

# Effectiveness of lumbar epidural injection in patients with chronic spinal stenosis accompanying redundant nerve roots

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## Abstract

Redundant nerve root syndrome (RNRS) is a phenomenon characterized by the presence of elongated, enlarged, tortuous nerve roots in the lumbar subarachnoid space. It is unclear whether RNRS is caused by spinal stenosis or causes these symptoms.

This study evaluated the effects of lumbar epidural steroid injection (LESI) on patients with RNRS and assessed factors associated with RNRS. This retrospective observational cohort study was conducted at a single pain clinic of a university hospital.

The medical records of 172 outpatients presenting with low back and/or leg pain from July to December 2014 were analyzed. Pain intensity (numeric rating scale [NRS]) and functional status were assessed at baseline and 2, 4, and 12 weeks after the LESI. Patients were considered moderate responders if they showed a 3-point or >30% reduction in baseline NRS, or said “better than 30%,” “a little better,” or “I feel an effect.” Patients were considered substantial responders if they showed a 5-point or >50% reduction in baseline NRS, or said “better than 50%,” “very good,” or “much better.” Generalized estimating equation (GEE) analysis was performed to identify the factors associated with moderate response to LESI. Factors associated with RNRS were also determined by logistic regression analysis.

The proportions of both moderate and substantial responders at 2, 4, and 12 weeks were significantly lower in patients with than without RNRS. GEE analysis showed that RNRS were the only factor significantly associated with moderate response to LESI (OR=0.400; 95% CI, 0.253–0.632;  $P < .001$ ). The distance from the conus medullaris to the closest level of stenosis was shorter in patients with than without RNRS ( $P < .001$ ) and was the only independent factor associated with RNRS on multivariate logistic regression analysis (OR=0.972;  $P < .001$ ).

LESI was less effective in patients with than without RNRS. The only independent factor significantly associated with RNRS was the distance from the conus medullaris to the nearest moderate stenosis.

**Abbreviations:** GEE = generalized estimating equation, LESI = lumbar epidural steroid injection, MRI = magnetic resonance imaging, NRS = numeric rating scales, OR = odds ratio, RNRS = redundant nerve root syndrome.

**Keywords:** chronic pain, epidural block, lumbar, redundant nerve root, spinal stenosis

## 1. Introduction

Redundant nerve root syndrome (RNRS) is a phenomenon characterized by the presence of elongated, enlarged, tortuous nerve roots in the lumbar subarachnoid space.<sup>[1–3]</sup> RNRS is thought to be caused by tightening of part of the nerve roots in areas of spinal canal constriction, inhibiting the normal movement of the spinal nerves, and their stretching during

flexion and extension of the spine. As a result, the nerve becomes redundant. These findings suggest that the occurrence of RNRS is closely related to the presence of spinal stenosis.<sup>[4,5]</sup> RNRS, which were previously diagnosed by myelography, are currently diagnosed by magnetic resonance imaging (MRI).

It is unclear whether RNRS are a simple phenomenon caused by spinal stenosis or a pathological cause of symptoms. Although

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some studies suggest that RNRS are degenerative changes,<sup>[5]</sup> studies on the use of decompressive laminectomy for lumbar spinal canal stenosis report that RNRS may resolve after surgery, with better outcomes observed for patients with than without RNR resolution.<sup>[6]</sup> From this perspective, RNRS is not always reversible, persistent RNR is associated with poor results.<sup>[7]</sup>

Although several studies have assessed the effects of surgery on RNRS, fewer studies have analyzed the effects of other types of intervention. This study was therefore designed to evaluate the effects of lumbar epidural steroid injection (LESI) on patients with RNRS and to identify the factors associated with RNRS.

