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Radiological outcomes of 360° lumbar fusion in patients with Modic changes

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Abstract

Introduction A cascade of degenerative spine changes affects the structures including vertebral endplates and bodies of adjacent vertebrae that can be visualized on MRI imaging as Modic changes. **The aim** of the study was to assess the role of changes in the endplates and adjacent vertebral bodies in radiological results of monosegmental posterior lumbar interbody fusion (PLIF) in patients with degenerative lesions of the spine. **Material and methods** The design of the study was a monocenter retrospective comparative cohort study. The radiological results of PLIF performed in combination with transpedicular screw fixation for 122 patients with Modic changes in adjacent endplates and adjacent vertebral bodies were evaluated for interbody fusion, subsidence of interbody implants, segmental angle, interbody space height. The followup period was 1-2 years. **Results** Complete interbody fusion was seen in 94.4 % of Modic type 0 and in 77.3 % of Modic type II changes. Interbody cage subsidence occurred in 38.9 % Modic type I, 22.7 % in Modic type II, 9.1 % in Modic type III and in 11.3 % Modic type 0 changes. A significant decrease in the segmental angle was found in all types of Modic changes ($p < 0.05$) at 1-2 years with the greatest decrease noted in Modic type I ($p = 0.000438$). A significant decrease in the interbody space height was noted in all groups ($p < 0.05$) with the greatest decrease seen in Modic type I changes ($p = 0.000438$) and the minimum decrease noted in Modic type III changes ($p = 0.000438$). **Discussion** The role of the endplates and adjacent vertebral bodies in the results of surgical treatment was evident, and more research is needed to explore the sort of this relationship. **Conclusions** Modic changes in the endplates and adjacent red bone marrow showed a significant relationship with the radiological outcomes of monosegmental PLIF. The interbody fusion Tan grade I and Tan grade II was more common for Modic type 0 and less common for Modic type II changes. Subsidence of interbody implants was more common for Modic type I and less common for Modic type III changes (9.1%). Postoperative loss of interbody space height and segmental correction was common for Modic type I.
Keywords: degenerative spine disease, posterior lumbar interbody fusion, Modic change, cage subsidence, fusion

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INTRODUCTION

Clinical manifestations of degenerative lesions of the lumbar spine are one of the most common causes of temporary or permanent disability of adult population in industrialized countries, and the number of surgical interventions aimed at their elimination is annually increasing. The morphological substrate of pain is normally degenerative lesions of the spinal motion segments. The cascade of these changes affects the facet joints, intervertebral discs and adjacent endplates, and the red bone marrow of adjacent vertebral bodies. The role of the pathology of the latter as a marker of pain is widely studied at the fundamental and applied levels. In 1988, Modic described three types of vertebral marrow signal changes adjacent to endplates on magnetic resonance imaging (MRI): type I was characterized by an acute inflammatory reaction, type II featured fatty transformation and type III was characterized by sclerotic changes.

The prevalence of Modic changes varies greatly, according to different studies and ranges between 19 % and 60 %. There are two main theories of the genesis. The first is biomechanical and is based on stress loading, leading to microfractures of the bone portion of the endplate and development of inflammatory pathophysiological manifestations of the adjacent cancellous bone of the vertebral body. The second theory is controversial based on infection caused by various microorganisms (for example, *Propionibacterium acnes*). The three types of Modic changes are stages of one process passing one into another: type I can last for 14 to 36 months, type II can develop for 3 years and over. Type I changes reflect the destabilization of the spinal motion segment that is indirectly confirmed by the correlation with segmental hypermobility, worse clinical results after decompression procedures as compared to stabilization interventions. Type II changes characterize a more stable condition that is confirmed by the lesser spread in patients with back pain, less significant clinical improvement after spinal fusion. The choice of surgical treatment would be dependent on the type of Modic in order to achieve good results. The review of publications showed the spinal fusion as the most effective method for eliminating vertebrogenic pain syndrome in degenerative pathology in the presence of changes in the endplates and adjacent red bone marrow. The creation of a primary stable segment contributes to a significant improvement of the clinical scenario at a short term. However, long-term clinical results largely depend on the degree of fusion of the bodies of adjacent vertebrae (fusion or pseudarthrosis), on the preservation of the segmental correction achieved (subsidence of interbody implants).

A number of studies indicate a significant relationship between the clinical outcome of spinal fusion and the completeness of the interbody fusion. Patients with an artificial fusion achieved showed a significantly lower level of pain and a higher level of quality of life. The condition of the endplates and the adjacent red bone marrow significantly contribute to a good result of spinal fusion. There is a paucity of studies reporting the influence of Modic changes on the clinical and radiological results of interbody fusion, and a low level of evidence does not allow for convincing conclusions due to smaller cohorts.

