

# Asymptomatic Stenosis in the Cervical and Thoracic Spines of Patients with Symptomatic Lumbar Stenosis

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## Abstract

**Study Design** Retrospective study.

**Objective** Studies on age-related degenerative changes causing concurrent stenoses in the cervical, thoracic, and lumbar spines (triple stenosis) are rare in the literature. Our objectives were to determine: (1) the incidence of asymptomatic radiologic cervical and thoracic stenosis in elderly patients with symptomatic lumbar stenosis, (2) the incidence of concurrent radiologic spinal stenosis in the cervical and thoracic spines, and (3) the radiologic features of cervical stenosis that might predict concurrent thoracic stenosis.

**Methods** Whole-spine T2 sagittal magnetic resonance images of patients older than 80 and diagnosed with lumbar spinal stenosis between January 2003 and January 2012 were evaluated retrospectively. We included patients with asymptomatic spondylotic cervical and thoracic stenosis. We measured the anteroposterior diameters of the vertebral body, bony spinal canal, and spinal cord, along with the Pavlov ratio and anterior or posterior epidural stenosis at the level of the disk for each cervical and thoracic level. We compared the radiologic parameters between the subgroups of cervical stenosis with and without thoracic stenosis.

**Results** Among the 460 patients with lumbar stenosis, 110 (23.9%) had concurrent radiologic cervical stenosis and 112 (24.3%) had concurrent radiologic thoracic stenosis. Fifty-six patients (12.1%) had combined radiologic cervical and thoracic stenosis in addition to their symptomatic lumbar stenosis (triple stenosis). Anterior epidural stenosis at C7–T1 was associated with a high prevalence of thoracic stenosis.

**Conclusions** It appears that asymptomatic radiologic cervical and thoracic stenosis is common in elderly patients with symptomatic lumbar stenosis.

## Keywords

- ▶ cervical spine
- ▶ thoracic spine
- ▶ lumbar spine
- ▶ concurrent stenosis

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## Introduction

Cervical stenosis can occur concurrently with thoracic stenosis. However, the predictable radiologic features in the cervical stenosis related to thoracic stenosis have not been described in the literature. The radiologic features in concomitant symptomatic cervical and thoracic stenosis clearly are more important than those of asymptomatic stenosis. However, by its very nature, symptomatic cervical and thoracic stenosis will present with symptoms. On the other hand, with asymptomatic stenosis, there is no clinical reason to obtain radiographic studies. One can have severe radiographic stenosis without any symptoms.<sup>1,2</sup> In most cases, such “silent” stenosis does not result in any clinical sequelae. However, there have been cases of paralysis from a spinal origin after anesthesia or sleeping in patients with asymptomatic spinal stenosis.<sup>3,4</sup> We therefore undertook this study to determine this “silent” stenosis.

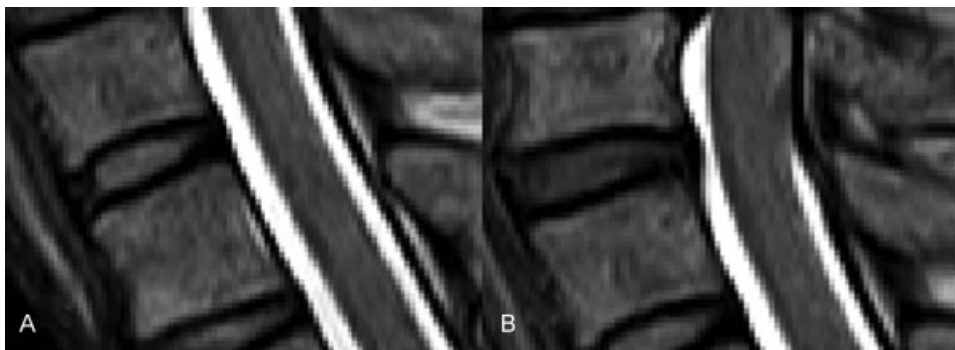
The purpose of this study is to investigate the incidence of asymptomatic radiologic cervical and thoracic stenosis in elderly patients with symptomatic lumbar stenosis, to investigate the incidence of concurrent radiologic spinal stenosis in the cervical and thoracic spines, and to identify the radiologic features of cervical stenosis that might predict concurrent thoracic stenosis.