## 2. Materials and methods

### 2.1. Patients

The protocol of this retrospective study was approved by our institutional review board (approval number: 2015-0161). The study cohort included patients who first visited the outpatient department of our pain clinic with low back and/or leg pain from July to December 2014. Patients were included if they were adults aged 20 to 90 years; patient with spinal stenosis who found to have a macroscopically distinct conus medullaris and cauda equina on lumbar MRI; and which morphologically classified as having a moderate or higher grade of spinal stenosis.<sup>[8]</sup> Patients were excluded if they had a history of spinal surgery; had a spinal deformity that could alter the effect of LESI (scoliosis, kyphoscoliosis, compression fracture, or a high grade of spondylolisthesis), except for spinal stenosis<sup>[9]</sup>; had an arteriovenous malformation on T2-weighted MRI<sup>[10,11]</sup>; had a history of cancer of the lumbar spine; or were deemed unsuitable for inclusion, including patients who were untreated or were lost to follow-up after the procedure. All the patients included in this study were followed up continuously in the outpatient pain clinic. Baseline characteristics, including gender, age, body mass index, underlying diseases, duration of pain, pain location, and pain intensity as numeric rating scale (NRS), were retrieved from their medical records. The location and grade of all spinal stenosis, and

the location of the conus medullaris on lumbar MRI, were recorded. The distance from the most proximal spinal stenosis to the conus medullaris was also measured on lumbar MRI.

### 2.2. Radiological evaluation

MRI images were analyzed on a picture archiving and communication system (PetaVision, Version 2.1, Seoul, Korea). The MRI images were confirmed by 2 pain clinic specialists and a radiologist with more than 5 years of clinical experience. The location, grade, and total number of spinal stenosis were measured on T2-weighted images. The presence or absence of RNRS and the distance from the conus medullaris to the most proximal site of spinal stenosis were measured on mid-sagittal images of the lumbar column. An example of a RNRS observed in this study is shown in Fig. 1.

### 2.3. Lumbar epidural steroid injection

Based on the patients' symptoms and MRI images, the target pathological location of the spinal level was determined. Subsequently, treatment to manage more severe pain was decided if the patients complained of both low back pain and buttock or leg pain. A fluoroscopic-guided interlaminar or trans-foraminal epidural steroid injection was performed. The correct needle position was confirmed, and adequate radiographic imaging was performed by the injection of a contrast dye (Omnipaque, Nycomed Imaging AS, Oslo, Norway). Following this, 5 mg of dexamethasone and 1500 IU of hyaluronidase in 1% lidocaine were administered to allow the drug to spread to the site of the target lesion.

### 2.4. Outcome evaluation and factors associated with response to LESI

Patients were divided into 2 groups, those with RNRS: Group R, and those without RNRS: Group C. For each patient, the LESI initially performed after the date of the MRI was considered the beginning of the study. Patients who complained of both low



**Figure 1.** Lumbar magnetic resonance image of redundant nerve root syndrome (RNRS). Both axial (A) and sagittal views (B) show tortuosity and redundancy of nerve roots.

back pain and buttock or leg pain set a more severe symptom as a treatment target and recorded the therapeutic effect of that part. The primary outcome of this study was to evaluate the response of LESI based on a NRS and its subjective efficacy on patients. The secondary outcome was to identify the factors associated with RNRS. Pain was assessed on NRS at baseline and 2, 4, and 12 weeks after the procedure, and patient response to LESI was determined. Patients were considered moderate responders if they showed a 3-point or >30% reduction in baseline NRS, or said “better than 30%,” “a little better,” or “I feel an effect.” Patients were considered substantial responders if they showed a 5-point or >50% reduction in baseline NRS, or said “better than 50%,” “very good,” or “much better.”

**2.5. Statistical analysis**

Continuous variables were expressed as mean ± standard deviation or median and interquartile range and analyzed by *t* tests or Wilcoxon rank sum tests. Categorical variables were expressed as frequency or percent and analyzed by either  $\chi^2$  or Fisher exact tests, as appropriate.

Generalized estimating equation (GEE) analysis was performed to identify the factors associated with moderate response to LESI. Factors associated with RNRS were determined by univariate and multivariate logistic regression analyses. Variables included in the final multivariate logistic regression analysis to evaluate independent factors associated with RNRS were chosen based on biological plausibility, clinical importance, and statistical considerations. In all analyses, a *P* value <.05 was considered statistically significant.

