

## Course of Modic 1 Six Months After Lumbar Posterior Osteosynthesis

J. M. Vital, O. Gille, V. Pointillart, M. Pedram, P. Bacon, F. Razanabola, C. Schaelederle, and S. Azzouz

**Study Design.** A prospective study was conducted to investigate the outcome of the Modic Type 1 inflammatory signal in magnetic resonance imaging (MRI) in 17 patients with chronic low back pain 6 months after instrumented posterior lumbar arthrodesis.

**Objective.** To assess the course of the inflammatory signal after stabilization of a painful intervertebral segment by posterior instrumentation alone visualized on MRI systematically performed 6 months after the operation.

**Summary of Background Data.** In 1988, Modic and colleagues described three degenerative stages of vertebral endplates and subchondral bone. The inflammatory stage, or Stage 1, is correlated with substantial functional disability. According to these authors, Stage 1 lesions naturally transform into Stage 2, the fatty stage. In the literature, patients with Modic 1 signal tend to have good results after arthrodesis, better than those with Modic 2 lesions.

**Methods.** This study included 17 patients (average age, 46 years) who had experienced chronic low back pain more than 1 year and showed Modic 1 changes in MRI and disc narrowing on plain radiographs. Every patient underwent posterior screw-rod osteosynthesis and posterolateral arthrodesis. Disc disease had occurred subsequently to discectomy ( $n = 7$ ), rapidly destructive disc disease ( $n = 5$ ), or spondylolisthesis resulting from spondylolysis ( $n = 5$ ). Clinical results were assessed according to a visual analog scale for pain, a functional disability score for the evaluation of patients with low back pain (Eiffel), and the validated French version of the self-administered Dallas quality-of-life test (DRAD).

**Results.** Systematic MRI at 6 months showed transformation from Modic 1 to Modic 0 (normal endplate signal) in 4 patients and transformation from Modic 1 to Modic 2 in the remaining 13 patients. Clinical evaluation was performed at 6 months (at the same time as the MRI) and at 1 year. In every patient, there was improvement in the visual analog score and the functional score, which remained stable at 1 year.

**Conclusions.** According to the literature, most Modic 1 lesions change to become Stage 2 lesions in 18 to 24 months. In this study, 17 patients with Modic Type 1

signal had changes after 6 months. It appears that posterior osteosynthesis combined with posterolateral arthrodesis accelerates the course of Modic 1 lesions, probably by correcting mechanical instability. [Key words: arthrodesis, low back pain, modic stage, vertebral endplate] *Spine* 2003;28:715-721

Degenerative lesions of lumbar vertebral endplates and subchondral bone were suspected by de Roos *et al*,<sup>1</sup> who observed in 41 patients undergoing MRI for degenerative disc disease that 50% of the changes in the hematopoietic marrow corresponded neither to infection nor to a malignant process. Modic *et al*<sup>2</sup> are credited with the classification of these lesions. Among 474 lumbar MRI performed in patients with low back pain or sciatica, they described Modic Type 1 lesions (hypointense signal in T1-weighted sequences and hyperintense signal in T2-weighted sequences) in 20 patients (4%) and Modic Type 2 lesions (hyperintense signal in T1 and hyperintense signal in T2) in 77 patients (16%). Only later were Type 3 lesions described (hypointense signal in T1 and hypointense signal in T2). This type of MRI signal change is much rarer.

Modic Type 1 change corresponds to vertebral body edema. Modic Type 2 signal changes reflect fatty degeneration of the bone marrow. Type 3 signal is observed in vertebral bodies with sclerotic changes. Percutaneous biopsies of Type 1 lesions obtained by Modic *et al*<sup>2</sup> showed fractures and cracks in vertebral endplates, with replacement of the hematopoietic marrow by richly vascularized fibrous tissue.