The aim of the study was to evaluate the radiological results of posterior lumbar interbody fusion (PLIF) performed for degenerative spine pathology in patients with Modic changes at the same level.

MATERIAL AND METHODS

Study design was a monocentric retrospective comparative cohort study. The study was approved by the local ethics committee and performed in accordance with the Declaration of Helsinki. The paper reported outcomes of patients who underwent surgical treatment between 2014 and 2018. Vertebrogenic pain syndrome with or without neurological deficit, neurogenic intermittent claudication syndrome were indications for surgery. The morphological substrate of clinical manifestations included degenerative changes with an involved lumbar segment (L3-L4, L4-L5, L5-S1): degenerative stenosis of the spinal canal, degenerative spondylolisthesis, segmental instability, isthmic spondylolisthesis combined with degenerative changes in the intervertebral disc. Patients underwent rigid monosegmental fixation in the presence of instability (initial or iatrogenic if extended decompression was required) and (or) the need for correction.

Inclusion criteria were age over 18; primary posterior monosegmental fusion at the levels L3-L4, L4-L5, L5-S1; preoperative and postoperative (after 1-2 years) radiological findings; posterior lumbar interbody fusion (PLIF) with two PEEK cages filled with homoosseous tissue and (or) tricalcium phosphate, in combination with transpedicular fixation. Exclusion criteria included age under 18; non-degenerative lesions of the spine (inflammatory, tumor, traumatic, anomalies); degenerative lesions requiring a decompression-stabilization and/or correction of 2 or more spinal motion segments; other types of interbody fusion (except PLIF): transforaminal (TLIF), lateral (LLIF), anterior (ALIF); previous surgical spine interventions.

Demographics included age, gender, and.clinical parameter explored was body mass index (BMI).

Preoperative examination included radiography of the lumbar spine in 2 projections (AP and lateral); functional spondylography of the lumbar spine (flexion and extension in the lateral projection); MRI and MSCT of the lumbar spine. Postoperative examination included radiography of the lumbar spine in 2 projections (AP and lateral); MSCT; MRI of the lumbar spine, if needed. Examinations performed at 1-2 years included radiography of the lumbar spine in 2 projections (AP and lateral); functional spondylography of the lumbar spine (flexion and extension in the lateral projection); MSCT; MRI of the lumbar spine, if needed.

Estimated parameters:

– changes in the endplates and adjacent red bone marrow of the bodies of adjacent vertebrae according to the Modic criteria

– formation of an artificial interbody block at the level of fusion;

– subsidence of interbody implants;

– segmental relationships: interbody space height index and segmental angle.

Changes in the endplates and adjacent red bone marrow were assessed according to the Modic classification. The first type was characterized by a hypointense signal on T1-weighted imaging (T1WI) and a hyperintense signal T2-weighted imaging (T2WI) due to edema and inflammatory changes; the second type was characterized by a hyperintense signal on T1WI and an isointense signal on T2WI due to red bone marrow replaced with adipose tissue; the third type was characterized by a hypointense signal on both T1WI and T2WI due to subchondral sclerosis.

The parameter was used to divide patients into four groups: group I (MCI) included patients with Modic I changes, group II (MCII) consisted of patients with Modic II, group III (MCIII) included patients with Modic III changes, group IV (MC0) included cases with Modic 0 changes (no changes on MRI).

The method of grouping patients is shown in Figure 1.