**3. Results**

Of the 1223 outpatients evaluated during the study period, 452 had moderate or higher grade spinal stenosis, and their conus medullaris and cauda equina were macroscopically visible on MRI, with 132 patients having RNRS. Of these 452 patients, 280 were excluded, including 177 with a history of prior spinal surgery, spinal deformity, or spinal cancer; and 44 who did not undergo LESI and 59 were lost to follow-up. The final study cohort consisted of 172 patients, 82 (group R) with and 90 (group C) without RNRS (Fig. 2), and a Cohen Kappa value of 0.99.

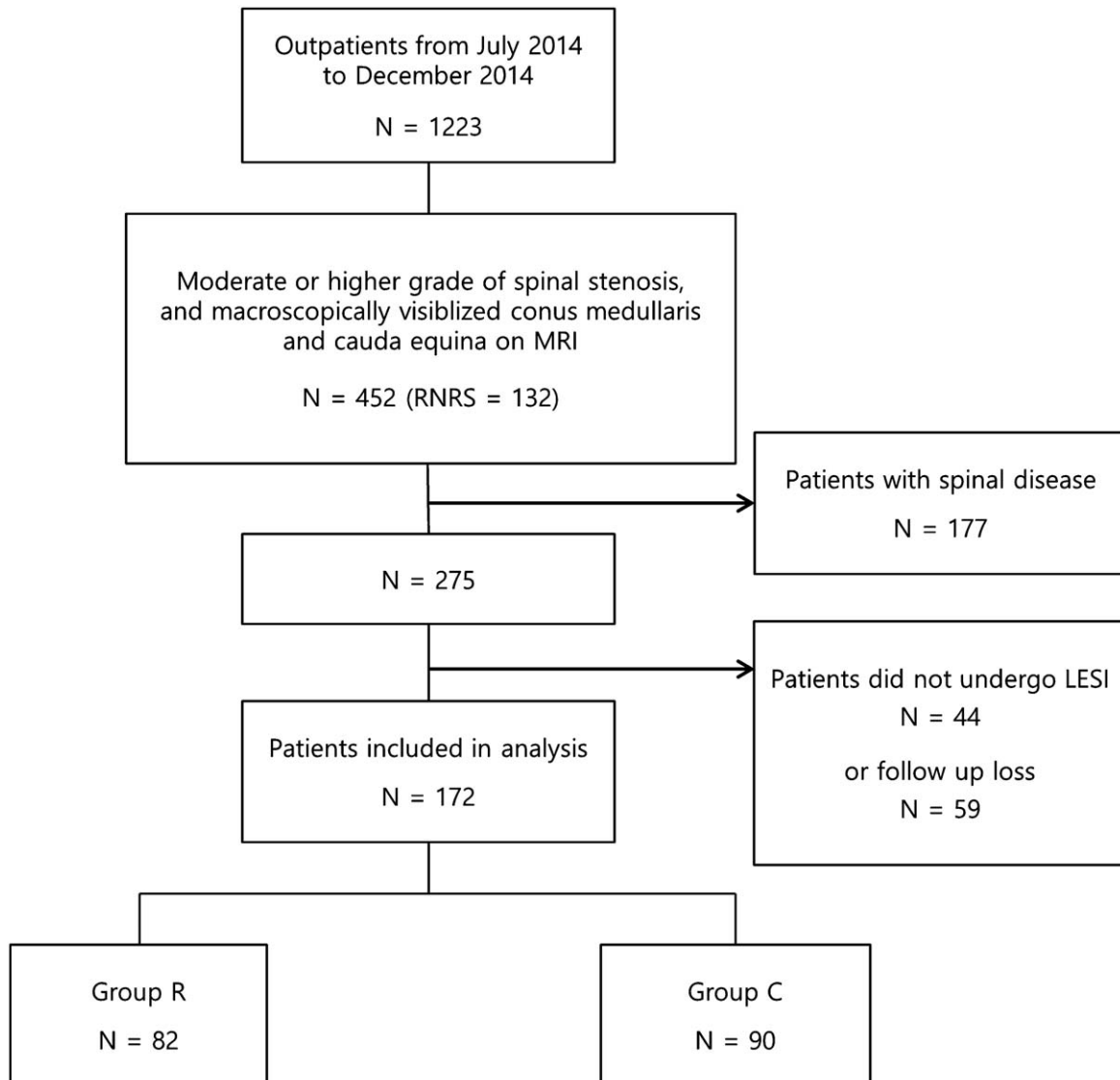


Figure 2. Study flow diagram.