The natural course of the signal anomalies reported by Modic *et al*<sup>2</sup> was subsequently followed up by the same authors. Five of the six Type 1 lesions were replaced by Type 2 signal anomalies over 14 to 36 months. The Type 2 lesions remained stable over 2 to 3 years of follow-up evaluation. Although the medical management (use of analgesics and antiinflammatory agents) associated with external immobilization is obviously proposed for patients with Modic Type 1 lesions, which are more disabling than Modic Type 2 lesions, arthrodesis also has been proposed and evaluated. Lang *et al*<sup>3</sup> showed that the persistence of Modic Type 1 signal after arthrodesis suggested pseudarthrosis. Toyone *et al*<sup>4</sup> concluded that Modic 1 signal is associated with instability requiring arthrodesis more commonly than Modic 2 change, which can accompany nerve-root compromise. This was confirmed by Chataigner *et al*,<sup>5</sup> who treated patients with low back pain patients with anterior discectomy

From the Unité de Pathologie Rachidienne, Hôpital Tripode, Centre Hospitalo-Universitaire, Place Amélie Raba Léon, 33076 Bordeaux Cedex, France.

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Address reprint requests to Jean-Marc Vital, MD, Unité de Pathologie Rachidienne, Hopital Tripode, Place Amélie Raba Léon, Bordeaux Cedex, 33076, France. E-mail: jmvital@aol.com.



and interbody grafting. They reported better results with Modic 1 than with Modic 2 lesions.

The purpose of the current prospective study was to assess MRI signal change in vertebral endplates and subchondral bone 6 months after posterolateral screw-rod arthrodesis in a series of homogeneous patients with chronic low back pain and Modic Type 1 lesions.

## ■ Methods

This prospective study included 17 patients who had experienced chronic low back pain more than 1 year, and who showed Modic Type 1 signal change on MRI obtained less than 3 months before arthrodesis surgery. In seven patients, disc disease appeared after discectomy for herniated disc. In five patients, rapidly destructive disc disease was involved. In the remaining five patients, disc disease developed subsequently to spondylolisthesis related to isthmic lysis. The levels involved were L2-L3 in one patient, L3-L4 in one patient, L4-L5 in seven patients, and L5-S1 in eight patients.

The current study included 10 women and 7 men whose average age was 46 years (range, 35-62 years). All these patients were actively employed before the intervention.

Clinical assessment criteria were lumbar pain measured using a visual analog scale (VAS) with a range of 0 to 10 cm and the vertical fingertip-to-floor distance measured in centimeters. Two self-administered questionnaires were completed by the patients: the Eiffel scale of functional disability for evaluation of patients with low back pain<sup>6</sup> and a quality-of-life scale derived from the self-administered Dallas test.<sup>7</sup> The Eiffel test consists of 24 questions to determine the degree of disability. The modified Dallas test was used to assess the degree of repercussions that chronic low back pain had for four quality-of-life categories: everyday activities, work-related and leisure activities, mood, and sociability.

The surgical treatment was uniform, consisting of single-level instrumented arthrodesis with titanium screw hardware that permits postoperative MRI and posterolateral grafting using the bone harvested in the operative field. This instrumented arthrodesis was performed only for disc disease resulting in Modic Type 1 change, and the procedure did not call for opening of the canal in 12 of the 17 patients.

In the five cases of spondylolisthesis caused by isthmic lysis, the free posterior arch was removed to serve as bone graft, and the freedom of the roots coursing under the isthmus was verified. No intervertebral body cages were used in this series.

Sagittal T1 and T2 fast spine echo-weighted sequences were obtained without injection of gadolinium. In all cases, the follow-up MRI was performed in the same machine used for the preoperative examination. But most often in the sagittal T2 sequence, TR was 3500 ms, and TE was 120 ms. In the sagittal T1 sequence, TR most often was 550 ms, and TE was 13 ms.

The Modic signal evolution was not compared with that of a control group that had no arthrodesis, but with the six patients followed up by Modic in a little but unique series characterized by natural evolution.

## ■ Results

The minimum follow-up period was 1 year. The duration of follow-up evaluation reached 3 years for some of the patients. Such a follow-up period is short for this type of disease, but the primary goal of this study was to

determine MRI signal change in Type 1 lesions 6 months after the surgical intervention.

All the studied clinical parameters were improved. The VAS improved by 50%, the fingertip-floor distance by 33%, the functional capacity score by 55%, and quality of life by 4%, with a particularly marked improvement in everyday activities and mood.

Nine of the patients returned to the same conditions of employment as previously. Four had less strenuous working conditions than previously. Two returned to part-time work, and two had not returned to work at latest follow-up assessment.

The originality of this study lies in the systematic MRI follow-up 6 months after surgery, a condition previously accepted by all the patients. Lesions were recorded according to the Modic classification by a senior radiologist blinded to the clinical status of the patient.