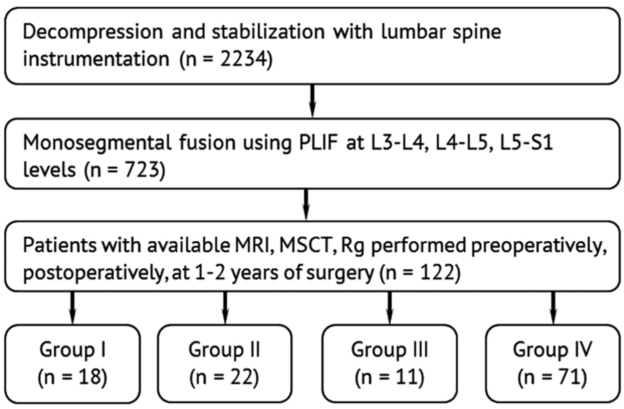

Fig. 1 Technique of grouping patients

Interbody fusion was evaluated with MSCT based classification offered by G.H. Tan et al. . The classification system included 4 grades describing morphological changes at the border of the vertebral bodies and interbody graft: grade 1 – complete fusion, grade 2 – partial fusion, grade 3 – unipolar pseudarthrosis, grade 4 – bipolar pseudarthrosis. Grades 1 and 2 were considered as a criterion for a bony union, and grades 3 and 4 denoted pseudarthrosis. Subsidence of an interbody implant was categorized as breakdown of the caudal endplate of the overlying vertebra and (or) the cranial of the underlying vertebra with the implant and introduction into the vertebral body. The parameter was assessed with MSCT. The subsidence was graded as 0 with implant penetrated into the vertebral body by less than 1 mm, as I with penetration of 1-3 mm and as II with penetration of greater than 3 mm. The height of the interbody space was estimated with radiography based on the method proposed by Kim K.T., and was measured as a disc height index (DHI) being the ratio of the height of the disc to the height of the overlying vertebral body. The segmental angle was the angle between the caudal endplate of the overlying vertebra and the cranial endplate of the underlying vertebra.

The description of continuous data was presented in the form of MED [IKI]; binary data as a number (%) [95 % confidence interval]; categorical data as a number per category (%). Due to the small size of the groups, the comparison between the groups was performed with the non-parametric Mann-Whitney U-test calculating the value and 95 % CI for the pseudo-median of the pairwise differences of the data as an estimate of the mean difference of the data. Binary data were compared using two-tailed Fisher's exact test with estimated OR and 95 % CI for OR. Correlation analysis was carried out using the Pearson coefficient. Statistical hypotheses were tested at a critical significance level of $p = 0.05$, i.e. the difference was considered statistically significant with $p < 0.05$. The lower limit of evidence power was taken equal to 80 %. SPSS 15.0 software was used for statistical data processing.

RESULTS

According to the inclusion criteria, the number of patients in the study was 122. Preoperative demographic and clinical data are presented in Table 1. Assessment of the significant differences between groups (MCI/MC0, MCI/MCII, MCI/MCIII, MCII/MC0, MCII/MCIII and MC0 /MCIII) showed only BMI was found to be significant between MCI and MC0 ($p = 0.004405$), the variables were statistically comparable in other cases ($p > 0.05$).

Radiological parameters are presented in Tables 2 and 3. The highest and the lowest frequency of the artificial fusion at 1-2 years was revealed in the absence of Modic changes, and in Modic II, respectively. The significant differences in the outcome of the formation of the interbody fusion was revealed in MCII/MC0 ($p = 0.000120$). Subsidence of the interbody implant was most common with Modic I (38.9 %), the least common with Modic III (9.1 %), however, significant differences were found only between Modic I and Modic 0 ($p = 0.008258$).

The preoperative segmental angle was the least with Modic I and was significantly increased postoperatively in all groups (MCI, MCII, MCIII, MC0) ($p = 0.000352$, $p = 0.000702$, $p = 0.017291$ and $p = 0.000065$ respectively). Comparison of postoperative parameters and at 1-2 years showed a significant decrease in the segmental angle in all groups: MCI, $p = 0.000982$; MCII, $p = 0.012655$; MCIII, $p = 0.043115$ and MC0, $p = 0.023547$. However, the greater decrease was observed in the Modic I group. The preoperative height of the intervertebral disc was statistically comparable in the groups. The DHI was significantly increased postoperatively in the groups: MCI, $p = 0.001609$; MCII, $p = 0.004550$; MCIII, $p = 0.026232$ and MC0, $p = 0.000392$. However, the DHI was significantly decreased in all groups ($p < 0.05$) during the observation period. The parameter had greater decreased values in Modic I patients ($p = 0.000438$), and the least decreased values in Modic III patients ($p = 0.000438$).

Correlation analysis of the parameters in the population of the patients showed significant relationships with interbody fusion graded by Tan at 1-2 years with subsidence at 1-2 years ($p = -0.6870$), preoperative segmental angle ($p = 0.3105$), segmental angle at 1-2 years ($p = 0.3534$), DHI at 1-2 years ($p = 0.3048$); subsidence at 1-2 years with preoperative segmental angle ($p = -0.5787$), segmental angle at 1-2 years ($p = -0.5805$), preoperative DHI ($p = -0.5739$) and at 1-2 years ($p = -0.5825$). The correlation of Modic changes with none of the radiological parameters did not reach the level of statistical significance ($p < 0.3$) (Table 4).