**Table 1**  
Demographic and clinical characteristics of the study population.

	Total (n = 172)	Group C (n = 90)	Group R (n = 82)	P value
Age, y	66.7 ± 8.6	67.3 ± 8.9	67.0 ± 8.6	.814
Gender, M/F				.910
Male	58 (33.7%)	30 (33.3%)	28 (34.1%)	
Female	114 (66.3%)	60 (66.7%)	54 (65.9%)	
Hypertension	83 (48.3%)	46 (51.1%)	37 (45.1%)	.432
Diabetes	34 (19.8%)	19 (21.1%)	15 (18.3%)	.643
Pain intensity, NRS	7.2 ± 1.6	7.1 ± 1.6	7.2 ± 1.5	.807
Duration of pain, mo	92.7 ± 84.2	94.5 ± 82.7	91.0 ± 86.4	.860
Pain location				
Low back pain	110 (64.0%)	59 (65.6%)	51 (62.2%)	.647
Buttock or leg pain	143 (83.1%)	73 (81.1%)	70 (85.4%)	.457

Data are expressed as mean ± standard deviation, or number (%).  
NRS = numeric rating scale.

No statistical difference of mean age was observed between the groups C and R (67.3 ± 8.9 and 67.0 ± 8.6, respectively,  $P = .814$ ). Proportion of female was higher in both groups, although the difference was not observed between 2 groups ( $P = .910$ ). Duration of pain between the groups C and R did not differ significantly (94.5 ± 82.7 and 91.0 ± 86.4 months, respectively,  $P = .860$ ). A comparison of the groups with and without RNRS showed no statistically significant differences in other parameters such as underlying disease, pain location, and pain intensity (Table 1).

In addition, the proportion of patients complaining of buttock or leg pain was higher than those complaining of low back pain (83.1% vs 64%, Table 1). Of the patients included in the study, 15 patients had low back pain alone (Group R = 6, Group C = 9, mean NRS of 7.3), and 62 of them had only buttock or leg pain (Group R = 31, Group C = 31, mean NRS of 6.9). There were 22 patients with only moderate grade spinal stenosis. Of these, 3

patients had RNRS. The characteristics of lumbar spinal stenosis differed significantly in the 2 groups (Table 2). A significantly higher percentage of patients with than without RNRS had multiple levels of spinal stenosis ( $P = .021$ ), and the distance from the conus medullaris to the closest site of moderate or severe stenosis was significantly shorter in patients with than without RNRS ( $P < .001$ ).

The percentages of patients responding to LESI at all 3 time points (2 weeks, 1 month, and 3 months) were significantly lower in patients with than without RNRS (Table 3). In particular, the percentages of substantial responders were significantly lower in patients with RNRS, with none of these patients having a substantial response after 3 months (Fig. 3).

GEE analysis showed that patient age, gender, pain duration, and number of sites of stenosis of more than moderate grade were not associated with moderate response to LESI (Table 4). Only RNRS was significantly associated with moderate response to LESI (odds ratio [OR] = 0.400; 95% confidence interval = 0.253–0.632;  $P < .001$ ).

In addition, univariate logistic regression analysis showed that ≥3 levels of stenosis and distance from the conus medullaris to the nearest site of moderate stenosis were associated with RNRS. Multivariate logistic regression analysis showed that the only independent factor significantly associated with occurrence of RNRS was the distance from the conus medullaris to the nearest site of moderate stenosis (OR = 0.972;  $P < .001$ ; Table 5).

