

Signal intensity changes of the posterior elements of the lumbar spine in symptomatic adults

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Abstract:

Introduction: Modic type 1 changes around the vertebral endplate of the lumbar spine are well known to indicate inflammation; however, the clinical significance of similar SCs of the posterior elements has not been elucidated.

Methods: Six hundred ninety-eight MRIs of patients with complaints of low back/leg pain were retrospectively examined. Target SCs in this study were hypointensity on T1-WI and hyperintensity on T2-WI or short tau inversion recovery sequences showing the same signal patterns seen in Modic type 1 change of the lumbar posterior elements. We analyzed the (1) Prevalence, symptom, and age distribution of SCs, (2) Localization of SCs and their association with Modic type 1 changes, (3) Spinal level distribution of SCs, (4) Association between SCs and disc degeneration of the affected spinal level, and (5) Association between SCs and radiological changes (spondylolisthesis, scoliosis).

Results: (1) Among 698 adult patients, 36 (16 men, 20 women) exhibited SCs (5.2%). No SCs were identified in patients age <40 years. (2) Of the 36 SCs, 9 (25%) were localized at a single spinal level, while 27 (75%) were found at neighboring spinal levels across the facet joint. Thirteen SCs (36.1%) had continuity with Modic type 1 changes around the vertebral endplate, while 23 (63.9%) were localized to the posterior elements. (3) SCs were frequently identified in the lower lumbar spine below the L4 level. (4) More than 80% of the SCs involved disc degeneration. (5) Spondylolisthesis was associated with 93% of SCs in double-level, and scoliosis was associated with SCs in unilateral side.

Conclusion: The prevalence of SCs in symptomatic adults was 5.2%. On the basis of observed disc degeneration, 75% of SCs were considered to indicate inflammation or bone marrow edema around the facet joint.

Keywords:

Modic change, lumbar spine, lamina, intervertebral disc, facet joint

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Introduction

Hypointense signal changes (SCs) seen on T1-weighted imaging (WI) and hyperintense SCs seen on T2-WI of bone are generally considered to indicate bone marrow edema or inflammation. Modic type 1 change, a well-known radiological finding around the vertebral endplates and subchondral bone marrow that neighbor degenerated intervertebral discs of the lumbar spine, suggests inflammation and bone marrow edema related to low back pain¹⁻³.

The clinical significance of similar SCs of the posterior elements has not yet been elucidated, although a few reports in the literature describe the occurrence^{4,5}. Such SCs identified in the pedicle of the lumbar spine in pediatric patients,

particularly those with high athletic activity, have been reported as an initial sign of stress fracture of the pars interarticularis (spondylolysis)^{6,9}. According to past reports, SCs in adult patients are thought to be associated with degeneration of the lumbar intervertebral disc or facet joint^{4,5}. However, to the best of our knowledge, no studies have described in detail the clinical significance of SCs of the posterior elements, including factors such as prevalence, age distribution, and spinal level.

The purpose of this study was to examine the magnetic resonance images (MRIs) of symptomatic adults and investigate the significance of SCs of the posterior elements.

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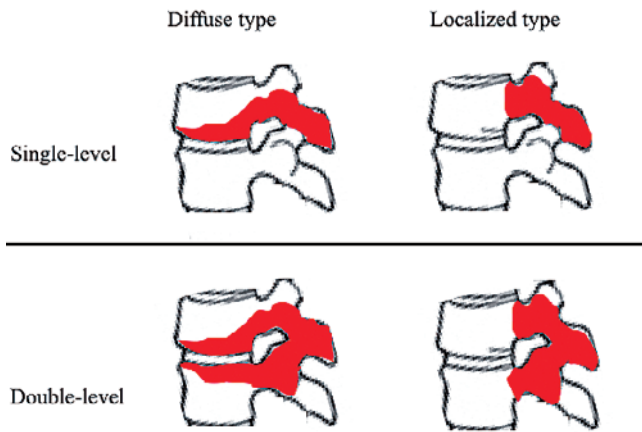


Figure 1. Categorization according to the location of signal changes (SCs). Subjects were categorized into four types according to SC location.