## Methods

Institutional board approval was obtained before initiating this study, and an approved informed consent form was signed by all patients who were enrolled (approval number:2013-1034). This is a retrospective magnetic resonance imaging (MRI) study. The study population consisted of patients older than 80 who visited the first author’s teaching hospital with the diagnosis of lumbar spinal stenosis and who had lumbar spine MRI with T2 sagittal view of the whole spine from January 2003 to January 2012. We chose to study older patients for several reasons. First, asymptomatic stenosis is rarely clinically relevant in the young and middle-aged population. However, spinal cord injury due to falls is much more prevalent in the elderly. Therefore, it is possible that asymptomatic stenosis might have greater implications for a

traumatic injury in the elderly. Second, in the elderly, the spines are more spondylotic and less mobile. An elderly patient who is placed prone for a lumbar operation may be at greater risk for injury to the thoracic and cervical cord due to a silent stenosis. We discussed their symptoms at length with the patients and their family to exclude the patients with myelopathy, and we performed a detailed examination of the upper and lower extremities of every patient including reflex, motor power, sensory dysfunction, walking difficulty, tandem gait, Romberg test, loss of hand dexterity, grip and release test, finger escape sign, Hoffmann reflex, and dysdiadochokinesia. No one had electromyography and nerve conduction studies because none had symptoms of cervical myelopathy or radiculopathy. We excluded patients showing definite hyper-reflexia, pathologic reflex with upper or lower extremities, symptoms from cervical or thoracic myelopathy, fractures, spondylolisthesis, tumor, ossification of posterior longitudinal ligament, and ossification of yellow ligament. According to Kang’s grading classification, grade 0 is normal.<sup>5</sup> Grade 1 denotes obliteration of more than 50% of the subarachnoid space without any sign of cord deformity.<sup>5</sup> Grade 2 denotes canal stenosis with any sign of cord deformity.<sup>5</sup> Grade 3 denotes increased signal intensity of cord near compressed level with any sign of cord deformity.<sup>5</sup> There were no grade 2 nor 3 stenoses in the current study population. Therefore, the stenosis was defined as the obliteration of more than 50% of the subarachnoid space of the anterior or posterior epidural spaces without any sign of a cord deformity (► Fig. 1).<sup>5</sup> The stenosis was assessed by independent orthopedic residents who were blinded to the current study.

Whole-spine T2 sagittal MRIs were performed in all patients using a 1.5-T superconductive imager (Intera, Koninklijke Philips Electronics N.V., Amsterdam, The Netherlands) under the following settings: sagittal T2-weighted fast spine-echo imaging (repetition time/echo time: 2,346/100; echo train length 16; slice thickness 4 mm; field of view 320 mm, matrix size 548 × 272, number of excitations 4). The anteroposterior diameter of vertebral body, anteroposterior diameter of bony spinal canal, Pavlov ratio, anteroposterior diameter of spinal cord, and anterior or posterior epidural stenosis at the disk level for the cervical and thoracic spines were measured on PACS (Picture



**Fig. 1** Canal stenosis in the sagittal scans of spines. There is no stenosis (A). Stenosis was defined as obliteration of more than 50% of the subarachnoid space without any sign of cord deformity (B).

Archiving and Communication System; Π view, Infinit, Seoul, Korea) at the midline, not at the foraminal area and lateral recess. The anteroposterior diameter of the vertebral body, anteroposterior diameter of the bony spinal canal, Pavlov ratio, and anteroposterior diameter of the spinal cord were measured at the vertebral body midportion level. At the C2 level, they were measured at 3 mm above the lower C2 end plate. The Pavlov ratio was defined as the ratio between the sagittal canal diameter and the vertebral body diameter of the same level,<sup>6,7</sup> and it was used to eliminate the difference in magnification. We compared the radiologic parameters between the subgroups of cervical stenosis with (stenotic thoracic group) and without thoracic stenosis (nonstenotic thoracic group) to elucidate the radiologic features of cervical stenosis that might predict concurrent thoracic stenosis. In the preliminary study, the MRIs of 30 patients (1,020 epidural spaces) were reread 2 weeks apart to determine the intraobserver reliability for epidural stenosis. In addition, the assessors were not aware of the source population of the MRIs. They also were not informed about the purpose of the study. They evaluated the MRIs in a randomized sequence and without discussion of the findings to minimize possible bias.