#### 4. Discussion

This study showed that the effects of LESI were lower in patients with than without RNRS. In the present study, we utilized NRS for measuring pain intensity. Compared with the other commonly used pain scales, such as the Visual Analogue Scale, Verbal Rating Scale, and the Faces or Pain Scale-Revised, NRS was known to be the most reliable and validated in clinical pain research.<sup>[12–14]</sup> In general, factors that may influence the outcome

**Table 2**  
Characteristics of lumbar spinal stenosis in the study population.

	Total (n = 172)	Group C (n = 90)	Group R (n = 82)	P value
Moderate or severe stenosis				.021
1 level	81 (47.1%)	50 (55.6%)	31 (37.8%)	
2 levels	58 (33.7%)	29 (32.2%)	29 (35.4%)	
≥3 levels	33 (19.2%)	11 (12.2%)	22 (26.8%)	
Distance from conus medullaris to nearest moderate stenosis, mm	78.3 ± 33.1	88.9 ± 31.6	68.1 ± 30.9	<.001
Distance from conus medullaris to nearest severe stenosis, mm	88.9 ± 28.8	99.3 ± 26.2	78.8 ± 27.9	<.001

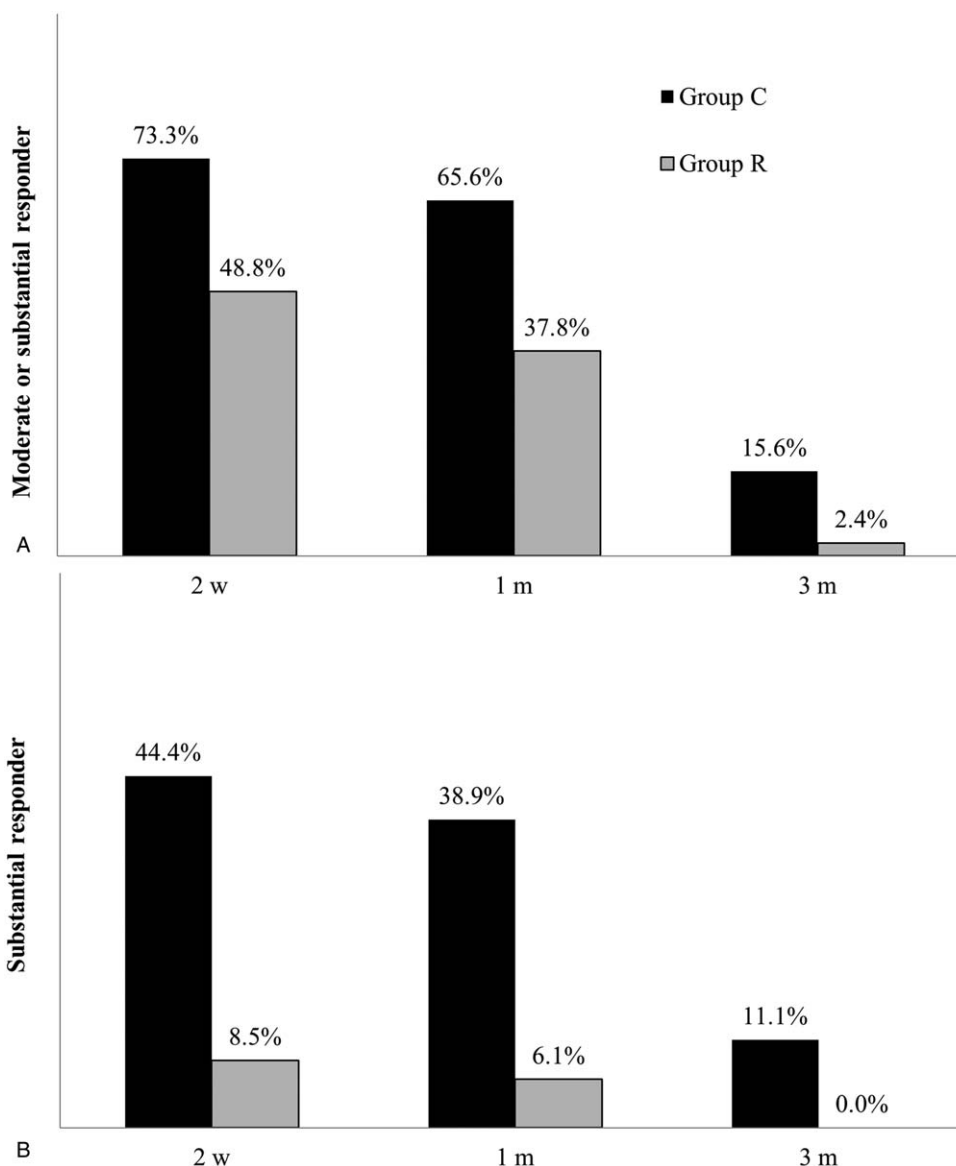
Data are expressed as mean ± standard deviation or number (%).

