

ORIGINAL

Kinematics of an intervertebral disc with type 1 Modic change : mechanical and non-mechanical causes

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Abstract : Purpose : Type 1 Modic change (MC) is associated with chronic low back pain and attributed to segmental instability. However, the relationship between type 1 MC and segmental instability is unclear. This study sought to clarify the role of mechanical abnormalities in type 1 MC. Method : Review of magnetic resonance images obtained for 727 patients over a 1-year period at our institution revealed 161 cases of type 1 MC. In 86 of these, the following indicators of mechanical abnormality could be evaluated on dynamic radiographs : segmental scoliosis ($>5^\circ$), forward slippage ($>1\%$), and posterior disc opening in flexion. Patients with one or more of these abnormalities were allocated to a mechanical group ($n=62$, 70%) and those with no abnormality to a non-mechanical group ($n=26$, 30%). The Pfirrmann grade of disc degeneration at the affected level was compared between the groups. Results : Segmental scoliosis, slippage, and posterior opening was observed in 34, 21 and 37 cases, respectively. Severe disc degeneration (grade IV or V) was present in 43 cases (69%) in the mechanical group and in 12 cases (46%) in the non-mechanical group ; the difference was statistically significant ($p=0.04$). Conclusion : We propose that there are mechanical and non-mechanical variants of type 1 MC. J. Med. Invest. 72 :385-389, August, 2025

Keywords : Modic type 1 change, inflammation, *Propionibacterium acnes*, mechanical type, non-mechanical type

INTRODUCTION

In 1988, Modic *et al.* reviewed the magnetic resonance imaging (MRI) findings in patients with degenerative disc disease and found three types of abnormality : marrow edoema or inflammation (type 1), fatty marrow degeneration (type 2), and sclerotic change (type 3) (1, 2). Modic change (MC) has been identified in 35%–40% of the population with LBP (3), and type 1 MC in particular is associated with chronic LBP (4, 5). Kuisma *et al.* found MC on MRI scans for 128 of 228 middle-aged male workers and concluded that type 1 MC was more likely to be associated with back pain (6).

In a radiological review of 70 patients who underwent stabilisation surgery for spinal instability, Ghodsi *et al.* (7) noted that 52 (74%) had some type of MC and found type 1 in 31 cases. Toyone *et al.* (8) also found a relationship between MC and spinal hypermobility. Vital *et al.* performed posterolateral fusion surgery in 17 patients with type 1 MC (9) and found that it converted to normal in 4 cases (24%) and to type 2 in the remaining 13 cases (76%). Based on these data, they suggested that type 1 MC could be related to spinal instability.

Reports in the literature suggest that the pathogenesis of type 1 MC is non-mechanical and may involve the low-virulence microorganism *Propionibacterium acnes*. A Danish research team first proposed this pathway in 2008 (10-13). Manniche and O'Neill recently reviewed the studies that had demonstrated a correlation between *P. acnes* and MC type 1 (14) and proposed the following explanation for how *P. acnes* infection causes this

change. Normally, a disc is surrounded by an anatomical barrier that prevents entry of bacteria. For an infection to occur, the disc needs to be leaky. *P. acnes* can then migrate into the disc, causing disc degeneration and endplate damage, resulting in type 1 MC.

Therefore, based on the literature, there could be two pathways for type 1 MC : mechanical and non-mechanical. The purpose of this study was to investigate the kinematics of intervertebral discs with type 1 MC and whether this type of MC can be classified as mechanical or non-mechanical.

METHODS

Subjects

A retrospective search of our medical records identified 727 patients for whom plain radiographs and MRI scans of the lumbar spine were obtained between July 2019 and July 2020. One hundred and sixty-one of these patients were found to have type 1 MC ; 86 (44 men, mean age 68.5 [range 30–87] years ; 44 women (mean age 74.0 [range 37–87] years) had plain radiographs with four views available (1 anteroposterior and 3 lateral views in flexion, neutral, and extension postures). The study was approved by the human research ethics committee of our institution (#IRB-202110), and was performed in accordance with relevant guidelines and regulations. Written informed consent was obtained from all patients.

