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Research Article

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Microendoscopic Posterior Decompression for the Treatment of Lumbar Lateral Recess Stenosis

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Abstract

Lateral recess stenosis (LRS) is a characteristic type of lumbar spinal canal stenosis, with symptoms of nerve root compression. The most common etiology is hypertrophy of the superior articular process. Conventional laminectomy and medial facetectomy are commonly used to treat LRS. This study investigated microendoscopic posterior decompression for the treatment of LRS.

Microendoscopic decompression was performed on 28 patients. Computed tomography and magnetic resonance imaging were used to calculate the lateral recess angle and depth. A 16 mm diameter tubular retractor and endoscopic system were used. Unilateral paramedian approaches were performed in all patients. Even using a unilateral paramedian approach, both sides of the nerve roots were decompressed in patients with bilateral radiculopathy. Pre- and postoperative status was evaluated using the visual analogue scale (VAS).

Patient's mean age was 62.9 years; there was single-level involvement, mostly at L4-5 (85.7%). Intraoperative findings revealed that the most common cause of nerve root compression was hypertrophy of the superior articular process and ligamentum flavum. VAS score improved in all patients following posterior decompression. Pre- and postoperative mean VAS scores were 6.5 and 1.1, respectively (P value < 0.01). No intra- or postoperative complications were observed during a mean follow-up of 10.5 months.

Keywords: Lateral recess; Lumbar spinal canal stenosis; Radiculopathy; Microendoscopic posterior decompression; Minimally invasive

Introduction

Lateral recess stenosis (LRS) is a characteristic type of lumbar spinal canal stenosis, with symptoms of nerve root compression [1,2]. The most common etiology is hypertrophy of the superior articular process [3]. We also have to keep the participation of ligamentum flavum in mind [4]. This pathological mechanism was known even before development of computed tomography (CT), and the diagnosis was supported by plain radiographs and myelography. In the past, LRS was also known as occult lumbar spinal stenosis [5], lateral recess syndrome [6], and superior facet syndrome [7]. This nomenclature was reasonable, but definitive diagnosis was only made at the time of surgical exploration.

With development of CT, more specific non-invasive preoperative diagnosis has become possible. Several criteria had been proposed by both surgeons and radiologists [6-9]. The superiority of magnetic resonance imaging (MRI) for diagnosis is still controversial [1,10]; MRI provides supplemental information, especially for soft tissues surrounding the superior articular process. MRI has at least contributed to preoperative procedure simulation.

LRS is occasionally associated with lumbar instability and degenerative changes of surrounding tissues, such as the facet joints, ligamentum flavum, endplate, and/or vertebral disc [3,11,12]. Surgical decompression using a conventional laminectomy and medial facetectomy is commonly used to treat LRS [13]. Although several different surgical techniques have been reported [10–12,14,15], no study was found evaluating the microendoscopic technique in surgery of the LRS alone. We therefore investigated the effectiveness and usefulness of microendoscopic posterior decompression for the treatment of LRS.

Materials and Methods

Twenty-eight consecutive patients with lumbar LRS underwent posterior decompression using the METRx endoscopic system (Medtronic Sofamor Danek, Memphis, TN, USA) between April 2014 and July 2015. All patients had unilateral or bilateral radiculopathy resistant to medical treatment, epidural steroids, and/or nerve block. To clarify the surgical benefit for LRS, we excluded patients who also underwent discectomy during microendoscopic decompression. We also excluded patients who previously underwent adjacent lumbar body fusion, because LRS as an adjacent segmental disease has different pathology than de novo LRS. We also excluded patients in whom we could not identify a separate cauda equina in the central spinal canal on axial T2 MRI (the midsagittal diameter of the canal was less than 10 mm). Even though a patient presented with radiculopathy alone, we assumed these patients had central or combined type lumbar canal stenosis. Furthermore, we considered to apply lumbar interbody fusion for the patients showing lumbar spinal instability or moderate to severe spondylolisthesis (Meyerding classification: grade ≧II). The instability was judged while taking "facet fluid sign" into account [16,17]. In case of degenerative scoliosis patients having coronal Cobb angle > 10° so-called adult scoliosis [18], we also considered the lumbar interbody fusion.