**Table 3**  
Proportions of responders in the 2 groups.

Responder	Total (n = 172)	Group C (n = 90)	Group R (n = 82)	P value
Moderate responder				
2 wks	106 (61.6% [53.9–68.9])	66 (73.3% [63.0–82.1])	40 (48.8% [37.6–60.1])	.001
1 mo	90 (52.3% [44.6–60.0])	59 (65.6% [54.8–75.3])	31 (37.8% [27.3–49.2])	<.001
3 mo	16 (9.3% [5.4–14.7])	14 (15.6% [8.8–24.7])	2 (2.4% [0.3–8.5])	.003
Substantial responder				
2 wks	47 (27.3% [20.8–34.6])	40 (44.4% [34.0–55.3])	7 (8.5% [3.5–16.8])	<.001
1 mo	40 (23.3% [17.2–30.3])	35 (38.9% [28.8–49.7])	5 (6.1% [2.0–13.7])	<.001
3 mo	10 (5.8% [2.8–10.4])	10 (11.1% [5.5–19.5])	0 (0.0% [0.0–0.4])	.002

Data are expressed as number (%) [95% confidence interval].

\* 97.5% confidence interval.



**Figure 3.** Proportions of (A) moderate and substantial responders and (B) substantial responders alone among patients with (group R) and without (group C) redundant nerve root syndrome (RNRS). The percentages of responders to lumbar epidural steroid injection were significantly lower in patients with than without RNRS at 2 weeks, 1 month, and 3 months. None of the patients in group R had a significant response at 3 months.

**Table 4**  
**Factors associated with moderate response to epidural steroid injection by generalized estimating equation.**

Variables	Adjusted OR	95% CI	P value
Age	0.999	0.972–1.028	.956
Gender	1.041	0.649–1.671	.868
Pain duration, mo			
≤12	1 (Ref.)		
>12 to 60	0.949	0.421–2.140	.901
>60	0.851	0.389–1.861	.686
Moderate or severe stenosis			
1 level	1 (Ref.)		
2 levels	1.298	0.788–2.138	.305
≥3 levels	0.832	0.440–1.575	.573
Redundant nerve root	0.400	0.253–0.632	<.001

Generalized estimating equation with robust standard error.  
 CI=confidence interval, OR=odds ratio, Ref=reference.

of LESI include age, grade and number of spinal stenosis, and chronicity. Patients included in this study had a relatively long duration of pain and old age, but there was no significant difference between the 2 groups, and this study found that only the presence of RNRS independently affected the outcome of LESI. An earlier study reported that patients with RNRS were older, had longer symptom duration, and had more severe neurological signs and symptoms than patients without RNRS.<sup>[3]</sup> However, in the present study, age, duration of pain, severity of stenosis, and location of stenosis were not associated with the occurrence of RNRS, but only with the distance from the conus to the nearest site of moderate stenosis. Min et al<sup>[7]</sup> also found that there was no statistically significant association between RNRS and age, duration of symptoms, and diameter of spinal canal, except advanced age.

Similarly, other studies reported that RNRS were associated with poorer outcomes. For example, the ability to walk

**Table 5****Logistic regression analysis of factors associated with redundant nerve root syndrome.**

Variables	Univariate			Multivariate		
	OR	95% CI	P value	OR	95% CI	P value
Age	0.996	0.962–1.031	.813			
Gender						
Male	1 (Ref.)					
Female	0.964	0.512–1.816	.910			
Moderate or severe stenosis						
1 level	1 (Ref.)			1 (Ref.)		
2 levels	1.613	0.815–3.191	.170	0.631	0.266–1.501	.298
≥3 levels	3.226	1.377–7.556	.007	0.455	0.123–1.677	.237
Distance from conus medullaris to nearest moderate stenosis	0.979	0.968–0.990	<.001	0.972	0.957–0.988	<.001
Duration of pain	0.999	0.995–1.004	.827			