Materials and Methods

Six hundred ninety-eight MRIs of the lumbar spine were retrospectively examined for consecutive adult (age ≥ 20 years) patients (292 men, 406 women; mean age 62.8 years, range 20-97 years) with complaints of low back pain (LBP), leg pain (LP), or both. Those symptoms were retrospectively reviewed using the past medical records. MRI examinations were performed between January and December 2013 on a 1.5-T MR scanner (Philips Achieva 1.5T Release 3.2; Philips Healthcare, Netherlands).

Images reviewed were obtained on sagittal T1-WI (repetition time [TR], 400-650 ms; echo time [TE], 10 ms; matrix size, 512×512 ; slices, 15; slice thickness, 4 mm; slice gap, 0.4 mm; flip angle, 90 degrees; acquisition time, 2 min 28 s), sagittal T2-WI (TR/TE, 3,000-8,000 ms/120 ms; matrix size, 512×512 ; slices, 15; slice thickness, 4 mm; slice gap, 0.4 mm; flip angle, 90 degrees; acquisition time, 3 min 11 s), axial T1-WI (TR/TE, 400-650 ms/10 ms; matrix size, 512×512 ; slices, 25; slice thickness, 4 mm; slice gap, 0.4 mm; flip angle, 90 degrees; acquisition time, 2 min 31 s), and axial T2-WI (TR/TE, minimum/120 ms; matrix size, 512×512 ; slices, 25; slice thickness, 4 mm; slice gap, 0.4 mm; acquisition time, 2 min 47 s). For short tau inversion recovery (STIR), the following sequences were used: sagittal STIR sequence (TR/TE, 2,500-5,000 ms/70 ms; inversion time, 160 ms; matrix size, 400×400 ; slices, 15; slice thickness, 4 mm; slice gap, 0.4 mm; flip angle, 120 degrees; acquisition time, 2 min 26 s) and axial STIR sequence (TR/TE, 2,500-5,000 ms/70 ms; inversion time, 160 ms; matrix size, 400×400 ; slices, 25; slice thickness, 4 mm; slice gap, 0.4 mm; flip angle, 120 degrees; acquisition time, 2 min 14 s). Interpretation of the MRI was independently done by two experienced orthopedic surgeons. Inter-observer and intra-observer errors were examined using kappa statistic.

Subjects with previous lumbar surgery, evidence of lumbar or sacral tumors, malignancy, serious congenital anomalies, infection, fracture, and spondylolysis were excluded

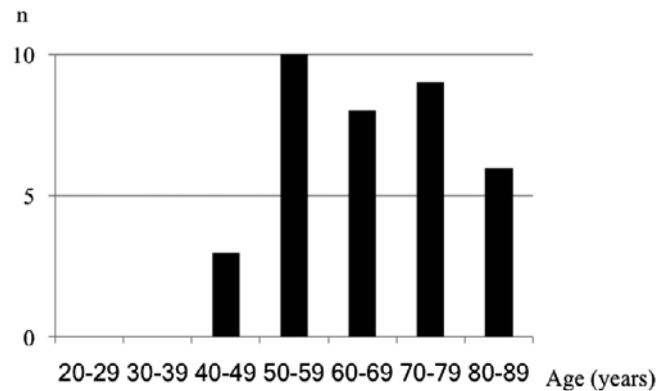


Figure 2. Age distribution of patients with signal changes (SCs) of the posterior elements of the lumbar spine. No SCs were identified in patients aged < 40 years, and most patients with SCs were aged > 50 years.

from this study. Target SCs were hypointensity on T1-WI and hyperintensity on T2-WI or STIR sequences, which showed the same signal pattern changes defined as Modic type 1 of the lumbar posterior elements.

