

# Type 2 Sclerotic Modic Change Affect Fusion Result in Patients Undergoing PLIF With Pedicle Screw Instrumentation: A Retrospective Study

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## Research article

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# Abstract

## Background

Bony fusion rate was significantly lower in patients with type 3 Modic change than patients with normal endplates. It is not known whether there are relevant differences in fusion efficiency among patients with type 2 sclerotic Modic change or non sclerotic Modic change, or no Modic change.

## Methods

A retrospective study contained 208 lumbar segments in 131 subjects undergoing posterior lumbar interbody fusion (PLIF) with pedicle screw instrumentation (PSI) to assess the effect of type 2 sclerotic Modic change on fusion efficiency. These endplates were allocated into groups A, B, and C, according to their Modic changes. Group A had endplates with type 2 Modic change and endplate sclerosis. Group B had type 2 Modic change without endplate sclerosis. Group C had neither Modic change nor endplate sclerosis. The presence of Modic change was determined by magnetic resonance imaging (MRI). Endplate sclerosis in type 2 Modic change was detected by computed tomography (CT). We collected CT data 3 months till more than 24 months after operation in patients to assess bony fusion.

## Results

Incidences of bony fusion were 55.3% in group A, 95.1% in group B, 93.8% in group C. The bony fusion rate was significantly lower in group A than in either group B or C. There was no significant difference between groups B and C. Thus, endplates with type 2 sclerotic Modic change had a lower fusion rate in patients undergoing PLIF with PSI.

## Conclusion

Type 2 sclerotic Modic change could be an important factor that affects solid bony fusion in patients undergoing PLIF with PSI. CT may help diagnose endplate sclerosis in patients with type 2 change and inform the choice of best site for spinal fusion.

## Background

Vertebral endplate (Modic) changes are abnormalities of the endplate and adjacent bone marrow that can be seen with magnetic resonance imaging (MRI). A classification of these changes was first provided by Modic et al. (Modic et al., 1988) based on the evaluation of 474 patients in 1988. Type 1 change was defined as a hypointense signal on T1-weighted images and hyperintense signal on T2-weighted images. Type 2 change was defined as a hyperintense signal on T1-weighted images and isointense or slightly hyperintense signals on T2-weighted images, reflecting fatty replacement of the bone marrow. Type 3 change was a hypointense signal on T1- and T2-weighted images.

In a study involving 351 patients who underwent PLIF with threaded fusion cages (TFC), Kwon et al.[1], showed the bony fusion rate after PLIF was lower in patients with Modic change than in those without Modic change, only in patients with type 3 Modic change. Endplate sclerosis is the pathological feature of the Modic changes type 3, just because of endplate sclerosis, the fusion rates in patients with Modic changes type 3 is lower than type 2 and type 1. Generally, endplate sclerosis exists only in type 3 Modic changes, but not in type 1 and 2[2–4]. However, recent studies revealed that sclerosis can occur in endplates with any type of Modic changes, especially in type 2[5–7].

Mari et al.[7] reported a total of 82 Modic changes at 216 endplates (38%). Of these changes, 53 (65%) were type 2, and one (1%) type 3. Twelve (22.6%) endplates with Modic changes type 2 in MRI had sclerosis in CT. In clinical practice we have noticed that type 3 Modic changes are extremely rare among patients, and endplate sclerosis is more frequently observed in patients with Modic changes type 2 using computed tomography (CT) images.

However, the effect of type 2 sclerotic Modic change on fusion efficiency in patients undergoing PLIF with pedicle screw instrumentation (PSI) is unclear. The purpose of the current study was to assess the effect of type 2 sclerotic Modic change on fusion efficiency in patients undergoing PLIF with PSI.

## Methods

### Study participants

This is a retrospective study. The study was conducted at a single institution between January 2009 and March 2018, and consisted of 131 patients (58 men, 73 women) who underwent PLIF with PSI (TABLE1). A total of 208 lumbar segments recorded in 131 subjects were allocated into groups A, B, and C according to the endplate changes: 1. Group A had endplates with type 2 Modic change and endplate sclerosis. 2. Group B had type 2 Modic change but without endplate sclerosis. 3. Group C had neither Modic changes nor endplate sclerosis. According to fusion potentiality at L5-S1 level would be lower than the upper lumbar levels[8], segments of the three groups were further divided into two subgroups: L5-S1 segment (groups A1, B1, C1) and L1-5 segments (groups A2, B2, C2). After reviewing the digital database of a radiology record system, patients meeting the following criteria were included: (1) patients age was more than 18 years; (2) patients who had been diagnosed with lumbar spondylolisthesis or lumbar spinal canal stenosis; (3) patients underwent lumbar spine surgery with pedicle screw instrumentation, and the decompressed space was implanted with cage; (4) patients had no history of adolescent scoliosis, spinal surgery, tumor, tuberculosis, infection and trauma; (5) patients had no hypertension, diabetes and heart disease. For the main purpose is to discuss the difference in fusion efficiency among patients with type 2 sclerotic Modic change or non sclerotic Modic change, a few patients with type 3 Modic change were excluded.

