besides, the difficulty of transforaminal approach is the exposure and decompression of lateral recess at the pedicle level [8]. The following surgical skills were taken in the current study to address this issue: (1) The puncture of the target point was emphasized, and the target was the most stenosed point in the lateral recess. CT and MR horizontal images were carefully analyzed to determine whether the stenosis was at the intervertebral foramen level or at the pedicle level. If the stenosis was at the pedicle level, the puncture of the lateral recess was set at the posterior upper edge of the inferior vertebral body of the responsible segment. (2) On the lateral fluoroscopic view, the needle was close to the ventral side of the superior facet as much as possible, which was better for the foraminoplasty. (3) The diameter could increase to 8.5 mm during trepan reaming if it is necessary. On the one hand, more facet joints could be abraded, while on the other hand, more observation and decompression space could be obtained by prying the sheath after placement. Although a larger trepan could damage the completeness of facet joints, resulting in an increase in the activity range of lumbar lateral flexion, there was no obvious influence of the stability of lumbar lateral flexion and rotation [1]. In this study, the overall mean reciprocal angulation change of the operated segment was $3.2° \pm 1.6°$ after an average 29-month follow-up, and none of the patients required additional surgery because of lumbar spine instability. (4) A part of the inner edge of the inferior pedicle could be abraded if necessary for the placement of sheath. Generally, the whole lateral recess nerve root could be well exposed under endoscopy by adopting the aforementioned approaches, and thus, various endoscopic instruments could be used for the full decompression of dorsal and ventral compression factors for the nerve root.

The characteristics of elderly patients with symptomatic lateral recess stenosis in this study included long disease course and severe symptoms. Lumbar degeneration is a slow process; as a result, the formation of various factors causing lateral recess stenosis needs accumulation with time, and it is also a relatively slow process from the appearance to the severity of symptoms. At the same time, the requirements for the quality of life for most elderly people gradually compromise with time, this may result in a tolerance of symptoms and a subsequent delay in surgical intervention (in this study, the mean duration of symptoms 18 months). Under this circumstance, the spinal structure of geriatric patients with lateral recess stenosis is not as clear as that of young patients with lumbar disc herniation. The nerve root always adheres to surrounding structures, and sometimes it is even wrapped by yellow ligament or fibrous scar [16, 17], which should be carefully distinguished and patiently separated. Blindly clamping must be avoided to prevent accidental injury. Besides, for patients with scar wrapping, forced separation between the scar and the nerve root should be avoided; instead, the separation should be conducted between the scar and the spinal canal. The symbol of complete decompression is the overall pulse of the nerve root with (or without) its wrapping scar.

In the present series, most were moderate or severe cases according to the Bartynski classification system. The radiological severity of lateral recess stenosis was not associated with clinical outcomes one year after surgery in our research, which was in accordance with the relationship between radiological severity and surgical outcome in patients who received either microsurgical decompression or open laminectomy for symptomatic lumbar spinal stenosis [18]. There are three poor efficacy cases according to MacNab criteria, whose symptom durations were the first three places (all more than 36 months), and severe nerve root adhesions were observed under the endoscope. It suggests that the timing of surgery may influence the efficacy of percutaneous endoscopic decompression via transforaminal approach for lumbar lateral recess stenosis in geriatric patients. One patient in our study had transient exacerbation of symptoms, which may be resulted from the mechanical compression caused by operating devices at the time of separating adhesions to the nerve root [19]. The above phenomenon may also be related to the unwise use of bipolar radiofrequency. Moreover, "sunburn syndrome" is a common post-operative comorbidity for the percutaneous endoscopic transforaminal approach [20]. As reported in the literature, the prevalence of this comorbidity was 5-15% [20]. But there was no such comorbidity in our study, the reason of which may be that the target point was relatively more downward, the foraminoplasty was more emphasized, and thus the risk of irritation for dorsal root ganglion of exiting nerve root was decreased.

Conclusion

Percutaneous endoscopic transforaminal decompression which performed under local anaesthesia achieved satisfactory results. And we considered that this minimally invasive

technique could provide a safe, effective, and low-traumatic alternative for treating symptomatic lumbar lateral recess stenosis in geriatric patients. Besides, a well-designed prospective study with large sample and long-term follow-up is necessary to draw a more convincing conclusion.

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