### Statistical Methods

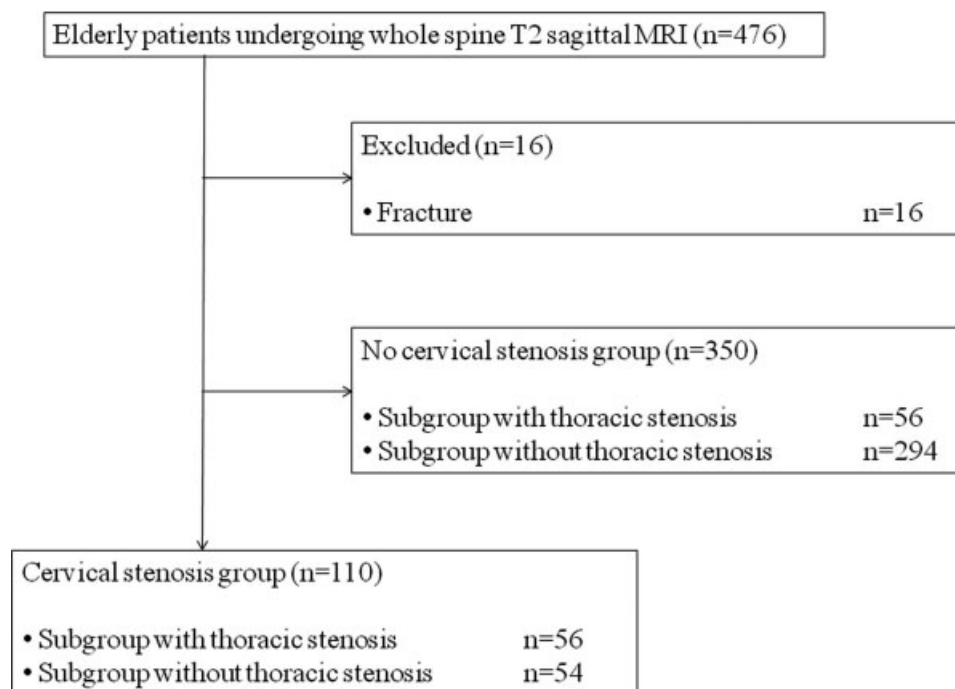
All the statistical analyses were performed with SPSS version 13.0 for Windows (Chicago, Illinois, United States). A *p* less than 0.05 was considered significant. The independent *t* test, chi-square test, or Fisher exact test was used to analyze the differences of measuring factors on each group according to categorized or noncategorized variables. Binary logistic regression was used to estimate the odds ratios and 95% confidence intervals for radiographic parameters with thoracic stenosis using backward stepwise regression. A *p* value

less than 0.001467 (0.05/12) was considered significant by Bonferroni correction because 12 radiographic parameters will be checked by binary logistic regression. Intraobserver and interobserver variabilities were assessed using kappa analysis. A *p* value less than 0.05 was considered significant. Landis and Koch characterized kappa values < 0 as indicating no agreement and 0 to 0.20 as slight, 0.21 to 0.40 as fair, 0.41 to 0.60 as moderate, 0.61 to 0.80 as substantial, and 0.81 to 1 as almost perfect agreement.<sup>8</sup>

### Results

There were 476 patients with lumbar stenosis who had total spine MRIs. Of these, 16 patients did not meet the study criteria and were excluded, leaving 460 (►Fig. 2). The study population was composed of 359 women and 101 men, age 80 to 98 years (mean  $83.3 \pm 3.1$  years) at the time of the radiologic evaluation. Of the 460 patients, 110 (23.9%) had cervical stenosis and 350 (76.1%) did not (►Fig. 2). Thoracic stenosis was found in 112 patients (24.3%, ►Fig. 2). Concurrent lumbar and cervical stenosis without thoracic stenosis was found in 54 of 460 patients (11.7%, nonstenotic thoracic group, ►Fig. 2). Concurrent lumbar and thoracic stenosis without cervical stenosis was found in 56 of 460 patients (12.2%, ►Fig. 2). Concurrent lumbar, cervical, and thoracic stenosis was found in 56 of 460 patients (12.2%, stenotic thoracic group, ►Fig. 2). The averages of the anteroposterior diameter of the vertebral body, bony spinal canal, spinal cord, and Pavlov ratio in the cervical stenosis group were  $19.58 \pm 4.66$  mm,  $13.04 \pm 0.62$  mm,  $4.64 \pm 0.58$  mm,  $0.71 \pm 0.16$ , respectively.