At the 6-month postoperative examination, all of the patients were clinically improved, and Modic Type 1 change persisted in none. In 13 of the patients, the Modic Type 1 lesion was replaced by a Modic Type 2 lesion (Figures 1 and 2). In the remaining four patients, the preoperative abnormal signal was replaced by signal practically identical to that of normal hematopoietic marrow near the vertebral endplates (*i.e.*, the hypointense signal in T1 was no longer present). This apparently normal state can be referred to as Type 0. All four cases in which the MRI aspect returned to normal occurred among the seven patients in whom degenerative disc disease developed after discectomy (4 of 7) (Figure 3).

## ■ Discussion

This focus in this discussion is on the origin of the Modic Type 1 signal, its importance in the evaluation of chronic low back pain with regard to results of other examinations such as discography, the natural course of this signal, and finally, the possible use of surgical treatment.

It may be helpful to review the nature of the Modic Type 1 signal changes. The cartilage of the vertebral endplates and the subchondral bone are submitted to compression in much the same way as the disc.<sup>2</sup> This zone near the disc often is less resistant than the disc, especially if there is osteoporosis, and can develop microfractures,<sup>8</sup> which are manifested by hypointense signal in T1 and hyperintense signal in T2 if the trauma is recent. This piston-like mechanical phenomenon is exacerbated if the disc has lost its function of shock absorption because of dehydration. Recently, Ariga *et al*<sup>9</sup> found evidence of increased apoptosis in chondrocytes near the endplates in a mouse model of spondylosis by destruction of the posterior intervertebral joints. Vertebral biopsies performed by Modic *et al*<sup>2</sup> in Modic Type 1 lesions showed a fibrous degenerative process with hypervascularization of the endplates. The latter phenomenon exists in mature subjects only when excessive constraints have been applied.<sup>10</sup> In 15 specimens of discs, vertebral endplates, and adjacent cancellous bone obtained during anterior discectomy followed by arthrodesis, Brown *et al*<sup>11</sup> ob-



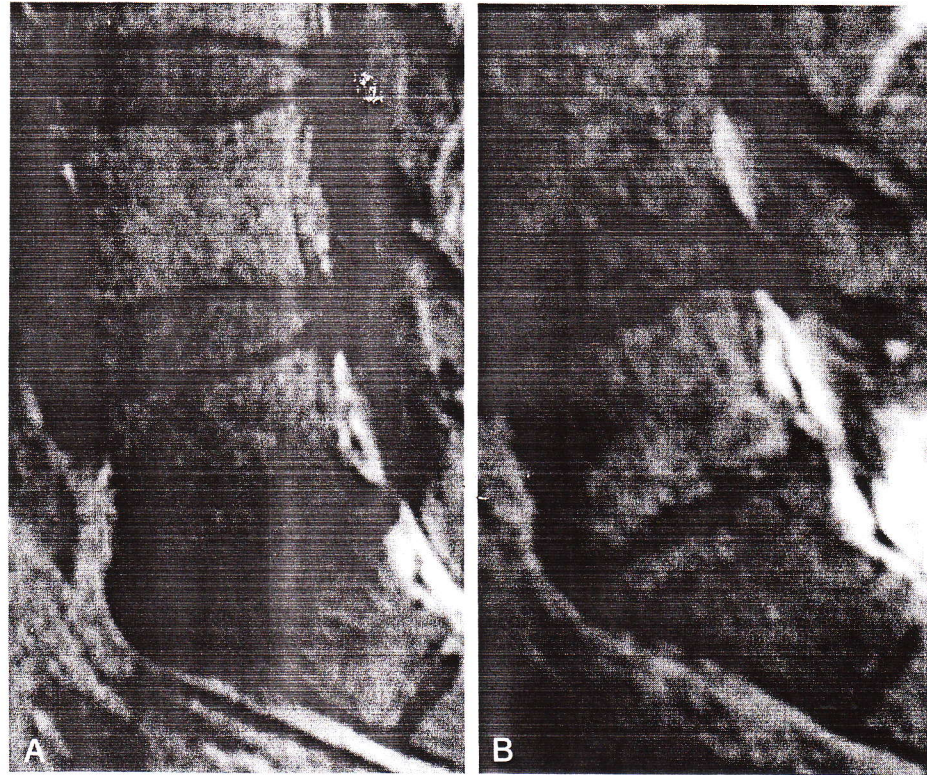


Figure 1. Change from Modic Type 1 signal (A) to Modic Type 2 signal (B) after arthrodesis in a patient with rapidly destructive L5-S1 disc disease (T1-weighted sequences).