At our institution, the standard exposure conditions when acquiring plain radiographic images are as follows : anterior view, 75 kV, 630 mA, 50 ms, 36 mAS ; lateral and dynamic lateral views, 75 kV, 630 mA, 160 ms, 100 mAS. On CT, patients were scanned at 120 kV and 150–250 mA with 300–400 slices. However, depending on the patient's physical constitution, these exposure conditions could be changed by either of two radiological technicians.

MRI was performed using a 3.0-T magnetic resonance

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scanner. The participant was positioned supine and the following scans were acquired: sagittal T1-weighted images from T12 to the sacrum (repetition time 450 ms, echo time 90 ms, slice thickness 4.0 mm); sagittal T2-weighted images from T12 to the sacrum (repetition time 3000 ms, echo time 90 ms, slice thickness 4 mm); and spectral attenuated inversion recovery (SPAIR) T2-weighted images from T12 to the sacrum (repetition time 3000 ms, echo time 90 ms, slice thickness 4.0 mm).

The 86 patients were divided into a mechanical group and a non-mechanical group. The mechanical group included patients with degenerative spondylolisthesis (vertebral shift >1% of the anteroposterior diameter of the inferior vertebrae on flexion radiographs), posterior opening (kyphotic slip angle >0° on flexion radiographs), and lumbar scoliosis (segmental Cobb angle >5°). The non-mechanical group included patients without degenerative spondylolisthesis, posterior opening, or lumbar scoliosis. The relationship between MC and Pfirrmann classification was compared between the two groups. All images were reviewed by a general orthopaedic surgeon (Y.Y.) and a certified spine surgeon (T.M.), and all diagnoses were made by consensus.

Modic change

Signal changes in the marrow of the vertebral body adjacent to the end plates visualised by MRI were described by de Roos *et al.* (15) in 1987. According to Modic *et al.* (1, 2), these changes are visible as three different types. Type 1 change is seen on T2-weighted images as areas of increased signal intensity and

on T1-weighted images as low signal intensity extending from the vertebral endplates into the vertebral body. Type 2 change is observed as increased signal intensity on both T1-weighted and T2-weighted images. Type 3 change is presumed to represent bone sclerosis and is visualised as decreased signal intensity on both T1-weighted and T2-weighted images. When we could not diagnose MC as type 1 or type 2, patients with a high signal intensity on SPAIR were diagnosed to have MC type 1. In a previous report, only type I MC showed a significant association with LBP (16). Therefore, in this study, we evaluated type I MC only (Figure 1).

Pfirrmann classification

Intervertebral disc degeneration was assessed on T2-weighted sagittal images using the Pfirrmann method (17) (Table 1). The Pfirrmann grading system assesses degenerated intervertebral discs by MRI based on asymmetry in disc structure, distinction of the nucleus and annulus, the signal intensity of the intervertebral discs, and intervertebral disc height, and assigns a grade of I–V for disc degeneration (Figure 2). In this study, grade IV or higher was considered to indicate degeneration.

Statistical analysis

Nominal variables were tested using the Pearson's chi-square test. The statistical analysis was performed using SPSS version 21.0 software (IBM Corp., Armonk, NY). A *p*-value <0.05 was considered statistically significant.

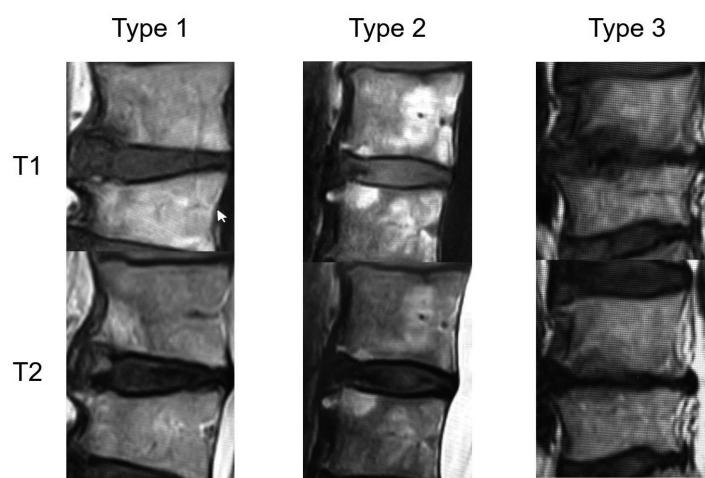


Figure 1. Three types of Modic change.

