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GRAND ROUNDS

# Rehydration of a degenerated disc on MRI synchronized with transition of Modic changes following stand-alone XLIF

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**Abstract**

Lumbar intervertebral disc degeneration (LDD) is known to be associated with low back pain (LBP) and leads to degenerative lumbar disease. LDD is considered to be irreversible, and no truly effective treatment that suppresses LDD or regenerates the degenerated disc has been established thus far. Here, we report the case of a 42-year-old woman with a 10-year history of persistent LBP. Magnetic resonance imaging (MRI) demonstrated degenerative changes (Pfirrmann classification: grade IV) in the L4–5 intervertebral disc with type I and III mixed Modic changes adjacent to the disc. Conservative treatments were not effective, so we opted for stand-alone extreme lateral interbody fusion (XLIF). One year after the operation, the LBP had almost disappeared. Follow-up MRI revealed transition of the Modic changes from type I to type III. In addition, rehydration of the degenerated disc behind the XLIF cage was evident (Pfirrmann classification changed from grade IV to grade II). To our knowledge, this is the first report of a change in LDD. Several factors are likely responsible for the regenerative response, including curettage of the hyaline cartilaginous endplates and auto-iliac cancellous bone grafting, which were considered to have affected nucleus pulposus cells in the residual disc.

**Keywords** Lumbar disc degeneration · Rehydration · Stand-alone XLIF · Modic change

## Introduction

Lumbar intervertebral disc degeneration (LDD), which is known to be associated with low back pain (LBP), leads to degenerative lumbar disease, including disc herniation and lumbar spinal canal stenosis [1, 2]. To evaluate the severity of LDD, the Pfirrmann classification is commonly used for assessment of spinal images taken by magnetic resonance imaging (MRI) [3]. Disc degeneration is classified into five grades according to disc signal intensity, disc structure, distinction between the nucleus and annulus, and disc height. In general, LDD has been considered to be irreversible, because it is deeply associated with the aging process [4]. Although many basic and clinical research studies target the treatment of LDD, including stem cell therapy, molecular biological therapy, or immunotherapy, have been published [4–6], a true, effective treatment that suppresses LDD or regenerates the degenerated disc has not yet been established.

Extreme lateral interbody fusion (XLIF) is a relatively new surgical procedure that can improve disc height and stabilization using a large cage [7], and the technique has been indicated for several diseases associated with LDD.

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Here, we report a case of LDD, where follow-up MRI following stand-alone XLIF demonstrated rehydration of the residual nucleus in the degenerated disc synchronized with transition of Modic changes across the affected disc.

## Case presentation

A 42-year-old woman presented to our outpatient clinic with a 10-year history of LBP. Her LBP increased on bending forward. The visual analogue scale (VAS) score for the LBP was 9/10 mm at the maximum point of pain. Clinical examination demonstrated no symptoms in the legs and no neurological findings. She had no relevant medical or traumatic history. Laboratory data showed no infectious or inflammatory findings.

### Diagnostic imaging section

At the first presentation, plain radiographs showed disc space narrowing at the L4–5 level. There was no obvious instability at L4–5, and the intervertebral movement at L4–5 was 14° (Fig. 1). MRI revealed degenerative changes (Pfirrmann classification: grade IV) in the L4–5 intervertebral disc with type I and III mixed Modic changes adjacent to the disc (Fig. 2).