All patients had LRS at only one vertebral level. Neurological examination, preoperative CT, MRI, and electrophysiological studies, such as sensory nerve action potentials (SNAP) for the peroneal nerve were used to identify the location of LRS and the target area for decompression. The extent of LRS was evaluated using two previously

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established parameters on preoperative CT. One parameter is lateral recess angle, defined as the angle between the lines parallel to the floor and roof of the lateral recess [8,9]. An angle < 30 degree is diagnostic of LRS. Another parameter is lateral recess depth, which is the measured distance between the superior articular facet and the top part of the pedicle [6,9]. A depth ≤ 5 mm is suspect for LRS. Patients were followed up for an average of 10.5 months (4–19 months) postoperatively. Pre- and postoperative status of radiculopathy was evaluated using visual analogue scale (VAS) scores.

Surgical technique

The patients were carefully logrolled into the prone position. During the operation, a fluoroscope was placed across the center of the operative table in order to ensure appropriate timing. An 18 mm skin incision was made at the target spinal level under fluoroscopic guidance. A 16 mm tubular retractor and endoscope were inserted after exposure of the vertebral lamina. A corresponding laminectomy was performed mainly using a chisel (width: 4 mm). After exposure of the ligamentum flavum, the lateral border of the ligament was carefully detached from the superior articular process. The thickened superior articular process was carefully removed piece-by-piece using a small angled Kerrison rongeur (width: 2 mm). After removal of these hypertrophic tissues, we confirmed good exposure and decompression of the corresponding nerve root by tilting and rotating the 25-degree angled endoscope. The extent of decompression was also confirmed with fluoroscopy using a ball hook (lengths: 5 and 10 mm). After decompression, the working channel was carefully removed, and a drain was placed. The fascia and skin were closed using standard techniques.

Results

Cases

Twenty-eight patients were registered for this study. There were 16 men and 12 women. The mean age was 62.9 years (range 31–80 years). All patients had unilateral or bilateral radiculopathy resistant to most medical treatments (non-steroidal anti-inflammatory drugs, tramadol, pregabalin, etc.) and/or nerve root block. Four patients showed bilateral radiculopathy at the same vertebral level. The most affected nerve root was L5 (25 cases), followed by S1 (2 cases), and L4 (1 case). Mean symptom duration was 20.4 months and ranged between 3 and 120 months. Eight patients had mild but distinct motor weakness of the corresponding nerve root (Table 1).

The lateral recess angle and depth were measured according to a previously reported formula using CT images (Table 1) [6,8,9]. Twenty-two patients met LRS criteria using at least one of these parameters, but six patients did not meet either criterion (Table 1).

Surgical findings

All patients had LRS at a single vertebral level in the lower lumbar area. Unilateral paramedian approaches were performed in all patients (Table 2). Eleven were operated on bilaterally and 17 unilaterally. Average duration of the surgical procedure was 39.1 min (range: 14-

Case No.	Age	Sex	Chief Complain Radiculopathy	Sides *	Level of Stenosis	Moter Dysfunction	Lateral Recess Angle (mm)		Lateral Recess Depth (mm)		Other Radiological Findings
							Right	Left	Right	Left	
1	70	F	L5	L	L4/5	(-)	**24**	**21**	**5**	**5**	-
2	70	M	L4	L	L3/4	(-)	**29**	30	8	7	-
3	73	M	L5	R	L4/5	(+)	**17**	37	**2**	8	spondylolisthesis I
4	79	F	L5	L	L4/5	(+)	37	**26**	**5**	**5**	kyphosis
5	47	F	L5	L>R	L4/5	(-)	**27**	**28**	**4**	6	spondylolisthesis I
6	70	F	L5	R	L4/5	(-)	**29**	38	**5**	7	-
7	71	M	L5	R	L4/5	(-)	30	31	**4**	**5**	-
8	76	F	L5	L>R	L4/5	(-)	**22**	33	6	7	spondylolisthesis I
9	79	M	L5	L	L4/5	(-)	**14**	**25**	**5**	**4**	spondylolisthesis I
10	56	M	L5	L	L4/5	(-)	37	43	6	6	-
11	61	M	L5	R	L4/5	(+)	**8**	**21**	6	6	-
12	69	M	L5	R	L4/5	(-)	**24**	**27**	**4**	**5**	-
13	38	M	L5	R>L	L4/5	(-)	31	30	**5**	**5**	-
14	43	F	L5	L	L4/5	(-)	33	36	6	7	-
15	72	F	L5	R	L4/5	(+)	30	38	6	7	-
16	72	M	L5	L	L4/5	(-)	39	**20**	7	**4**	-
17	50	F	L5	L	L4/5	(-)	34	**28**	6	6	-
18	40	M	L5	R	L4/5	(-)	38	49	**5**	7	-
19	55	M	S1	R	L5/S1	(-)	32	35	**4**	**5**	-
20	58	F	L5	R	L4/5	(+)	36	41	**5**	**4**	-
21	65	M	L5	R>L	L4/5	(-)	**20**	**18**	**4**	**5**	spondylolisthesis I
22	66	M	L5	R	L4/5	(+)	**27**	30	7	6	degenative scoliosis
23	67	M	L5	L	L5/6 **	(+)	34	30	6	**2**	degenative scoliosis
24	80	F	L5	L	L4/5	(-)	30	**7**	**5**	**5**	degenative scoliosis
25	31	M	L5	R	L4/5	(-)	32	31	**4**	**3**	-
26	66	M	L5	R	L4/5	(-)	34	32	6	6	
27	69	F	S1	R	L5/S1	(+)	**14**	33	**1**	8	Degenative scoliosis
28	68	F	L5	R	L4/5	(-)	34	30	6	**5**	spondylolisthesis I