served cracks in the vertebral endplates, with increases in vascular density and the number of nerve endings. These phenomena were hypothesized to represent a means of increasing disc nourishment. Kauppila<sup>12</sup> analyzed lumbar angiographies performed in 22 cadavers with degen-

erative lesions. He reported obliteration of the posterior anastomoses near the posterior longitudinal ligament, increased density of anterior vasculature, and disappearance of the vertical disposition of the arteries. Kauppila<sup>12</sup> suggested that such vascular changes might precede de-

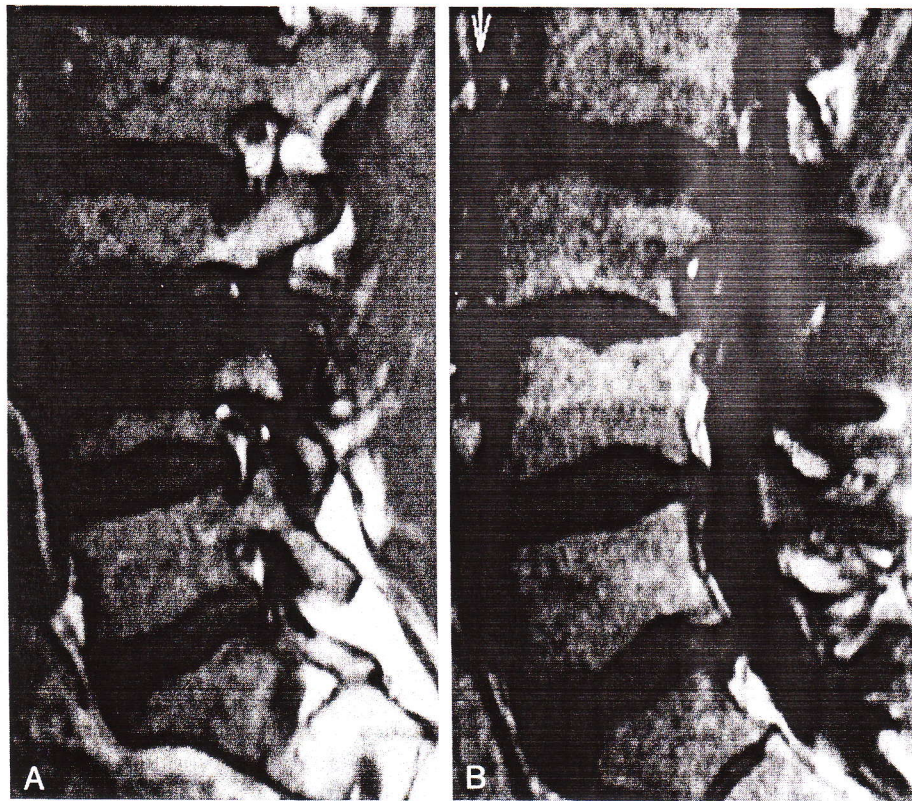


Figure 2. Change from Modic Type 1 signal (A) to Modic Type 2 signal (B) after arthrodesis in a patient with L3-L4 spondylolisthesis caused by isthmic lysis (T1-weighted sequences).