We analyzed the following five parameters: (1) Prevalence, symptom, and age distribution of SCs, (2) Localization of SCs and their association with Modic type 1 change: The localization of SCs were classified into two types, localized type and diffuse type. The localized type was defined as the SCs localized in the posterior element including pedicle and lamina on MRI (Fig. 1), (3) Spinal level distribution of SCs, and (4) Association between SCs and disc degeneration of the affected spinal level. Intervertebral disc degeneration was defined as grade IV/V according to Pfirrmann's classification¹⁰, (5) Association between SCs and radiological changes (spondylolisthesis, scoliosis). Spondylolisthesis and scoliosis were evaluated using the lumbar spine radiographs of standing position taken in the same period with MRI. Spondylolisthesis was defined as 3-mm anterolisthesis¹¹. Scoliosis was evaluated by Cobb angle between T12 and L5 vertebrae¹², and was defined as a spinal curvature of more than 10 degrees on the Cobb angle.

Results

(1) Prevalence, symptom, and age distribution of SCs

Among 698 adult patients, 36 (16 men, 20 women) exhibited SCs (5.2%). No SCs were identified in patients aged < 40 years (Fig. 2). Notably, most patients with SCs (91.7%) were aged > 50 years (mean \pm standard deviation: 65.7 ± 11.2 years).

Fifteen patients had SCs identified bilaterally. In those patients, 6 had LBP, 4 had LP, and 5 had both symptoms. In 21 patients, SCs were identified unilaterally. In those patients, 10 had LBP, 4 had LP, and 7 had both symptoms.

Among 20 patients with LP, 14 had unilateral LP, and 6 had bilateral LP. Concordance rate of laterality between SCs

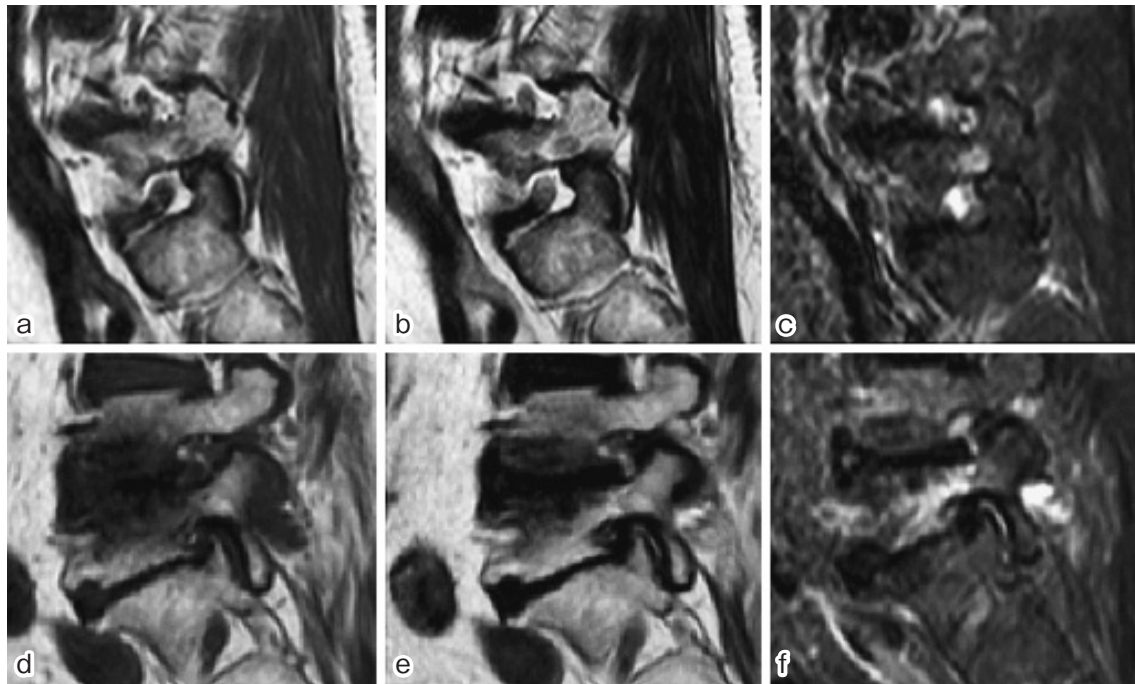


Figure 3. Upper panels: Parasagittal MR images (a: T1-WI, b: T2-WI, c: STIR image) of a 69-year-old woman with low back pain show targeted SCs in right L5 pedicle and pars interarticularis. This SC was categorized into localized type and single-level group.