Bold number in "Lateral Recess Angle" and "Lateral Recess Depth" columns indicates the upper estimation of LRS by preoperative computed tomography.
* In case of bilateral radiculopathy, the more severe side is indicated to the left of the > symbol (more than).
** Lumbarization of the first sacral segment was present in this case and we designated this segment as L6.

Table 1: Summary of characteristic features for the 28 cases of lumbar LRS.

Case No	Level of Decompression	Extent of Decompression	Operative Findings	Operation Time (min)	hospitalization	Postoperative Follow-up Periods (months)	Preop VAS Score	Pstop VAS Score
1	L4/5	bilateral	HT of SAP	42	5	19	3	2
2	L3/4	L	HT of SAP and LF	34	6	19	4	0
3	L4/5	R	OP of IAP	64	6	18	7	2
4	L4/5	L	HT of LF	60	6	17	8	3
5	L4/5	bilateral	HT of SAP and LF	48	5	17	10	2
6	L4/5	bilateral	HT of LF, OP of SAP	30	6	14	7	0
7	L4/5	R	HT of SAP and LF	35	6	14	8	0
8	L4/5	bilateral	HT of SAP and LF	25	5	13	5	2
9	L4/5	bilateral	HT of SAP and LF	43	3	13	5	0
10	L4/5	L	HT of SAP and LF	36	4	12	5	0
11	L4/5	R	OP of SAP, OLF	47	4	12	6	0
12	L4/5	R	HT of SAP	35	4	11	6	3
13	L4/5	bilateral	HT of SAP and LF	31	3	10	9	0
14	L4/5	bilateral	OLF	20	5	10	6	2
15	L4/5	bilateral	HT of LF	31	4	10	5	2
16	L4/5	bilateral	OLF	50	6	9	5	0
17	L4/5	bilateral	HT of SAP	42	4	8	8	0
18	L4/5	R	HT of LF *	34	4	8	8	0
19	L5S1	R	HT of LF	40	3	8	4	0
20	L4/5	R	HT of LF	41	5	8	10	0
21	L4/5	bilateral	HT of SAP	59	4	8	5	0
22	L4/5	R	HT of LF	34	5	7	3	0
23	L5/6	L	HT of SAP	50	5	7	6	0
24	L4/5	L	HT of SAP	31	4	6	7	0
25	L4/5	R	HT of LF	34	6	5	8	0
26	L4/5	R	HT of LF	14	4	4	10	7
27	L5S1	R	HT of SAP	56	4	4	5	3
28	L4/5	R	HT of LF	29	6	4	8	2

Table 2: Summary of surgical outcomes of the 28 cases of lumbar LRS. VAS = visual analogue scale. Abbreviations in "Operative Findings" column are as follows. HT = hypertrophy; SAP = superior articular process; LF = ligamentum flavum; IAP = inferior articular process; OP = osteophyte; OLF = ossification of ligamentum flavum.* In this study, we found caudal divergence of the corresponding nerve root origin, and the nerve root was mainly compressed by a hypertrophic ligamentum flavum at the vertebral disc level.

64), and the intraoperative blood loss was less than the lower limit of measurement (within 10 ml). Operative findings are indicated in Table 2. Even in the six patients who did not meet preoperative LRS criterion, operative findings demonstrated degenerative changes of the ligamentum flavum such as hypertrophy and ossification.

Clinical outcomes

Pre- and postoperative mean VAS scores were 6.5, and 1.1, respectively (Table 2). The VAS score improved in all patients (non-parametric Wilcoxon test, P value < 0.01). All patients recovered immediately after the operation, and were discharged from the hospital within 7 days after decompression (average: 4.7 days, range: 3-7 days), walking without a cane. We did not observe any intra- or postoperative complication during a mean follow-up period of 10.5 months (4–19 months).