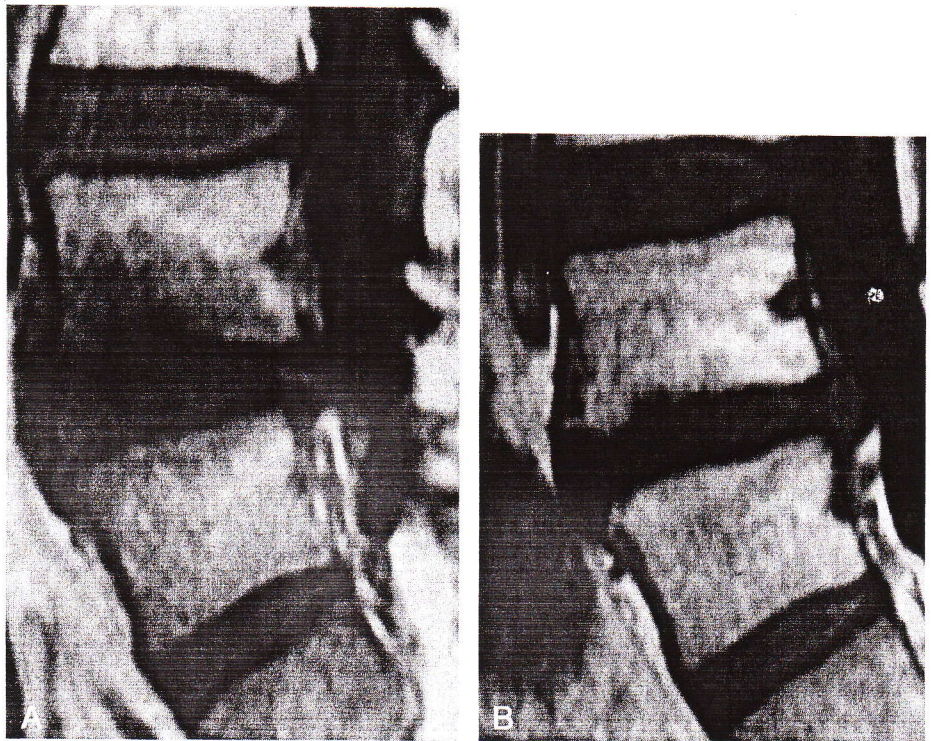


Figure 3. Change from Modic Type 1 signal (A) to Modic 0 signal (B) after arthrodesis in a patient with disc disease after L5-S1 discectomy caudal to a junctional anomaly (T1-weighted sequences).

generative disc disease and constitute a repair process for disc rupture.

Numerous studies have reported chemical anomalies involved in disc herniation. Burke *et al*<sup>13</sup> determined levels of interleukin 6 and 8 and prostaglandin E2. They stressed the distinction between the Modic Type 1 stage, in which low back pain predominates, and the Modic type 2 stage, which tends to be complicated by sciatica. In the Modic Type 1 stage, they noted a greater increase in proinflammatory chemical mediators.

Modic Type 1 degenerative lesions correspond to edema of vertebral endplates and subchondral bone that could correspond to microfractures of the cancellous bone and endplate cracks accompanied by increased vascular density, primarily on the ventral side, along with an increase in the number of nerve endings and in the levels of proinflammatory chemical mediators. These vascular and inflammatory phenomena follow the initial mechanical phenomena. The MRI aspects of the hematopoietic bone marrow (hypointense signal in T1 and hyperintense signal in T2) are not specific to degenerative disease. They also may be seen in traumatic, infectious, or tumoral disorders.

Correlations of the information provided by lumbar plain radiographs, bending radiographs, and even computed tomographic scans with the causes of low back pain are poor.<sup>14</sup> Especially when the search targets pain elicited during injection, discography is superior to the former examinations for assessment of low back pain resulting from disc disease.<sup>14,15</sup> Next to the signs of endplate and subchondral bone involvement considered earlier, MRI may show disc dehydration (black disc) and the presence of a high-density zone reflecting rupture on the

posterior side of a disc. The latter sign is only slightly more specific to chronic low back pain than the former. It is most important, in fact, to compare results of discography with those of MRI. Many authors have done so with contradictory conclusions.<sup>16,17</sup> Among 23 patients with Modic Type 1 or 2 lesions, Braithwaite *et al*<sup>18</sup> elicited diagnostic pain during discography in 21 patients. Two limitations of that study were the low number of Modic Type 1 lesions and the presence of false-positive results (*i.e.*, painful discography with no corresponding signal anomaly on MRI). A further advantage of MRI in such patients is that it appears to provide the greatest amount of information on the vertebral endplates and subchondral bone.

It also is interesting to consider specifically the natural course of Modic Type 1 signal anomalies. Aside from the report by Modic *et al*,<sup>2</sup> there is little data in the literature on the course of Modic Type 1 signal. It is noteworthy that they observed replacement of Modic 1 change by Modic 2 change in five of six patients over a period ranging from 14 to 36 months. In the remaining patient, the Modic 1 lesion lasted longer than this. It should also be noted that the Modic Type 1 signals involved in the report by Modic *et al*<sup>2</sup> developed after chemonucleolysis using chymopapain, which leads to a very particular context of disc collapse without notable initial instability. In the experience of the current authors, there also are cases of passage from Modic 1 to Modic 0 after conservative treatment.