Lower panels: Parasagittal MR images (a: T1-WI, b: T2-WI, c: STIR image) of a 53-year-old man with low back and occasional left leg pain show targeted SCs of bilateral L5 pedicle continuous with Modic type 1 changes. This SC was categorized into diffuse type and single-level group.

and symptoms in those 14 patients was 85.7% (12/14).

(2) Localization of SCs and association with Modic type 1 changes of the vertebral endplate (Fig. 1)

Of the 36 SCs identified, 9 (25%) were localized at a single spinal level (single-level group) (Fig. 3), while 27 (75%) were found at neighboring spinal levels across the facet joint (double-level group) (Fig. 4). Thirteen SCs (36.1%) had continuity with Modic type 1 changes around the vertebral endplate (Fig. 3, 4, lower panels), while 23 SCs (63.9%) were localized to the posterior elements (Fig. 3, 4, upper panels). Details of the types of SCs were shown in Table 1.

Using the kappa statistic, a significance agreement between the two observers in the judgement about of continuity of SCs in the posterior element to Modic type 1 change was found. On the Inter-observer error, kappa index was 0.94; 95% confidence interval 0.92-0.96; $p < 0.05$. On the intra-observer error, kappa index was 0.94; 95% confidence interval 0.92-0.96; $p < 0.05$. The agreement was “almost perfect.”

(3) Spinal level distribution

The distribution of spinal levels with SCs was evaluated separately in the single-level group and double-level group. As shown in Fig. 5, among 9 SCs in the single-level group, 6 (66.7%) were below the L5 level. Among 27 SCs in the double-level group, 20 (74.1%) were below the L4-5 level. Thus, SCs were frequently identified in the lower lumbar

spine.

(4) Association between SCs in double levels and disc degeneration

We evaluated 27 SCs in the double-level group to confirm an association with disc degeneration at the affected facet joint. Among these, 23 (85.2%) were associated with disc degeneration of Pfirrmann grade IV/V. In addition, >80% of both diffuse and localized SCs involved disc degeneration (87.5% and 84.2%, respectively).

(5) Association between SCs and radiological changes

Among 36 SCs identified, 33 plain radiographs of the lumbar spine of standing position were available. Among those 33 radiographs, 15 (45.5%) showed spondylolisthesis. In the 15 with spondylolisthesis, 14 (93.3%) presented SCs in double-level in the affected level. On the other hand, in 18 with non-spondylolisthesis, 12 (66.7%) had SCs in double-level in the affected level (Table 2). Cobb angle between T12 and L5 vertebrae was 4.8 degrees in average. Five radiographs showed a spinal curvature of more than 10 degrees. All of those patients (100%) had SCs in unilateral side (convex side: 3, concave side: 2) (Table 3).

Discussion

In this study, SCs were found in 5.2% of adult patients with low back, leg pain, or both, and all patients with SCs