In 11 of the 28 cases, other degenerative changes such as scoliosis, spondylolisthesis, and kyphosis were also observed during preoperative evaluation. Although the duration of the operation in these patients was slightly longer (45.3 min vs. 35.1 min), the microendoscopic procedure even completely decompressed the hypertrophic surrounding structure in these complicated cases. We show examples for degenerative scoliosis (coronal Cobb angle = 8°; Figure 1) and spondylolisthesis (Figure 2). The former revealed LRS only on the concave side of the scoliosis; the latter revealed LRS on both sides, depending on the association with mild spondylolisthesis (Meyerding classification: grade I).

Discussion

The lateral recess is defined as the area bordered laterally by the pedicle, dorsally by the superior articular process, and ventrally by the vertebral body and disc [2]. Early studies on the treatment of this

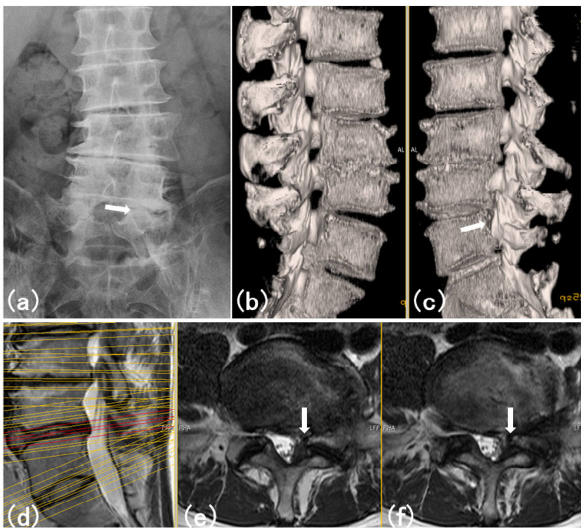

Figure 1: Preoperative radiographic findings of LRS patient with degenerative scoliosis (case 23) (a) Plain antero-posterior radiograph of lumbar spine; 3D-reconstructed computed tomography of lateral recess observed from inside to outside, (b) right side, (c) left side; T2-weighted magnetic resonance imaging, (d) sagittal view of middle lumbar spine, (e, f) axial views corresponding to the red scout lines on the sagittal view. We found LRS only on the left side of the lateral recess (arrows). The normal mid-sagittal diameter of the spinal canal was retained (12 mm) (d) as was that of the right lateral recess.

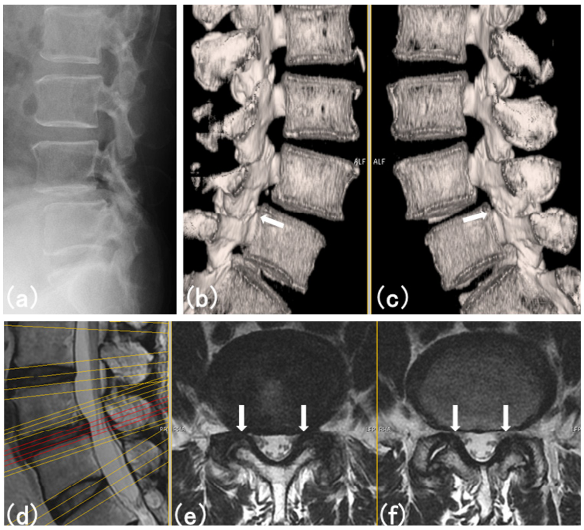

Figure 2: Preoperative radiographic finings of LRS patient with spondylolisthesis (case 21) (a) Plain finding of lateral radiograph of lumbar spine; 3D-reconstructed computed tomography of lateral recess observed from inside to outside, (b) right side, (c) left side; T2-weighted magnetic resonance imaging, (d) sagittal view of middle lumbar spine, (e, f) axial views corresponding to the red scout lines on the sagittal view. We found grade I spondylolisthesis and bilateral LRS (arrows). The normal mid-sagittal diameter of the spinal canal was retained (12 mm) (d).

pathological condition recommended wide laminectomy combined with unroofing of the lateral recess and excision of overhanging facet joints [5]. Excess facetectomy subsequently causes degeneration of the spine such as scoliosis and spondylolisthesis [11,12]. To avoid subsequent pedicle screw fixation and fusion surgery, several different surgical techniques have been developed to preserve the function of the facet joint [10–12,14,15,19]. Among these techniques, microscopic decompression is one of the most sophisticated [14,15,19]. Although microendoscopic decompression surgery has been widely used for lumbar canal stenosis [20–23], no report could be found on surgical results confined to lumbar LRS. We therefore investigated the effectiveness and usefulness of microendoscopic posterior decompression for the treatment of LRS.