There were no statistically significant differences in the anteroposterior diameters of the vertebral body, bony spinal canal, and Pavlov ratios of the thoracic spine between the



**Fig. 2** Flow diagrams for the current study. Abbreviation: MRI, magnetic resonance imaging.

stenotic thoracic group and the nonstenotic thoracic group ( $p > 0.05$ ), but the anteroposterior diameters of the bony spinal canal at T6 and T8 levels were smaller in the stenotic thoracic group ( $p < 0.05$ ). There were no statistically significant differences in the anteroposterior diameter of the spinal cord of the thoracic spine. Anterior epidural stenosis of the subjects in the stenotic thoracic group was found at the T5–T6, T6–T7, T7–T8, T8–T9, T9–T10, and T10–T11 disk levels (► **Table 1**). Posterior epidural stenosis of the subjects in the stenotic thoracic group was found at the T7–T8, T8–T9, and T9–T10 disk levels (► **Table 1**).

Between stenotic and nonstenotic thoracic groups, there were no statistically significant differences in the anteroposterior diameter of the vertebral body, spinal canal, or Pavlov ratio and anteroposterior diameter of the spinal cord of the cervical spine ( $p > 0.05$ ). The patients with anterior epidural stenosis at C7–T1 or posterior epidural stenosis at C2–C3 had a high prevalence of thoracic stenosis (► **Table 2**). Concurrent thoracic stenosis was common with C7–T1 anterior epidural stenosis by binary logistic regression (► **Table 3**,  $p = 0.000428$ ). The odds ratio of concurrent thoracic stenosis with C7–T1 anterior epidural stenosis was 4.493.

The intraobserver reliability for cervical epidural stenosis and thoracic epidural stenosis and the interobserver reliability for cervical epidural stenosis and thoracic epidural stenosis were good at 0.714, 0.676, 0.534, and 0.459, respectively, using kappa analysis.

## Discussion

Numerous studies have reported on concurrent stenosis of the cervical and lumbar spine.<sup>9–16</sup> When operating on one of these areas, one should therefore consider evaluating the other. However, studies based on concurrent cervical and thoracic spinal stenosis, as well as triple stenosis (cervical, thoracic and lumbar), are rare.<sup>17–19</sup> The purpose of this study

is to determine the incidence of asymptomatic radiologic cervical and thoracic stenosis in patients with symptomatic lumbar stenosis.

In the current study, among the 460 patients with symptomatic lumbar stenosis, 110 (23.9%) had concurrent radiologic cervical stenosis and 112 (24.3%) had concurrent radiologic thoracic stenosis. Fifty-six patients (12.1%) had combined radiologic cervical and thoracic stenosis in addition to their symptomatic lumbar stenosis (triple stenosis). Fifty-six patients (50.9%) with asymptomatic cervical stenosis exhibited asymptomatic tandem thoracic spinal stenosis. Anterior epidural stenosis at the C7–T1 level of the cervical spine was a common finding in the group with thoracic stenosis.

Arana et al studied the relation between the degenerative disks of the upper thoracic and cervical spine in 156 patients with cervical pain and found that degenerative changes in the thoracic disks were observed in 13.4% of the patients with cervical pain.<sup>17</sup> Matsumoto et al evaluated the concurrent degeneration in the cervical and thoracic spines on the MRIs of 94 asymptomatic volunteers.<sup>18</sup> Eighty-five (90.4%) patients had degenerative changes in the cervical spine and 44 (46.8%) had changes in the thoracic spine.<sup>18</sup> However, neither of these studies evaluated the radiologic features in the cervical spine that might predict thoracic stenosis.

Okada et al demonstrated that an asymptomatic decreased signal intensity and a posterior disk protrusion in the cervical spine were associated with the presence of a symptomatic lumbar disk herniation.<sup>14</sup> They found that 98.0% of 51 patients with lumbar disk herniation had degenerative changes in their cervical disks.<sup>14</sup> Similarly, in this study C7–T1 anterior epidural stenosis at the disk level was a predictive factor of thoracic stenosis.