Table 1. Pfirrmann classification.

Grade	Structure	Distinction of nucleus and annulus	Signal intensity	Height of intervertebral disc
I	Homogenous bright white	Clear	Hyperintense, isointense to cerebrospinal fluid	Normal
II	Inhomogenous with or without horizontal bands	Clear	Hyperintense, isointense to cerebrospinal fluid	Normal
III	Inhomogenous grey	Unclear	Intermediate	Normal to slightly decreased
IV	Inhomogenous, grey to black	Lost	Intermediate to hypointense	Normal to moderately decreased
V	Inhomogenous, black	Lost	Hypointense	Collapsed disc space

RESULTS

Non-mechanical and mechanical groups

Segmental scoliosis, slippage, and posterior opening were observed in 34, 21, and 37 cases, respectively. At least one of these abnormalities was present in all cases in the mechanical group ($n=62$, 70%) but in none of those in the non-mechanical group ($n=26$, 30%).

Pfarrmann classification

The Pfarrmann grade was II in 4 patients (6.4%), III in 15 (24.1%), IV in 15 (24.1%), and V in 28 (45.1%) in the mechanical group and I in 1 patient (3.8%), II in 7 patients (26.9%), III in 6 (23.1%), IV in 5 (19.2%), and V in 7 (26.9%) in the non-mechanical group (Table 2). The prevalence of grades IV and V, which are thought to indicate degenerative disease, was significantly higher in the mechanical group than in the non-mechanical group (69.4% [$n=43$] vs 46.2% [$n=12$]; $p=0.040$).

Representative cases

Case 1 : Mechanical type 1 MC at L3/4, Pfarrmann grade IV

The case was an 83-year-old woman with a diagnosis of degenerative scoliosis of the lumbar spine based on findings in plain radiographs (Figure 3a, 3b). A SPAIR MRI scans showed inflammation of the endplate (i.e., type 1 MC, Figure 3c). Decreased signal intensity was seen on T1-weighted images (Figure 3d) and increased signal intensity was seen on T2-weighted images. (Figure 3e).

Case 2 : Non-mechanical type 1 MC at L4/5, Pfarrmann grade III

The patient was a 31-year-old woman in whom plain radiographs indicated an almost normal lumbar spine with no

scoliosis or disc collapse (Figure 4a, 4b). A SPAIR MRI scan showed inflammation of the endplate (i.e., type 1 MC, Figure 4c). Decreased signal intensity was seen on T1-weighted images (Figure 4d) and increased signal intensity was seen on T2-weighted images. (Figure 4e).

DISCUSSION

This study had two important findings. First, 62 (70.5%) of the 88 cases of type 1 MC had abnormal kinematics parameters (the mechanical group) and the remaining 26 cases (29.5%) did not have any such abnormalities (the non-mechanical group). Second, severe disc degeneration was found in 43 cases (69.4%) in the mechanical group but in only 12 cases (46.2%) in non-mechanical group.

Mechanical pathway in type 1 MC

Crockett *et al.* (18) reviewed the pathology of patients with type 1 MC and divided them into three types according to whether the injury was due to mechanical stress, inflammation, or infection. The initial report by Modic *et al.* (1) also stated that type 1 MC could be associated with mechanical stress, and their histological analyses revealed disruption and fissuring of the endplate in patients with type 1 MC. Furthermore, there are reports in the literature indicating a close relationship between type 1 MC and spinal instability (7-9).