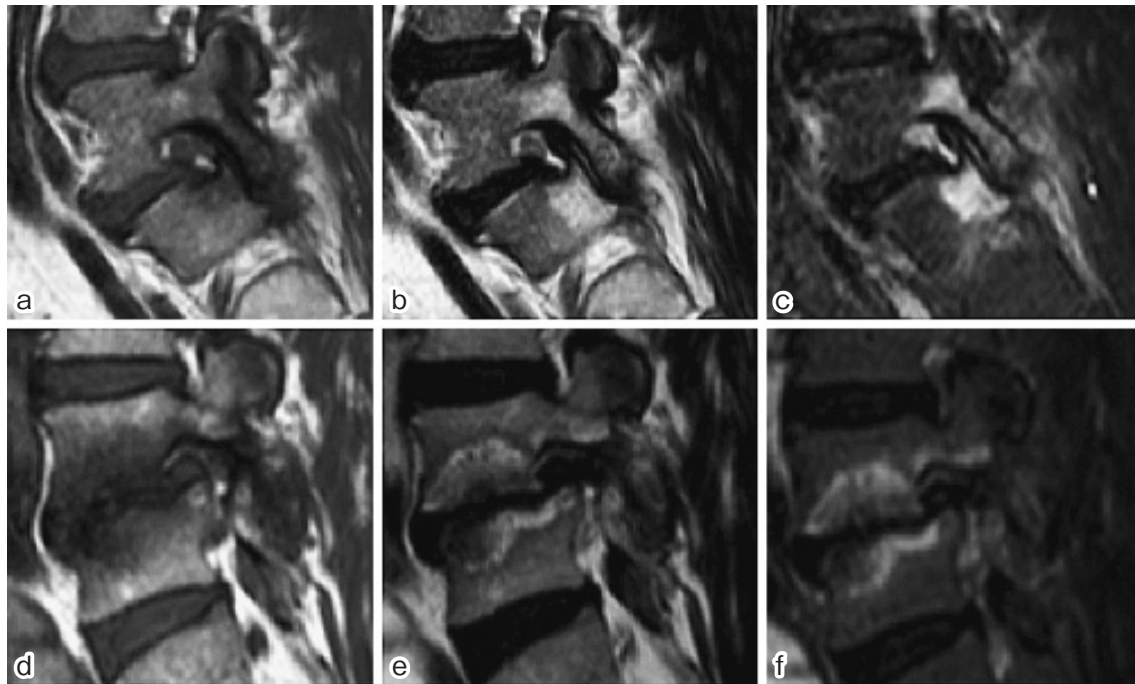


Figure 4. Upper panels: Parasagittal MR images (a: T1-WI, b: T2-WI, c: STIR image) of a 57-year-old man with low back pain show targeted SCs in bilateral L5-S1 pedicle. This SC was categorized into localized type and double-level group.

Lower panels: Parasagittal MR images (a: T1-WI, b: T2-WI, c: STIR image) of a 71-year-old woman with low back and right leg pain show targeted SCs of the right L4-5 pedicle continuous with Modic type 1 changes. This SC was categorized into diffuse type and double-level group.

Table 1. Details of Categorization According to the Location of Signal Changes.

	Diffuse type (n)	Localized type (n)	Total (n)
Signal-level (n)	5	4	9
Double-level (n)	8	19	27
Total (n)	13	23	36

were >40 years of age. In a previous study, the prevalence of SCs in MRIs of patients with low back pain was reported to be 1.8% (7/400), and 2 out of the 7 patients with SCs were <30 years of age, with no additional abnormal findings⁵. These differences in prevalence and age distribution could have resulted mainly from variations in the analysis method. In the present study, we defined SC as hypointensity on T1-WI or hyperintensity on T2-WI of the posterior elements, including the pedicle, lamina, and facet joint, whereas the previous study focused on SCs in the pedicle only. Indeed, we found 7 SCs that were localized on the facet joint and did not affect the adjacent pedicle. The age of the study subjects also may have played a role in the different findings; mean age in our study was 62.8 years, compared with approximately 50 years in the previous studies^{4,5}.

There were two main findings related to the localization of the SCs: that 75% (27/36 SCs) were found at neighboring spinal levels across the facet joint, and that 36% (13/36 SCs) had continuity with Modic type 1 changes of the verte-

bral endplate. This is the first detailed report of SC localization to the posterior elements, although there is a previous report describing a case with multiple pedicle SCs⁴.

SCs were frequently identified in the lower lumbar spine, which was consistent with past reports. These findings may be associated with disc degeneration. In this study, 85.2% of SCs were accompanied by disc degeneration of Pfirrmann grade IV/V. We, therefore, speculate that these SCs indicate a process of degeneration or aging, which is also in agreement with the literature.