Non-steroidal anti-inflammatory drugs and a lumbar brace were started as initial treatment but were not effective. To confirm the source of the pain and relieve the LBP, a small amount of 1% xylocaine and 3.3 mg dexamethasone were injected into the L4–5 intervertebral disc. Complete pain relief was obtained immediately after the intradiscal steroid injection, but it was only temporarily effective. MRI was repeated 3 months after the patient's first presentation and revealed an increase in type 1 Modic changes and degenerative changes of Pfirrmann grade IV (Fig. 3b). Another intradiscal steroid injection (with the same protocol as before) was administered, and pain relief was obtained. MRI performed at 8 months after the first presentation showed a diminished signal for Modic changes, and the Pfirrmann grade was observed to have changed from IV to III (Fig. 3c). However, the patient's LBP recurred again at 14 months after the first visit, and MRI showed exacerbation of the type 1 Modic changes and disc degeneration (from grade III to grade IV) (Fig. 3d). She received another intradiscal steroid injection again, and the LBP was temporarily relieved. Follow-up MRI at 19 months after the first visit showed that the type 1 Modic changes almost disappeared and that disc degeneration turned type III (Fig. 3e). However, LBP recurred and exacerbation of the type 1 Modic changes was observed on MRI at 22 months after the first visit (Fig. 3f). The Pfirrmann grade was still grade III. Thus, conservative therapy was unable to resolve the LBP associated with the MRI findings of LDD and Modic change, and the patient decided to undergo surgical treatment.

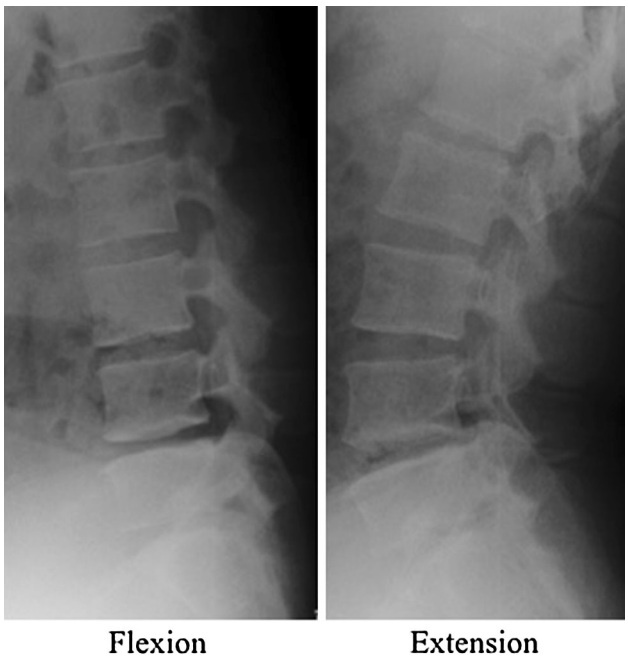


**Fig. 1** Plain radiographs at the first presentation showing a slight narrowing of the L4–5 disc height and subtle sclerotic changes on the endplates across the L4–5 disc

## Procedure

Based on her clinical symptom and radiological findings, the pain source causing her low back pain was considered to be due to the inflammatory changes (type 1 Modic change) on the subchondral areas of the vertebral endplate adjacent to the degenerated L4–5 intervertebral disc. Particularly, on the MRI just before surgery, the type Modic changes were localized on the anterior half of the vertebral bodies. Stand-alone XLIF was indicated to access the lesion directly without any damage to the posterior elements on the lumbar spine, because she had only an anterior column disorder, with no apparent facet degeneration or intervertebral instability. The operation followed the published surgical technique with the patient in the right lateral decubitus position (left side up). Autografted bone was harvested from the left iliac crest and was packed into a polyetheretherketone (PEEK) cage (8-mm height, 10-degree lordosis, CoRoent®; NuVasive, Inc.). The discectomy and endplate preparation were performed through the corridor of the cage placement. The cage was inserted adjacent to the type I Modic changes (Fig. 4).


**Fig. 2** MRI at the first presentation showing degenerative changes at the L4–5 intervertebral disc (Pfirrmann grade IV) and type I Modic changes at the adjacent endplates. **a** T1WI, **b** T2WI, and **c** STIR

## Outcome

The postoperative course was uneventful. The patient's LBP gradually improved, and the VAS score decreased to 7/10 immediately after the operation. Follow-up MRI after 9 months revealed transition of the Modic changes from type I to type III. In addition, rehydration of the degenerated disc behind the PEEK cage was observed. The Pfirrmann classification on MRI changed from grade IV to grade II (Fig. 5a).