In this study, the kinematics parameters analysed were segmental scoliosis, slippage, and posterior opening, which were found in 34, 21, and 37 cases, respectively. Overall, 70% of our 88 patients had at least one abnormal kinematics parameter. Therefore, our data also suggest that type 1 MC could be caused

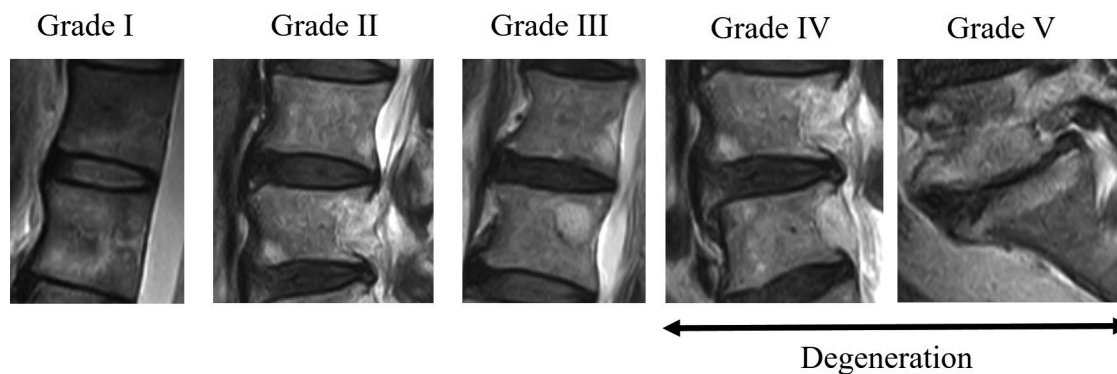


Figure 2. Pfarrmann classification of severity of disc degeneration.

Table 2. Comparison of Pfarrmann grades at the affected level between the mechanical and non-mechanical groups

Grade	Mechanical		Non-mechanical	
	<i>n</i>	(%)	<i>n</i>	(%)
I	0	0	1	3.8
II	4	6.5	7	26.9
III	15	24.2	6	23.1
IV	15	24.2	5	19.2
V	28	45.2	7	26.9
Total	62		26	

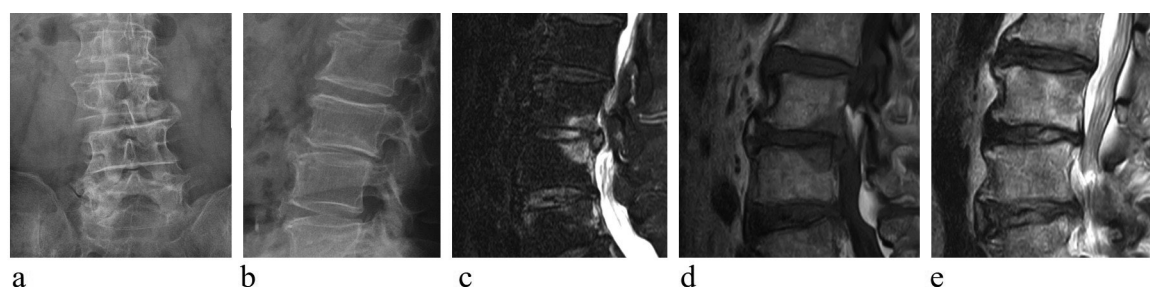


Figure 3. Imaging findings for an 83-year-old woman with mechanical Modic change (segmental scoliosis). (a, b) Plain anteroposterior and lateral radiographs. (c–e) SPAIR (c), T1-weighted (d), and T2-weighted (e) magnetic resonance images.

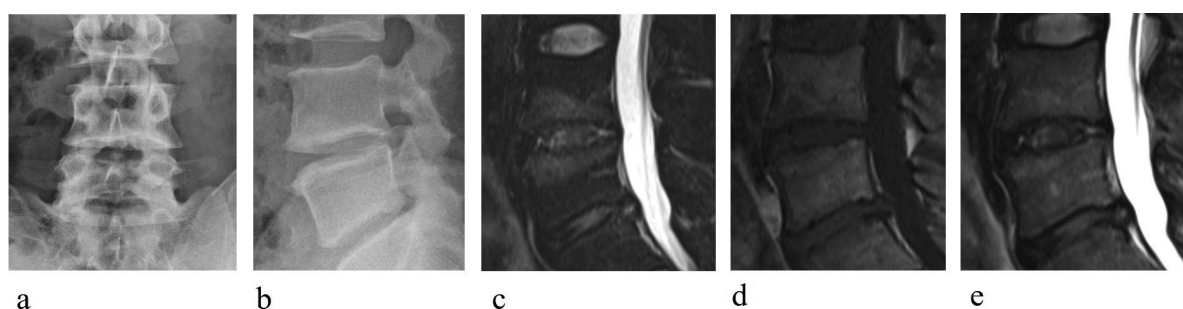


Figure 4. Imaging findings for a 31-year-old man with non-mechanical Modic change. (a, b) Plain anteroposterior and lateral radiographs. (c–e) SPAIR (c), T1-weighted (d), and T2-weighted (e) magnetic resonance images.