CI = confidence interval, OR = odds ratio, Ref = reference.

before and after surgery differed significantly in patients with and without RNRS.<sup>[1]</sup> In addition, postoperative JOA scores were found to be significantly lower in patients with than without RNRS.<sup>[6,7]</sup> Although surgical decompression of the narrowed spinal canal may lead to a loss of RNRS by releasing the tightened nerve, the persistence of RNRS after decompression<sup>[6]</sup> suggests that RNRS may be an irreversible change. Biopsies show that histological changes accompany RNRS,<sup>[3,5]</sup> including a reduction in the density of nerve fibers. This reduction was found to result from the disarrangement and degenerative changes of nerve fibers, including their demyelination and endoneurial fibrosis, as well as from Schwann cell proliferation in these roots.<sup>[1,5]</sup> These findings may explain the reduced effect of LESI in patients with than without RNRS observed in the present study.

In agreement with a previous study,<sup>[7]</sup> we observed an association between the length of the redundant nerve roots and patient outcomes in patients with RNRS. We found that RNRS were significantly more likely to occur when the distance from the conus medullaris to the nearest site of spinal stenosis was shorter, a result directly related to patient outcomes. However, in Min et al's study,<sup>[7]</sup> if RNRS is present, the longer the redundant nerve roots, the better the outcome. Because spinal canal constriction compresses the nerve roots, thereby limiting the normal movement and stretching of the tightened nerve during flexion and extension of the lumbar spine,<sup>[4,5]</sup> a longer tightened nerve would be better able to withstand stretching.

RNRS can be classified into 2 types.<sup>[3,15]</sup> Type I is characterized by the presence of a mild degree of coiling or tortuosity of nerve roots, without any thickening, and with normal intradural pressure. In this type, decompressive laminectomy alone is sufficient. Type 2 is rare and characterized by grossly thickened nerve roots, often with an increased intradural pressure. In type 2, decompressive laminectomy alone is insufficient. If type 1 progresses to type 2 over time, resulting in irreversible changes, then early surgical decompression may avoid this progression. At present, however, methods are not available to determine whether RNRS are irreversibly changed. Thus, although many studies have evaluated the pathogenesis of RNRS, few have assessed the effects of treatment.

In this study, the effect of LESI for spinal stenosis was low compared with other studies such as Hong et al.<sup>[16]</sup> The reason for this is that only patients with moderate or higher stenosis were included in the study and the patients' chronicity was high (duration of pain =  $92.7 \pm 84.2$  months).

#### 4.1. Limitations

The major limitations of this study are those inherent to a retrospective study. These include the possibility of reporting undocumented factors or biases, and differences of effects for routes of epidural injection. In addition, we were unable to control and evaluate drug uses and changes during follow-up. Therefore, pain relief may have been underestimated. Another important limitation was that the exact functional outcome or claudication was not evaluated. Therefore, to more rigorously analyze responses, moderate responders were defined as those with a NRS reduction of 3 rather than 2 points, and substantial responders were defined as those with a NRS reduction of 5 rather than 4 points. In addition to differences in the NRS, the definition of a "positive responder" included patients' expressions such as, "a little better," "better," "much better," "very good," or "I feel an effect." These expressions may be considered an indirect reflection of the functional outcome. Finally, when analyzing the effect of the procedure, we did not consider the type of redundant nerve roots. Their more common presence in the proximal region<sup>[17]</sup> may be related to the blood supply of the spinal cord,<sup>[18]</sup> but the exact cause has not yet been determined. Because no studies have demonstrated efficacy of epidural steroid for the treatment of RNRS, we could not predict how these agents affect patient outcomes. Further studies on the pathogenesis of RNRS are required.

#### 5. Conclusion

In the present study, we demonstrated that RNRS was independently associated with a moderate response to LESI. This showed that LESI was less effective in lumbar spinal stenosis patients with RNRS than in patients without RNRS. In addition, the only independent factor significantly associated with occurrence of RNRS was the distance from the conus medullaris to the nearest site of moderate stenosis.

#### Author contributions

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**Validation:** Gunn Lee.

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