### Ethics statement

The research was conducted according to the principles of the Declaration of Helsinki. The ethics committee of the First Affiliated Hospital of Guangxi Medical University approved the study, and written informed consent was obtained from all patients (2019(KY-E-033)).

### Operative technique

Patients were operated on in a prone position under general anesthesia. A midline incision was made to expose the spinous processes, laminae, and transverse processes. The initial stage involved inserting posterior transpedicular screw instrumentation (Common Spinal Fixation Device, Ltd., Li Bell, China) through a paraspinal muscle-splitting approach. The transpedicular screws were inserted under C-arm fluoroscopic guidance in all patients. The next stage involved posterior decompression (including laminectomy, medial facetectomy, and aminotomy), which was undertaken in all patients. A nearly complete discectomy was done. Intervertebral disc space spreaders were then inserted sequentially and rotated to restore the normal disc space. Next, an appropriate size of cage was inserted into the disc space directly under C-arm fluoroscopy so it would lay in the middle of the interbody space.

### Imaging analysis

Modic changes were determined using MRI (GE Signa Twinspeed; GE Medical Systems, Milwaukee, WI, USA), and endplate sclerosis was detected on sagittal and coronal reconstructed CT scans (GE Light Speed Pro 16; GE Healthcare, Milwaukee, WI, USA). MRI and CT analyses included the operated lumbar levels. Endplate sclerosis was seen adjacent to the endplate and usually localized in the same area as the lumbar interbody fusion Modic change (Fig. 1). At 3 months or longer after surgery, the patients were evaluated with CT. Classification of Modic changes was based on the T1- and T2-weighted MRI results in the middle five sagittal planes. The upper and lower endplates at each disc level were graded separately regarding the presence of type 2 Modic change or absence of Modic change, as previously defined [2] (Fig. 1a,b). Endplate sclerosis was visually evaluated from the sagittal and coronal reconstructed CT scans by comparing them with the MRI at a workstation (Fig. 1a–d). The presence of endplate sclerosis was defined as yes or no. Bony fusion was evaluated according to the postoperative sagittal and coronal reconstructed CT scans (Fig. 1c, d). CT became the preferred method for assessing interbody fusion [9–13]. Details of the bony fusion evaluation were as follows [13–15]: (1) complete fusion: evidence of bridging trabecular bone through the disc space with no cystic lucencies adjacent to the implant and no linear defects through the bridging bone; (2) partial fusion: trabecular bone seen extending from the endplate into the disc space but forming an incomplete bridge; (3) no fusion: no evidence of trabecular bone formation extending from the endplates. Because the aim of this study was to assess the bony fusion of vertebral body endplates, both complete and partial fusion were considered fusion.

Three experienced spine surgeons (JL, FZ and CZ.) who were blinded to the radiographic images independently classified the endplate changes and evaluated the images for the presence of bony fusion. If at least two of the observers agreed about the type of endplate change, the classification was carried out [16]. The binary logistic regression analysis was used to examine the association between type 2 sclerotic Modic change and bony fusion; three binary logistic regression analysis models were inputted in

turn. The models were performed as follow: a model adjusted for groups A and C (model 1); a model adjusted for groups A and B (model 2); a model adjusted for groups B and C (model 3).

## Results

### Modic change and sclerosis in endplates

Among a total of 208 endplates from 131 patients, 79 (38.0%) had evidence of type 2 Modic change. Of these 208 segments, 38 (18.3%) exhibited type 2 sclerotic change (group A), 41 (19.7%) had type 2 nonsclerotic change (group B), and 129 (62.0%) had no Modic change (group C)(TABLE2).