In a cadaveric study of 440 skeletally mature skeletons, the midsagittal canal diameter was measured with the definition of stenosis as a midsagittal diameter of less than 12 mm.<sup>10</sup>

**Table 1** Anterior or posterior epidural thoracic stenosis between stenotic thoracic group and nonstenotic thoracic group

Level	Anterior epidural stenosis <sup>a</sup>	Posterior epidural stenosis <sup>a</sup>
T1–T2	21 (37.5%)/12 (22.2%)	8 (14.3%)/4 (7.4%)
T2–T3	16 (28.6%)/10 (18.5%)	4 (7.1%)/3 (5.6%)
T3–T4	11 (19.6%)/8 (14.8%)	5 (8.9%)/3 (5.6%)
T4–T5	12 (21.4%)/7 (13.0%)	5 (8.9%)/0 (0.0%)
T5–T6	21 (37.5%)/6 (11.1%) <sup>b</sup>	5 (8.9%)/0 (0.0%)
T6–T7	25 (44.6%)/10 (18.5%) <sup>b</sup>	8 (14.3%)/2 (3.7%)
T7–T8	25 (44.6%)/7 (13.0%) <sup>b</sup>	9 (16.1%)/1 (1.9%) <sup>b</sup>
T8–T9	23 (41.1%)/9 (16.7%) <sup>b</sup>	11 (19.6%)/2 (3.7%) <sup>b</sup>
T9–T10	23 (41.1%)/12 (22.2%) <sup>b</sup>	17 (30.4%)/4 (7.4%) <sup>b</sup>
T10–T11	27 (48.2%)/11 (20.4%) <sup>b</sup>	8 (14.3%)/5 (9.3%)
T11–T12	20 (35.7%)/12 (22.2%)	8 (14.3%)/4 (7.4%)

<sup>a</sup>Expressed as the number of patients in stenotic thoracic group (percentage)/number of patients in nonstenotic thoracic group (percentage).

<sup>b</sup>Statistically significant.

**Table 2** Anterior or posterior epidural cervical stenosis between stenotic thoracic group and nonstenotic thoracic group

Level	Anterior epidural stenosis <sup>a</sup>	Posterior epidural stenosis <sup>a</sup>
C2–C3	19 (33.9%)/18 (33.3%)	39 (69.6%)/27 (50.0%) <sup>b</sup>
C3–C4	48 (85.7%)/42 (77.8%)	50 (89.3%)/42 (77.8%)
C4–C5	53 (94.6%)/49 (90.7%)	50 (89.3%)/46 (85.2%)
C5–C6	56 (100%)/51 (94.4%)	52 (92.9%)/49 (90.7%)
C6–C7	51 (91.1%)/50 (92.6%)	46 (82.1%)/43 (79.6%)
C7–T1	42 (75.0%)/23 (42.6%) <sup>b</sup>	21 (37.5%)/15 (27.8%)

<sup>a</sup>Expressed as the number of patients in stenotic thoracic group (percentage)/number of patients in non-stenotic thoracic group (percentage).

<sup>b</sup>Statistically significant.

**Table 3** Radiographic parameters associated with thoracic stenosis

Risk factor	p Value	Exp(B)	OR (95% CI)
Anterior epidural stenosis			
C7–T1	0.000428	4.493	1.947, 10.367
Posterior epidural stenosis			
C2–C3	0.053458	3.045	0.984, 9.430

Abbreviations: CI, confidence interval; OR, odds ratio.

Bony cervical stenosis had a positive predictive value of 16.7% for bony lumbar stenosis.<sup>10</sup> A decreased Pavlov ratio of the lumbar spine has been shown to be a predictive factor of cervical spondylotic myelopathy in the patients with lumbar spinal stenosis.<sup>13</sup> In the current study, the anteroposterior diameter of the bony spinal canal and the Pavlov ratio of the cervical spine were not predictive factors for thoracic stenosis. It might be explained that the anteroposterior diameter of the spinal canal and Pavlov ratio of the thoracic spine were not different but the epidural stenosis of the thoracic spine was different between the stenotic and nonstenotic thoracic groups in the current study.