At the 1-year follow-up, MRI findings were similar to those at the 9-month follow-up (Fig. 5b). Bone union was found to be progressing on the lateral side of the L4–5 intervertebral disc space, and the intervertebral range of motion had almost disappeared on plain radiographs and CT scans (Fig. 6). Her LBP had resolved almost completely (VAS score: 1/10).

## Rationale for treatment and evidence-based literature

LDD is commonly defined based on the appearance of the intervertebral disc on MRI [8]. Basically, signal loss of the disc on the $T_2$-weighted MR image is considered to reflect a decrease in proteoglycans and water content (dehydration) in the disc [8].

LDD plays an important role in LBP [1, 2]. Theoretically, if regeneration or rehydration of the degenerated disc was feasible, it would markedly improve the therapeutic outcomes of patients with LDD. LDD has, however, been considered to be an irreversible change. Moreover, no breakthroughs have been achieved for procedures targeting disc regeneration or for suppression of the degenerative changes [4], although many studies have attempted this using stem cell biology, immunology, and molecular biology [4–6].

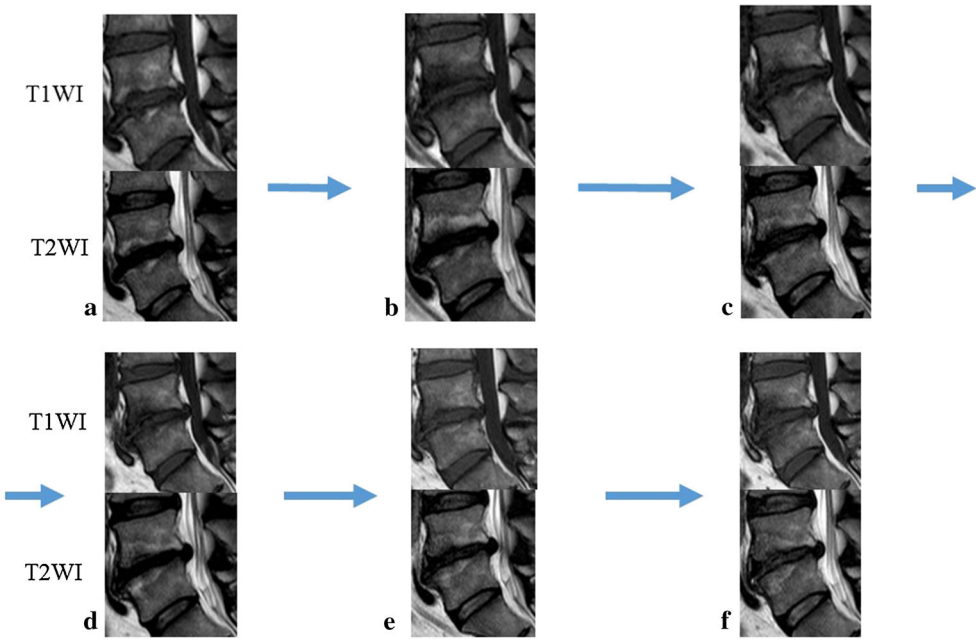


**Fig. 3** Time course of the Modic changes and disc degeneration on follow-up MRIs before stand-alone XLIF (*upper* T1WI, *lower* T2WI). **a** At the first presentation, an insignificant type I Modic change (MC) and disc degeneration of Pfirrmann grade IV at L4–5. **b** Three months later, an increase in the type 1 MC and Pfirrmann grade IV (**b**). **c** Eight months later, a diminished signal for the MC, and the Pfirrmann grade has changed from IV to III. **d** Fourteen months later, exacerbation of the type 1 MC and disc degeneration (from grade III to grade IV). **e** Nineteen months later, the type 1 MC has almost disappeared. **f** Twenty-two months later, type 1 MC were again observed on MRI