### Bony fusion in the three groups

The bony fusion rates were 55.3% in group A, 95.1% in group B, and 93.8% in group C. The fusion rate was significantly lower in group A than in the other two groups ( $P < 0.001$ ), while there was no statistical difference in the fusion rates between groups B and C ( $P = 0.754$ )(Fig. 2a)(TABLE3).

### Bony fusion in the subgroups

In the subgroup, the bony fusion rates were 55.6% in group A1, 94.4% in group B1, and 90.0% in group C1. The fusion rate was lower in group A1 than in the other two groups ( $P < 0.05$ ), while there was no statistical difference in the fusion rates between groups B1 and C1 ( $P = 0.595$ )(TABLE4). The bony fusion rates were 55.0% in group A2, 95.7% in group B2, and 94.9% in group C2. The fusion rate was lower in group A2 than in the other two groups ( $P < 0.05$ ), while there was no statistical difference in the fusion rates between groups B2 and C2 ( $P = 0.888$ )(Fig. 2b,c)(TABLE5).

## Discussion

The aim of this study was to investigate the effect of bony fusion after PLIF with PSI in patients with type 2 sclerotic Modic change. In endplates with either lumbar spondylolisthesis or lumbar spinal canal stenosis, we found that bony fusion was positively associated with type 2 sclerotic Modic change. The bony fusion rate was 55.3% in group A, which is significantly lower than that in either group B or group C. However, there was no clear association between type 2 nonsclerotic Modic change and no Modic change in the fusion rate.

Interestingly, bony fusion rates in this study are somewhat different from those published previously. Earlier studies compared bony fusion rates of endplates with different types of Modic change and found that the bony fusion rates were lower than that of normal endplates[1.17]. A study involving 351 patients who underwent PLIF with TFC had been conducted by Kwon et al., whose results showed that the bony fusion rate in each group of Modic change was as follows: 81% in type 1, 84% in type 2, 55% in type 3, and 97% in patients with no Modic degeneration. The bony fusion rate was significantly low in the patients with type 3 Modic change[1]. One reason for the difference might be the existence of endplate

sclerosis in type 2 change, but those authors did not further classify type 2 sclerotic Modic change into subgroups.

The bony fusion rate of endplates with type 2 sclerotic Modic change is significantly lower than that in patients with no Modic change after PLIF with PSI—a point worthy of preoperative attention.

Regarding the pathology of Modic change, it has been reported that type 2 change showed bone marrow being replaced with abundant fat[2,18]. Type 2 change showed high signal intensity on T1-weighted images and isointense or slightly hyperintense signal on T2-weighted images. Shaikh et al.[19,20] reported that low-signal-intensity reactive sclerosis was observed on both T1- and T2-weighted images. Due to low-signal-intensity reactive sclerosis was covered by high-signal-intensity reactive fat. In type 2 sclerotic Modic change, endplate sclerosis might not be seen on MRI. Preoperative CT examinations of every patient with Modic change would be wise.

It has been suggested that endplate sclerosis exists in different Modic types, especially in type 3 change and mixed Modic change, which (mixed Modic change) means that inflammation (type 1) and fatty (type 2), fatty and sclerotic (type 3) or inflammation and sclerotic are simultaneous existence in same endplate)[21], and that it can be detected by CT[7]. Endplate sclerosis in type 3 Modic change was a reflection of dense mineralized bone in the vertebral body rather than the marrow elements[2]. Kuisma et al. believed that the sclerosis seen in most of the mixed Modic types and in some types 1 and 2 change might reflect a regenerative process in the marrow with new bone formation. Hence, they speculated that the reactive sclerosis seen in Modic change on CT scans might reflect a healing process of the bone marrow[7]. In our study, however, the bony fusion rate was lower in the presence of type 2 sclerotic change than in the presence of type 2 nonsclerotic change or no Modic change. We therefore speculated that endplate sclerosis in type 2 change—which was similar to that seen in type 3 Modic change via plain radiography or CT—was a reflection of dense mineralized bone in the vertebral body rather than completely a regenerative process with new bone formation. Thus, endplate sclerosis in type 2 Modic change may reduce blood supply to the vertebral body–graft interface, leading to fusion delay or failure. This assumption needs to undergo more studies that involve histopathological evidence.

As a result of the above analysis, we propose a simple algorithm for imaging patients with type 2 Modic change. If the patients' MRI scan shows type 2 Modic change, CT should be performed as a routine examination before surgery. It might also provide a definitive imaging basis for the most advantageous location for spinal fusion. If the endplate sclerosis is mild or local, we would have a choice of interbody fusion or avoiding interbody fusion through the sclerotic area. If the endplate sclerosis is severe and widespread, our choices would be posterolateral fusion (Fig. 3).