Although there are few literatures referring to association SCs in the lumbar posterior element and lumbar alignment, this study revealed the strong association between SCs which spread in double-level and spondylolisthesis. There was an association between unilateral SCs and scoliosis over 10 degrees or axial rotation; however, there was no association between the laterality of SCs with scoliosis and axial rotation.

This study had several limitations. Because this study included only Mongolian race in Japan, ethnic difference could not be investigated. As it was a cross-sectional study, the pathomechanism of the findings is not known; a prospective study is required to clarify this. In addition, this study did not include control subjects without symptoms. If similar findings were obtained in asymptomatic subjects, it would indicate that the observed SCs may be regarded as simply indicating an aging process. Also, we could not confirm whether SCs indicated the source of the patients' pain;

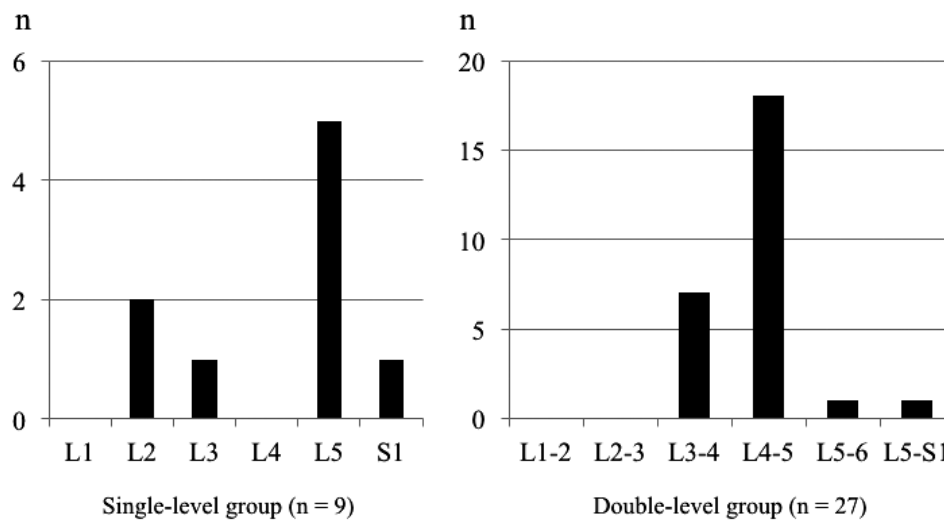


Figure 5. Spinal-level distribution of SCs is shown. The left and right graphs show the spinal-level distribution of SCs among single-level and double-level lesions, respectively.

Table 2. Details of Association of Spondylolisthesis and the Location of Signal Changes.

	Spondylolisthesis (n)	Non-spondylolisthesis (n)	Total (n)
Signal-level (n)	1	12	13
Double-level (n)	14	6	20
Total (n)	15	18	33

this would require a procedure such as xylocaine injection into the affected facet.

In summary, SCs of the posterior elements were found only in patients aged ≥ 40 years, and 75% of these SCs were considered to be derived from the facet joint, while the remaining 25% may be due to another factor such as osteoporosis. Most SCs (85.2%) were associated with disc degeneration. The presence or absence of continuity with Modic type 1 changes around the vertebral endplate may be affected by differences in the stress distribution of each patient. Spondylolisthesis was associated with SCs in double-level, and scoliosis or axial rotation was associated with SCs in unilateral side.

Conclusion

SCs of the lumbar posterior elements, including the pedicles, were present in 5.2% of the MRIs of adult patients with low back/leg pain. SCs were common at lower lumbar spinal levels accompanied by lumbar disc degeneration. SCs that occurred at neighboring spinal levels across the facet joint were mainly associated with degenerative change of the facet joint or secondary to intervertebral disc degeneration. Malalignment of lumbar spine affected the type of SCs.

Conflicts of Interest: All authors confirm that there are no conflicts of interest with people or organizations that could

Table 3. Details of Association of Scoliosis and the Location of Signal Changes.

	Scoliosis (n)	Non-Scoliosis (n)	Total (n)
Unilateral (n)	5	13	18
Bilateral (n)	0	15	15
Total (n)	5	28	33

bias the nature of this report.

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