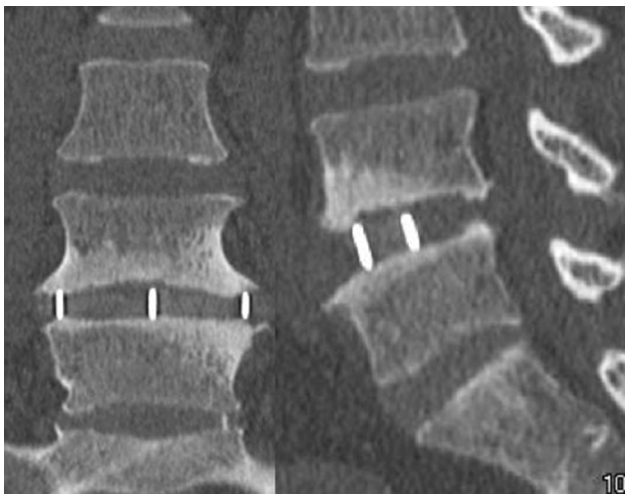

**Fig. 4** Stand-alone XLIF at L4–5 performed using a PEEK cage (CoRoent®; NuVasive, Inc.) packed with autografted cancellous bone harvested from the iliac crest. The cage was found to be placed appropriately

We have described here our experience of a patient who showed rehydration of the degenerated disc accompanied by type I Modic changes behind the stand-alone XLIF cage. No such cases of rehydration following stand-alone XLIF have been reported thus far. Jiang et al. reported that following surgeries using the Wallis interspinous device, rehydration of the nucleus was observed, similar to the present case [9]. The Wallis interspinous device is also made of PEEK and it can restore the disc height as well as provide and maintain motion and stability at the instrumented level. A similar mechanism may have been involved in the present case, since stand-alone XLIF was expected to provide the same effects.

Modic changes represent pathological changes in the bone marrow and endplate observed on MRI in patients with degenerative disc disease [10]. Type I Modic changes appear hypointense on $T_1$-weighted MRI and hyperintense on $T_2$-weighted MRI, indicating disruption and fissuring of the endplates and vascular granulation in the affected area. It is well known that endplate damage, including type I Modic changes, is associated with disc degeneration [11]. Therefore, it is possible that an interruption of progressive endplate damage may lead to repair of the degenerated disc.

As preparation for interbody fusion, curettage of hyaline cartilage is usually performed before cage insertion. Specifically, for XLIF cage insertion, such curettage is performed only at the corridor of the cage placement, while the disc materials behind the cage, including the nucleus pulposus, remain partially intact. Hyaline cartilage is much less permeable than perforated bone [12]. The curettage of the endplate cartilage may affect the permeability of the endplate, which leads to rehydration of the residual nucleus