In the same report by Modic *et al*,<sup>2</sup> the 10 cases of Type 2 change remained stable for 2 to 3 years. The development of Type 3 change, corresponding to sclerotic degeneration, was not described. It may be con-



cluded that a possible natural course occurs in which Modic Type 1 lesions are replaced by Modic Type 2 lesions, which correspond to a globally less disabling state in terms of low back pain.

Intermediate stages can sometimes be seen between the Modic Type 1 and 2 lesions, tending to confirm the hypothesized natural history for such lesions. These intermediate stages probably are observed just before evolution to the true Modic 2 stage. Fatty deterioration of the hematopoietic marrow is a phenomenon very commonly observed in elderly subjects. Degenerative fatty lesions also are seen with various disorders, in which they correspond to a latent, only slightly active state (e.g., stable vertebral angioma and irradiated marrow). The Modic 3 or sclerotic stage, which is much rarer than Modic Types 1 or 2, probably corresponds to a state close to natural fusion.

As for surgical management of patients with type Modic 1 or 2 lesions, Lang *et al*<sup>3</sup> reported plain radiograph, CT, and MRI studies assessing osseous fusion in 33 patients who had undergone arthrodesis. In 19 patients with solid fusion, they noted fatty Modic Type 2 signal, and in 14 patients in whom nonunion was suspected, they observed 10 cases of inflammatory Modic Type 1 images. Toyone *et al*<sup>4</sup> made a distinction between the patients who had Modic Type 1 anomalies and tended to exhibit hypermobility (17 of 37 patients who had undergone arthrodesis) and the patients who had a Modic Type 2 change and tended to undergo surgery for radicular decompression (6 of 37 patients). Chataigner *et al*<sup>5</sup> studied 56 patients who underwent anterior procedures with bone grafting for low back pain. Their best results were obtained in patients with Modic Type 1 lesions. The results were poorer in patients who had black discs without endplate involvement or Modic Type

2 lesions, among whom they noted three cases of pseudarthrosis requiring posterior revision surgery.

In the current study, surgery was performed for patients with low back pain who harbored a signal Modic 1 only after they had resisted conservative treatment (lumbar corset, analgesic combined with antiinflammatory agents) for more than 1 year. Posterior screw-rod hardware was used for the arthrodesis without addition of anterior cages. In all 17 of the treated patients in the current study, disc height had diminished. The nerve roots were decompressed only in the five patients with spondylolisthesis, in whom unilateral or bilateral nerve root pain accompanied the low back pain.

The 17 patients were improved in terms of pain, disability, and fingertip-floor distance. Concomitant with the good early clinical results, MRI obtained 6 months after surgery showed in every case a modification of the Modic Type 1 signal, which changed to Modic 0 in four patients and Modic 2 in 13 patients. The rapid evolution in 6 months from stage Modic 1 to stage Modic 2 probably is explained by the same loss of intervertebral mobility and decrease in the piston-like phenomenon observed in the natural evolution series of Modic *et al*,<sup>2</sup> but over a longer period.

Posterior arthrodesis alone was investigated by Weatherley *et al*.<sup>19</sup> In more than 1000 patients who had undergone laminectomy and noninstrumented posterior, or more rarely, posterolateral fusion, they noted residual low back pain in five patients who had a disc that was symptomatic during discography in the region of the arthrodesis. An additional, anterior bone graft improved these five patients. Both the low frequency associated with this type of complication (0.5%) and the noninstrumented nature of the arthrodesis, which was always preceded by laminectomy, were noteworthy.