Kim et al found that of 101 elderly patients older than 65 who had undergone surgery for lumbar spinal stenosis, 26 (25.7%) had triple stenosis (cervical, thoracic, and lumbar stenosis).<sup>19</sup> The authors included patients with degenerative stenosis and stenosis from the ossification of posterior longitudinal stenosis or ossification of the yellow ligament.<sup>19</sup> They found that the symptom duration of lumbar stenosis was positively correlated for the presence of the asymptomatic cervical and thoracic stenosis.<sup>19</sup> However, they did not elucidate the radiologic degenerative parameter in the cervical spine that can predict thoracic stenosis.

There have been cases of paralysis from a spinal origin after anesthesia or sleep in patients with asymptomatic spinal stenosis.<sup>3,4</sup> Two patients following non-cervical spine surgery had postoperative transient tetraplegia despite optimal anesthetic management.<sup>3</sup> Postoperative MRI of the cervical spine showed a cervical disk herniation and protrusion of the hypertrophic ligamentum flavum causing spinal cord compression.<sup>3</sup> Their muscle weakness gradually improved without surgery and completely recovered by the following morning.<sup>3</sup> The authors recommended that the neck be posi-

tioned carefully and intubation be performed without hyperextension of the neck for patients with spondylosis.<sup>3</sup> A 56-year-old man developed an acute, nontraumatic onset of tetraplegia during a 1-hour nap.<sup>4</sup> MRI of the cervical spine revealed canal stenosis and an increased T2 signal within the cord.<sup>4</sup> After rehabilitation for 6 months, he recovered trace strength bilaterally in the extensor hallucis and required continued respiratory rehabilitation.<sup>4</sup>

As with any study, the present investigation may have some potential problems. First, it is possible that some patients who were labeled as asymptomatic may not have truly been asymptomatic. Myelopathy is a clinical diagnosis and not all such patients have the telltale pathologic reflexes. A mild loss of manual dexterity is not uncommon in the elderly. Furthermore, a gait disturbance may be attributed to lumbar stenosis. Therefore, it is possible that some of our patients had myelopathy that was missed. Second, we made the diagnosis of concurrent stenosis using only a T2-weighted sagittal image at the midline. This is likely to have missed some stenosis that is only evident on axial images. Therefore, the true incidence may be higher than what we report. Third, there might be a correlation between the severity of their symptoms in the lumbar spine and stenosis in the thoracic spine. Most patients in the study population had relief of their symptoms with medications and did not undergo lumbar surgery because of their age. Therefore, it is difficult to analyze lumbar surgery as a risk factor for thoracic stenosis due to the small number of the patients who underwent lumbar surgery. Fourth, only patients over 80 years old were enrolled. The current study's definition of stenosis as having a single spinal level (either cervical or thoracic) with loss of >50% anterior or posterior subarachnoid space may lead to significant overestimation of the incidence of concomitant

stenosis, especially in a population that is over 80 years old. This was based upon a previously published definition of grade 1 stenosis used by Kang et al.<sup>5</sup> Therefore, further study of various age groups is necessary to determine the true incidence of triple stenosis in all patients. Fourth, the current study did not show how many patients with symptomatic cervical stenosis also have thoracic stenosis. Nevertheless, it is the first study to identify the incidence of concomitant asymptomatic cervical and thoracic stenosis in patients with symptomatic lumbar stenosis and to elucidate the predictable radiologic factors for concurrent cervical and thoracic stenosis in such patients.

In conclusion, patients with symptomatic lumbar stenosis often have asymptomatic radiologic cervical and thoracic spinal stenosis. Although the majority of these cases probably remain asymptomatic, some may become symptomatic over time. Furthermore, with prolonged surgical positioning during lumbar decompression, they may become symptomatic. Finally, when choosing surgical levels for lumbar arthrodesis, it may be wise to evaluate the entire thoracic spine to ensure that the arthrodesis does not stop close to a stenotic thoracic level. This can be done with only a T2 scout sagittal view of the whole spine, saving cost and time. In addition, in the patient with C7–T1 anterior epidural stenosis at the disk level, it may be reasonable to obtain an MRI of the thoracic spine to rule out thoracic stenosis.