## Conclusion

Our results support the possibility that type 2 sclerotic Modic change could be an important factor that affects solid bony fusion in patients undergoing PLIF with PSI. We should pay more attention preoperatively to patients with type 2 sclerotic Modic change, including performance of a preoperative

MRI/CT examination and determining the best site for spinal fusion. The limitation of this research was that the sample size was too small. To further understand the influence of these factors on bone fusion rate, further research is needed.

## Abbreviations

PLIF

posterior lumbar interbody fusion

PSI

pedicle screw instrumentation

MRI

magnetic resonance imaging

CT

computed tomography

TFC

threaded fusion cages

## Declarations

**Ethics approval and consent to participate:** Informed consent was obtained from all individual participants included in the study. And the ethics approval number was 2019(KY-E-033).

**Consent for publication:** All authors have approved the manuscript for submission.

**Availability of data and material:** All data generated or analysed during this study are included in this published article [and its supplementary information files].

**Competing interests:** The authors declare that they have no conflict of interest.

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**Authors' contributions:** SSY and HYQ analyzed and interpreted the patient data. JSY and FYZ carried out the study. HYW and CYH collected important background information. HL and SC was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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## Tables

<b>Table 1.</b> Demographic characteristics of the patients.	
Variable	Outcome
No. of patients	131
Age range (years), mean	53.4(24-76)
No. of endplates	416
Sex	
Male	58(44.3%)
Female	73(55.7%)
Follow-up period(CT imaging), mean	12.0(3–39)

**Table 2.** Number of segments in three groups at different levels(N=208).

Group				
Level	Group A	Group B	Group C	Total
L1-2		2	2(1.0%)	
L2-3		4	4(1.9%)	
L3-4	8	5	30	43(20.7%)
L4-5	12	18	63	93(44.7%)
L5-S1	18	18	30	66(31.7%)
Total	38(18.3%)	41(19.7%)	129(62.0%)	208

**Table 3.** Independent predictors of bony fusion in patients undergoing PLIF with PSI (L1-S1).

Logistic Regression Models	$\beta$	Wald	P value	Odds ratio	95% CI
Model 1	2.759	12.044	<0.001	15.786	3.323-74.990
Model 2	2.505	26.179	<0.001	12.244	4.690-31.965
Model 3	-0.254	0.098	=0.754	0.776	0.158-3.807

Sample size, n = 208. Data are expressed as odds ratios  $\pm$  95% confidence intervals (CI) as assessed by binary logistic regression analysis. All covariates included in binary regression models were as follows: model 1: groups A and C, model 2: groups A and B, model 3: groups B and C.

**Table 4.** Independent predictors of bony fusion in patients undergoing PLIF with PSI (L5-S1).

Logistic Regression Models	$\beta$	Wald	P value	Odds ratio	95% CI
Model 1a	1.974	6.545	<0.05	7.200	1.587-32.668
Model 2a	2.610	5.306	<0.05	13.600	1.476-125.314
Model 3a	-0.636	0.283	=0.595	0.529	0.051-5.513