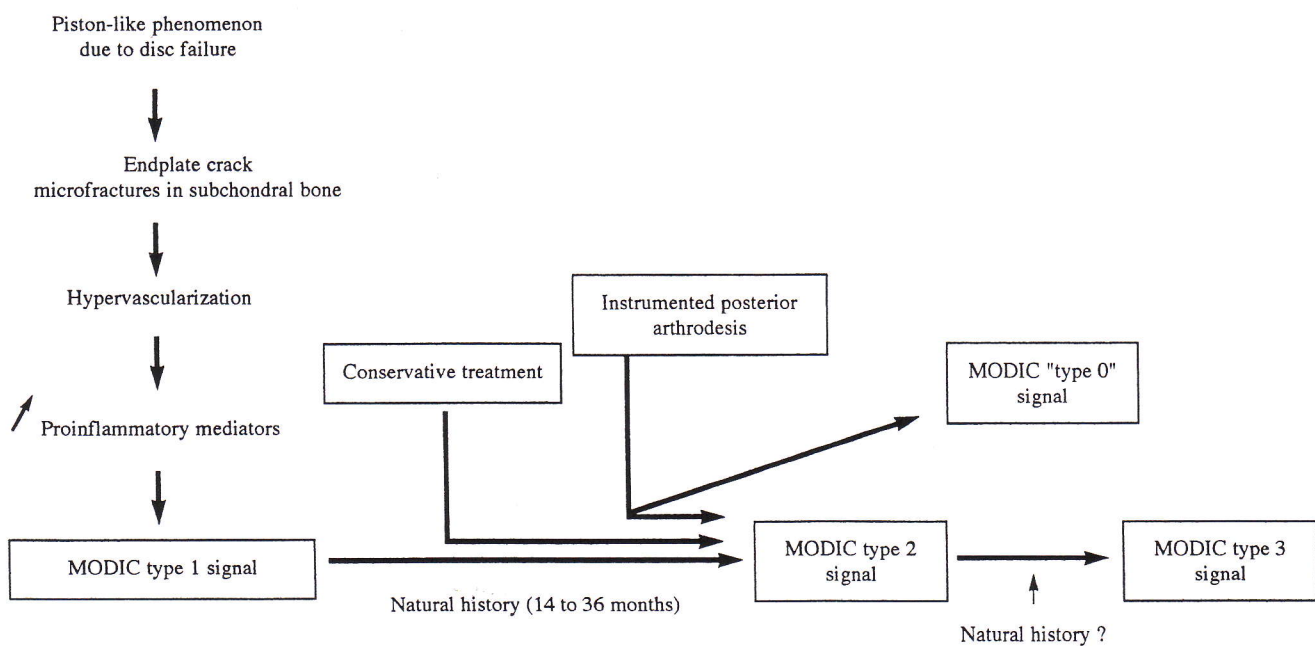


Figure 4. Mechanisms of Modic Type 1 MRI signal, natural history and effects of conservative and surgical treatment.



Buttermann *et al*<sup>20</sup> also reported average results using posterolateral arthrodesis performed in patients who had Modic Type 1 or 2 lesions. Among 24 patients with Modic Type 1 lesions, 19 had residual low back pain and 37% were dissatisfied. In fact, the indications varied (*e.g.*, spondylolisthesis, sometimes of Grade III, or multiple disc surgery). There often was associated nerve root decompression. Instrumentation was not always used, and the arthrodesis was sometimes extended to two or three segments. On the other hand, the current results were consistent with the observation of Buttermann *et al*<sup>20</sup> that nonfusion was associated predominantly with the persistence of Modic Type 1 anomalies.

### ■ Conclusion

In conclusion, in 17 patients with Modic Type 1 change and chronic low back pain resistant to medical treatment administered more than 1 year (Figure 4), instrumented arthrodesis involving only the altered intervertebral segment was followed within 6 months by a change to Modic 0 in four patients and to Modic Type 2 lesions in 13 patients. A good clinical outcome 1 year after surgery was observed in all 17 patients. This isolated instrumented posterior arthrodesis stabilized piston-like instability sufficiently in these segments in which the disc was narrow. The phenomena of microtrauma, hypervascularization, and inflammation declined, and the hematopoietic marrow either recovered a normal aspect or underwent fatty degeneration. The presence of Modic Type 1 signal appears to constitute a reasonable surgical indication if conservative treatment fails. Instrumented posterior arthrodesis alone accelerates healing in patients with Modic Type 1 lesions. In contrast, Modic Type 2 lesions do not appear to constitute a good indication for arthrodesis in cases of isolated low back pain.

### ■ Key Points

- Inflammatory Modic Type 1 signal had been replaced by fatty Modic Type 2 signal 6 months after posterior instrumented arthrodesis.
- Concomitant with this change in MRI, clinical results were satisfactory.
- Posterior instrumented arthrodesis appears to accelerate the natural history of Modic Type 1 signal anomalies.
- Modic Type 1 signal appears to be a good indicator of satisfactory surgical outcome after arthrodesis.

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