#### Disclosures

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#### References

- 1 Boden SD, McCowin PR, Davis DO, Dina TS, Mark AS, Wiesel S. Abnormal magnetic-resonance scans of the cervical spine in asymptomatic subjects. A prospective investigation. *J Bone Joint Surg Am* 1990;72(8):1178–1184
- 2 Matsumoto M, Fujimura Y, Suzuki N, et al. MRI of cervical intervertebral discs in asymptomatic subjects. *J Bone Joint Surg Br* 1998;80(1):19–24
- 3 Kudo T, Sato Y, Kowatari K, Nitobe T, Hirota K. Postoperative transient tetraplegia in two patients caused by cervical spondylotic myelopathy. *Anaesthesia* 2011;66(3):213–216
- 4 Young IA, Burns SP, Little JW. Sudden onset of cervical spondylotic myelopathy during sleep: a case report. *Arch Phys Med Rehabil* 2002;83(3):427–429
- 5 Kang Y, Lee JW, Koh YH, et al. New MRI grading system for the cervical canal stenosis. *AJR Am J Roentgenol* 2011;197(1):W134–W140
- 6 Pavlov H, Torg JS, Robie B, Jahre C. Cervical spinal stenosis: determination with vertebral body ratio method. *Radiology* 1987;164(3):771–775
- 7 Yue WM, Tan SB, Tan MH, Koh DC, Tan CT. The Torg–Pavlov ratio in cervical spondylotic myelopathy: a comparative study between patients with cervical spondylotic myelopathy and a nonspondylotic, nonmyelopathic population. *Spine (Phila Pa 1976)* 2001;26(16):1760–1764
- 8 Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33(1):159–174
- 9 Jacobs B, Ghelman B, Marchisello P. Coexistence of cervical and lumbar disc disease. *Spine (Phila Pa 1976)* 1990;15(12):1261–1264
- 10 Lee MJ, Garcia R, Cassinelli EH, Furey C, Riew KD. Tandem stenosis: a cadaveric study in osseous morphology. *Spine J* 2008;8(6):1003–1006
- 11 Vogt MT, Cawthon PM, Kang JD, Donaldson WF, Cauley JA, Nevitt MC. Prevalence of symptoms of cervical and lumbar stenosis among participants in the Osteoporotic Fractures in Men Study. *Spine (Phila Pa 1976)* 2006;31(13):1445–1451
- 12 Edwards WC, LaRocca SH. The developmental segmental sagittal diameter in combined cervical and lumbar spondylosis. *Spine (Phila Pa 1976)* 1985;10(1):42–49
- 13 Iizuka H, Takahashi K, Tanaka S, Kawamura K, Okano Y, Oda H. Predictive factors of cervical spondylotic myelopathy in patients with lumbar spinal stenosis. *Arch Orthop Trauma Surg* 2012;132(5):607–611
- 14 Okada E, Matsumoto M, Fujiwara H, Toyama Y. Disc degeneration of cervical spine on MRI in patients with lumbar disc herniation: comparison study with asymptomatic volunteers. *Eur Spine J* 2011;20(4):585–591
- 15 Park JY, Chin DK, Kim KS, Cho YE. Thoracic ligament ossification in patients with cervical ossification of the posterior longitudinal ligaments: tandem ossification in the cervical and thoracic spine. *Spine (Phila Pa 1976)* 2008;33(13):E407–E410
- 16 Lee SH, Kim KT, Suk KS, et al. Asymptomatic cervical cord compression in lumbar spinal stenosis patients: a whole spine magnetic resonance imaging study. *Spine (Phila Pa 1976)* 2010;35(23):2057–2063
- 17 Arana E, Martí-Bonmatí L, Mollá E, Costa S. Upper thoracic-spine disc degeneration in patients with cervical pain. *Skeletal Radiol* 2004;33(1):29–33
- 18 Matsumoto M, Okada E, Ichihara D, et al. Age-related changes of thoracic and cervical intervertebral discs in asymptomatic subjects. *Spine (Phila Pa 1976)* 2010;35(14):1359–1364
- 19 Kim BS, Kim J, Koh HS, Han SY, Lee DY, Kim KH. Asymptomatic Cervical or Thoracic Lesions in Elderly Patients who Have Undergone Decompressive Lumbar Surgery for Stenosis. *Asian Spine J* 2010;4(2):65–70