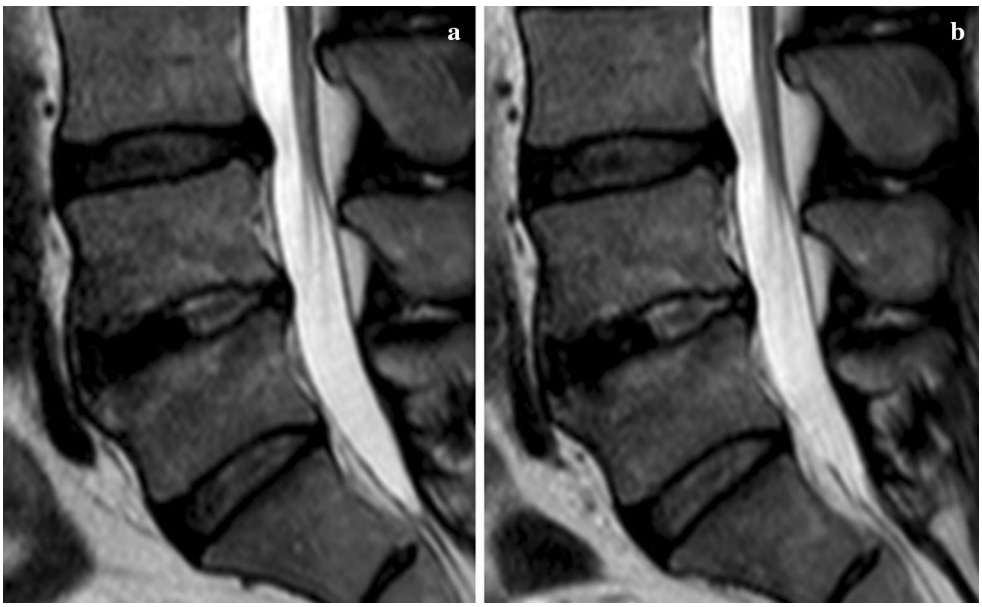


**Fig. 5** **a** Follow-up MRI at 9 months after stand-alone XLIF showing transition of the Modic changes from type I to type III. Rehydration of the degenerated disc behind the PEEK cage is also evident. The Pfirrmann classification on MRI improved from grade IV to grade II. **b** At the 1-year follow-up, the MRI findings are similar to those at the 9-month follow-up

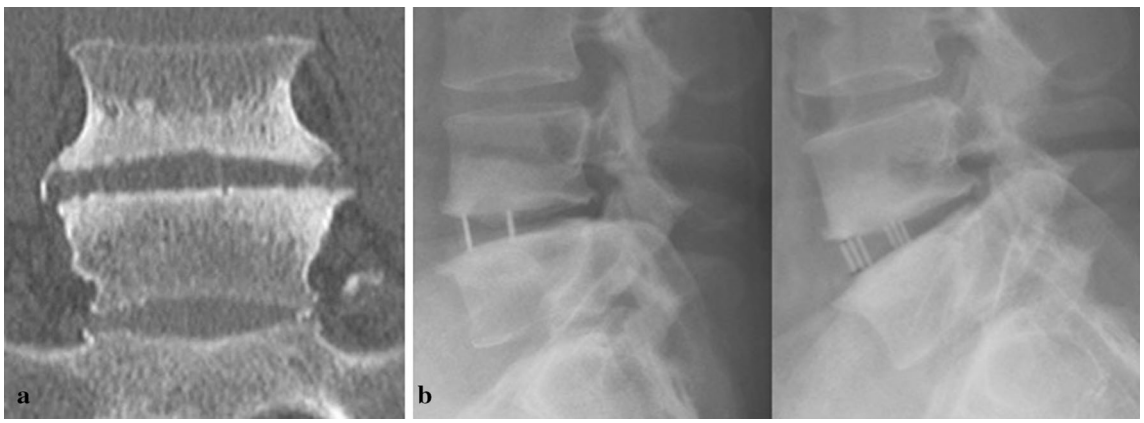


**Fig. 6** **a** Reconstructed CT scan showing the progression of bony union on the lateral side of the L4–5 intervertebral disc space and **b** plain radiographs showing the intervertebral range of motion had almost disappeared

pulposus through improvement of metabolite transport and fluid flow. In addition, we packed autografted cancellous bone harvested from the iliac crest into the XLIF cage, which may also have been a factor. Research in cell therapies for LDD has been ongoing in recent years, although a satisfactory treatment remains to be found [4, 13–15]. The transplantation of mesenchymal stem cells and autologous nucleus pulposus cells can potentially regenerate the degenerative disc. Autografted cancellous bone contains rich bone marrow, and it is plausible that stem cells in this bone marrow may have affected the nucleus pulposus cells in the residual disc, leading to a regenerative response in our case.

**Compliance with ethical standards**

**Conflict of interest** None declared.

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