Minimally invasive spine surgery (MISS) is a prospective surgical technique in recent years, because of rapid recovery, short hospital stay, limited blood loss, less destruction of surrounding tissues, less postoperative pain, and so on. Furthermore, the need for subsequent fixation or instrumentation is decreased. Nevertheless, insufficient decompression may occur, mainly because of the limited operative field. In 2008, Çolak et al. [24] described a less invasive surgical technique for lumbar LRS, accomplished by changing the angle of the operating microscope; the medial aspect of the facet complex was decompressed by a high-speed drill, and the extent could be confirmed by using a Murphy ball hook [24]. This technique achieved good surgical results. However, Crock expressed concern about insufficient decompression in a letter to the editor [25], and discussed two clinical observations during surgery. One is the loss of extreme sensitivity of the exposed nerve root, when decompression is complete. In the early stages of exposure in the stenotic canal, the nerve root is generally extremely sensitive. When touched with a blunt probe, it will cause the leg on the affected side to go into a vigorous spasm. We concur with this clinical observation; therefore, we monitor leg movement during the entire operative procedure in all patients undergoing MISS decompression in our hospital.

The operative visual field is only 16 mm in diameter for microendoscopic decompression. Despite this, we can acquire a wider operative field by tilting the endoscope in all directions; a 25-degree angled endoscope can provide a wider visual field when rotated. Therefore, we make the best use of tilting and rotation techniques to avoid insufficient decompression, in addition to monitoring leg movement. Furthermore, the development of new operative instruments suitable for microendoscopic decompression is important. Nakamura et al. reported the development of a new angled chisel to allow an osteotomy at the desired angle [26]. We have also developed and frequently use a new instrument such as a curved Kerrison rongeur. The major limitation of microendoscopic decompression is the 2D visualization of operative field. The 2D visualization has disadvantages of accurate depth measurement, hand-eye coordination, and poorer estimation of sizes in different depth. These disadvantages have to be compensated by the experience, anatomical knowledge, haptic feedback, and continuously movement of the endoscope.

To date, several studies have reported surgical outcomes for lumbar LRS. Most studies reported the outcome of pain relief using the VAS, numerical rating scale (NRS), or pain intensity score of the Oswestry Disability Index (ODI). Among these, the range of preoperative mean VAS scores was 5.5 to 7.0 and that of postoperative mean VAS scores was 4.0 to 1.5 [24,27,28]. In our study, the pre- and postoperative mean VAS scores were 6.5 and 1.1 respectively. The follow-up period of our study is short; however, our results are comparable to those of previous studies. Short operative time (mean: 39.1 min) and rapid recovery from surgical treatment should be emphasized as a potential advantage of microendoscopic MISS. In this study, the operation was performed by six different surgeons. We divided the surgical results into two groups, consisting of operations performed by experienced surgeons and by trainees in microendoscopic surgery, and reanalyzed the results. This analysis confirmed that an operation performed by an experienced surgeon is generally shorter than that performed by trainees (37.5 min vs. 49.8 min: non-parametric Wilcoxon test, P value < 0.05). We previously emphasized that training and surgical experiences are crucial, as microendoscopic decompression surgery has a steep learning curve [29]. Microendoscopic MISS is harder to perform in lumbar LRS than for central canal stenosis, mainly due to the need for tilting and rotation techniques. For bilateral decompression through a unilateral paramedian approach, in particular, surgeons must master these techniques in order to increase the visual field and subsequently reduce operative time.

Other associated degenerative deformities are commonly observed in lumbar LRS [11,12,28]. Most recently Lee et al. reported that more than a third of patients had degenerative spondylolisthesis [28]. They performed a spinous process splitting laminectomy (SPSL) assisted by an operating microscope, and found that patients were no worse at a mean follow-up period of 7.3 months. They concluded that SPSL has the potential to prevent the progression of degenerative deformities [28]. Eleven of 28 patients in our study had associated degenerative deformities (Table 2). Even though the follow-up period was short, our patients were no worse, similar to the findings of Lee et al. Although long term follow-up is necessary for to demonstrate efficacy, microendoscopic decompression has the potential to prevent progression of associated degenerative deformities.

Conclusion

Preliminary results during a short follow-up period show that microendoscopic posterior decompression is feasible for the treatment of patients with radiculopathy caused by lumbar LRS, even with combined mild degenerative changes.

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Conflicts of Interests

The authors declare that there are no conflicts of interest.

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