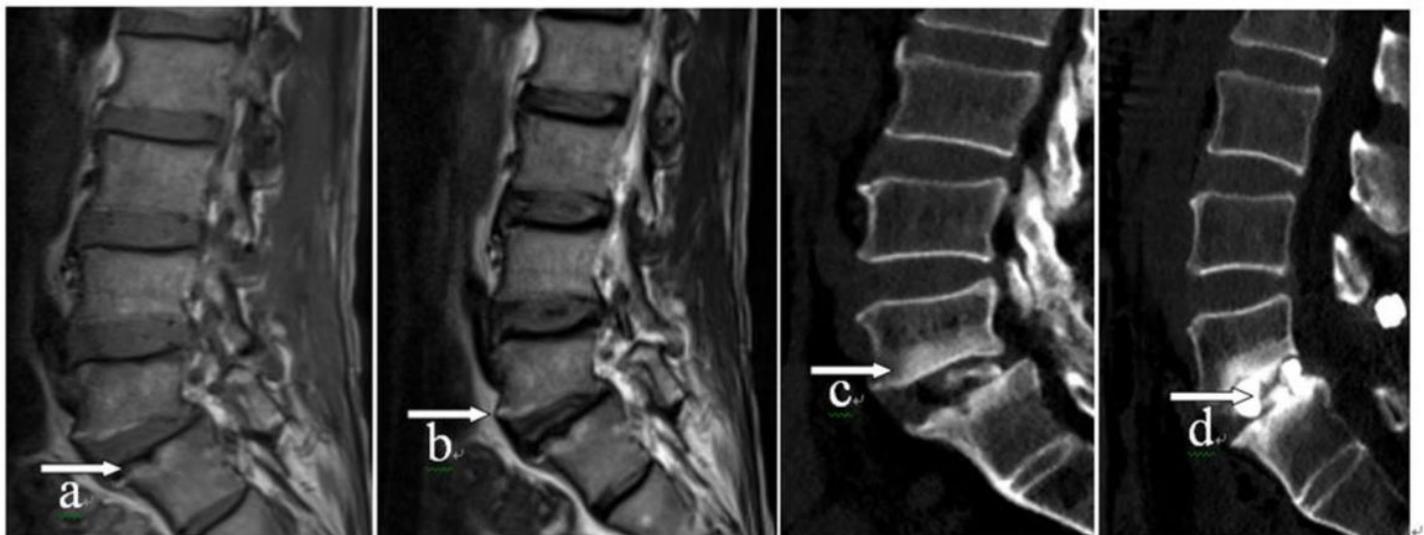
Sample size, n =66. Data are expressed as odds ratios  $\pm$  95% confidence intervals (CI) as assessed by binary logistic regression analysis. All covariates included in binary regression models were as follows: model 1a: groups A1 and C1, model 2a: groups A1 and B1, model 3a: groups B1 and C1.

**Table 5.** Independent predictors of bony fusion in patients undergoing PLIF with PSI (L1-5).

Logistic Regression Models	$\beta$	Wald	<i>P</i> value	Odds ratio	95% CI
Model 1b	2.733	18.103	<0.01	15.382	4.367-54.176
Model 2b	2.890	6.697	<0.05	18.000	2.016-160.688
Model 3b	-0.157	0.020	=0.888	0.855	0.095-7.686

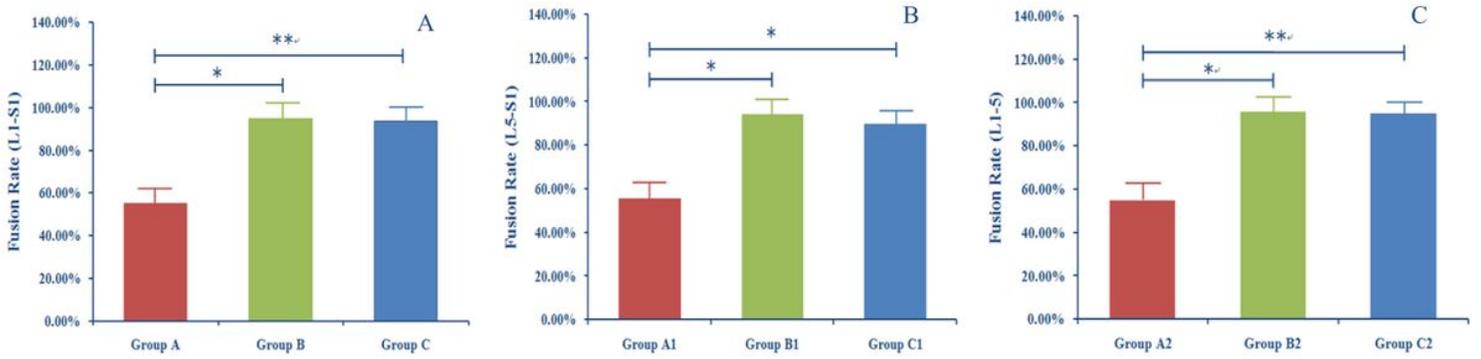
Sample size, n =142. Data are expressed as odds ratios  $\pm$  95% confidence intervals (CI) as assessed by binary logistic regression analysis. All covariates included in binary regression models were as follows: model 1b: groups A2 and C2, model 2b: groups A2 and B2, model 3b: groups B2 and C2.