by spinal instability. Akazawa *et al.* (19) reviewed 25 patients with adolescent idiopathic scoliosis who had reached middle age without undergoing corrective surgery and found that these patients had a similar prevalence of disc degeneration but were more likely to have MC. Other studies have similarly reported a higher rate of MC at the unfused scoliotic segment following surgery for adolescent idiopathic scoliosis and at the level of the degenerative scoliosis (20).

Aunoble *et al.* (21) performed fusion surgery in 20 patients with L5 spondylolisthesis and found MC in 50% of cases while Li *et al.* (22) analysed the MRI scans of 204 patients with degenerative spondylolisthesis and found endplate defects that were closed related to MC in 47% of cases. Meanwhile Ghodsi *et al.* (7) detected MC in 74% of 70 patients with spinal instability, which they defined as slippage and hypermobility. In our study, we assessed hypermobility by measuring posterior opening on flexion radiographs. According to our findings, slippage and hypermobility should be related to occurrence of type 1 MC.

Non-mechanical pathway in type 1 MC

In this study, none of the above-mentioned abnormal kinematics parameters were found in 26 (29.5%) of 88 cases, suggesting that there may be another pathway for occurrence of type 1 MC that is not mechanical. The relationship between MC and *P. acnes* infection was first reported by Albert *et al.* in 2008 (10). Albert *et al.* subsequently used antibiotics to treat type 1 MC and found significant improvement in all outcome measures (11, 14). These findings supported the notion that bacterial infection plays a role in type 1 MC. In an experimental study, Dudli *et al.* injected *P. acnes* into rat tail discs and clearly demonstrated type 1 MC on MRI on day 20 (23). Chen *et al.* reported similar findings

in a rabbit model (24). Therefore, low-virulence disc infection is a potential non-mechanical pathway for occurrence of type 1 MC.

Disc degeneration and type 1 Modic change

The initial report by Modic *et al.* (1) stated that any type of MC could be related to degenerative disc disease. Luoma *et al.* (25) reviewed 28 disc spaces with type 1 MC and initially found that 71% had decreased disc height and that the disc was dark in 57% of cases. During follow-up, they noted a further decrease in disc height in 29% of cases and a further decrease in the disc signal in 46% of cases. Therefore, they concluded that type 1 MC can accelerate the process of disc degeneration.

In the present study, we defined severe disc degeneration as Pfirrmann grade IV or V. Severe disc degeneration was found in 69.4% of patients in the mechanical group but in only 46% of those in the non-mechanical group. Our data strongly suggest that there is a close association between type 1 MC that develops by a mechanical pathway and disc degeneration. However, there may be another form of type 1 MC that is not related to the mechanical pathway nor disc degeneration, namely, non-mechanical type 1 MC.

Limitation

This study has several limitations. First, it included only patients with some form of low back pain or lower limb pain, without the inclusion of asymptomatic or healthy controls. As a result, it was not possible to evaluate the association between the presence of MC and the occurrence of low back pain. Second, the number of patients exhibiting Type 1 MC was 163, which is relatively small and may limit the generalizability of the results.

CONCLUSION

In this study, we attempted to clarify the role of mechanical abnormalities in the development of type 1 MC. Seventy percent of our study population had at least one abnormal mechanical parameter and 30% did not. Severe disc degeneration was more common in patients with mechanical MC than in those with non-mechanical MC. Our data strongly suggest that mechanical-related type 1 MC is closely associated with disc degeneration, as has often been proposed in the literature. However, there may be another form of type 1 MC, which is not related to mechanical pathway nor disc degeneration, namely non-mechanical type 1 MC.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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