## Figures



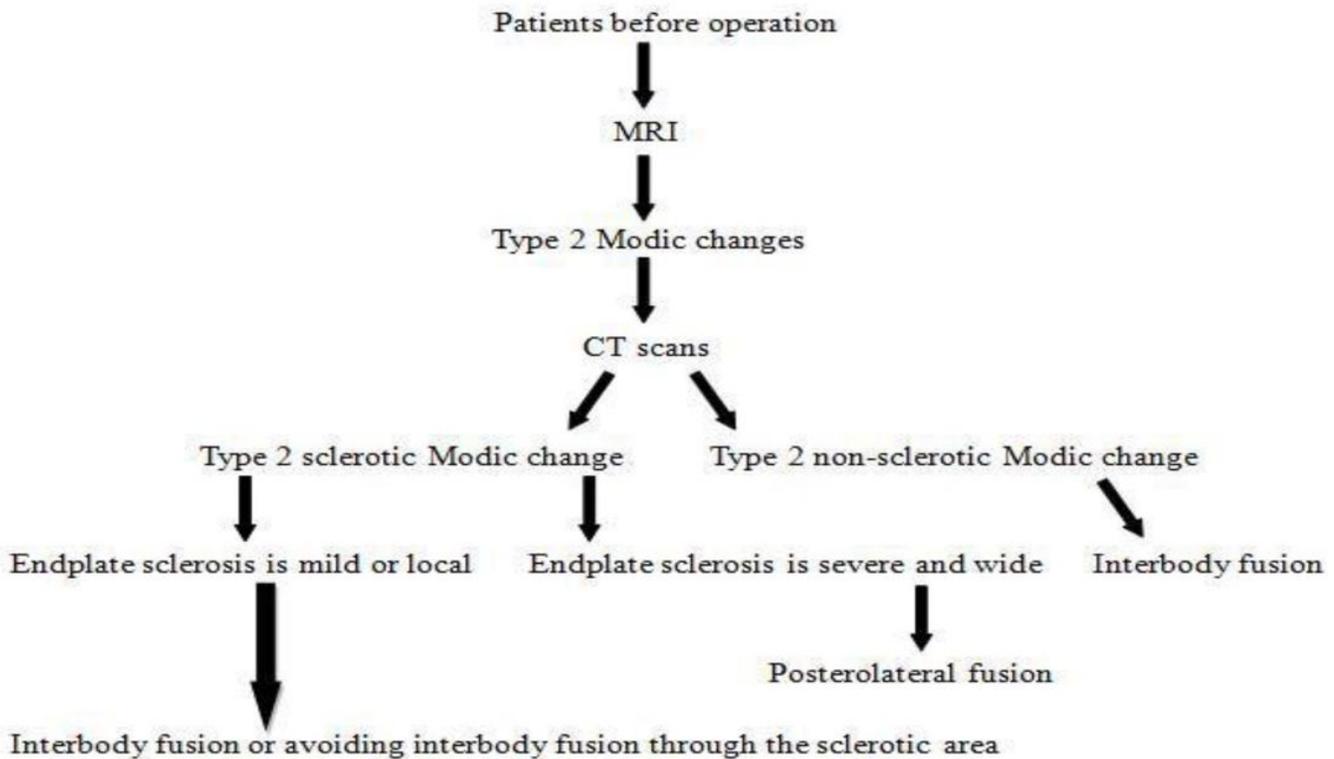
**Figure 1**

59-year-old man with type 2 sclerotic Modic change (indicated by arrow)—high T1- and T2-weight magnetic resonance imaging (MRI) signals—showing the anatomical areas. a, b Sagittal T1-weighted (a) and T2-weighted (b) MRI scans show high signal at the L5-S1 endplates. Sagittal reconstructed (c) computed tomography (CT) scans show sclerosis at the L5-S1 endplates. Sagittal reconstructed (c, d) CT scans at the 12-month follow-up evaluations show that there was no evidence of trabecular bone formation extending from the upper or lower endplate of L5-S1 (no fusion).



**Figure 2**

Fusion rates for the groups and subgroups. The fusion rates were 55.3 % in group A, 95.1 % in group B, and 93.8 % in group C (a). In the subgroup (L5-S1), the bony fusion rates were 55.6% in group A1, 94.4% in group B1, and 90.0% in group C1 (b). In the subgroup (L1-5), the bony fusion rates were 55.0% in group A2, 95.7% in group B2, and 94.9% in group C2 (c). \*\*Significantly low fusion rate ( $P < 0.01$ ) \*Low fusion rate ( $P < 0.05$ ).



**Figure 3**

Simplified algorithm for imaging patients with type 2 Modic change.

## Supplementary Files

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- [PatientImageology1.rar](#)
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