Table 1

Preoperative demographic and clinical parameters in the groups

Description	Modic I (n = 18)	Modic II (n = 22)	Modic III (n = 11)	Modic 0 (n = 71)
Age, years	46.0 [37.0; 56.0]	49.0 [38.0; 58.0]	45.0 [32.0; 58.0]	54.0 [40.0; 59.0]
BMI, kg/m^2	32.7 [29.7; 34.5]	30.0 [27.6; 33.6]	30.5 [28.6; 34.1]	29.8 [26.5; 32.2]
Gender (m/f)	5/13 (27.8 %/72.2 %)	7/15 (31.8 %/68.2 %)	3/8 (27.3 %/72.7 %)	21/50 (29.6 %/70.4 %)

Table 2

Descriptive statistics of radiological parameters in groups

Description	Modic I (n = 18)	Modic II (n = 22)	Modic III (n = 11)	Modic 0 (n = 71)
Fusion by at 1-2 years (united/ununited)	2 (11.1 %) / 16 (88.9 %)	5 (22.7 %) / 17 (77.3 %)	2 (18.2 %) / 9 (81.8 %)	4 (5.6 %) / 67 (94.4 %)
Subsidence at 1-2 years (present/none)	11 (61.1 %) / 7 (38.9 %)	17 (77.3 %) / 5 (22.7 %)	10 (90.9 %) / 1 (9.1 %)	63 (88.7 %) / 8 (11.3 %)
Preoperative segmental angle, degrees	2.5 [1.0; 4.0]	4.0 [2.0; 5.0]	4.0 [2.0; 5.0]	4.0 [4.0; 5.0]
Postoperative segmental angle, degrees	6.0 [6.0; 7.0]	5.0 [5.0; 6.0]	6.0 [5.0; 7.0]	5.0 [4.0; 6.0]
Segmental angle at 1-2 years, degrees	4.0 [4.0; 6.0]	4.0 [4.0; 5.0]	6.0 [4.0; 6.0]	4.0 [4.0; 5.0]
Preoperative DHI	0.27 [0.22; 0.29]	0.26 [0.24; 0.29]	0.26 [0.23; 0.31]	0.28 [0.25; 0.31]
Postoperative DHI	0.30 [0.28; 0.32]	0.30 [0.28; 0.31]	0.28 [0.27; 0.30]	0.29 [0.26; 0.30]
DHI at 1-2 years	0.27 [0.26; 0.30]	0.28 [0.25; 0.30]	0.27 [0.26; 0.29]	0.27 [0.25; 0.29]

Table 3

Comparison of radiological parameters in the groups

Description	MCI / MCII	MCI /MCIII	MCI / MC0	MCII / MCIII	MCII / MC0	MCIII / MC0
Fusion by at 1-2 years (0/1)	0.240869	0.400508	0.056301	0.884198	0.000120*	0.006052
Subsidence at 1-2 years (0/1)	0.491207	0.105048	0.008258*	0.249951	0.067322	0.917908
Preoperative segmental angle, degrees	0.411222	0.203814	0.001930*	0.611489	0.041817*	0.305589
Postoperative segmental angle, degrees	0.062068	0.947159	0.005399*	0.204202	0.618237	0.067842
Segmental angle at 1-2 years, degrees	0.757206	0.122306	0.719188	0.048072*	0.996420	0.013973*
Preoperative DHI	0.840246	0.982376	0.322203	1.000000	0.155493	0.325261
Postoperative DHI	0.311684	0.111544	0.028338*	0.375236	0.262423	0.989297
DHI at 1-2 years	0.882490	0.877092	0.659466	0.836240	0.825961	0.957205

*statistically significant changes.

Table 4

Correlation analysis of radiological parameters and Modic changes

Description	Modic I	Modic II	Modic III	Modic 0
Fusion by at 1-2 years (0/1)	-00061	-0.1835	-0.0768	0.1920
Subsidence at 1-2 years (0/1)	0.2389	0.0685	-0.0677	-0.1858
Preoperative segmental angle, degrees	-0.2468	-0.1023	-0.0168	0.2669
Postoperative segmental angle, degrees	0.2232	-0.0336	0.1386	-0.2148
Segmental angle at 1-2 years, degrees	0.0432	-0.0188	0.2254	-0.1473
Preoperative DHI	-0.0675	-0.1054	-0.0407	0.1544
Postoperative DHI	0.2000	0.0436	-0.0304	-0.1601
DHI at 1-2 years	0.0511	0.0240	0.0161	-0.0648

* statistically significant changes.

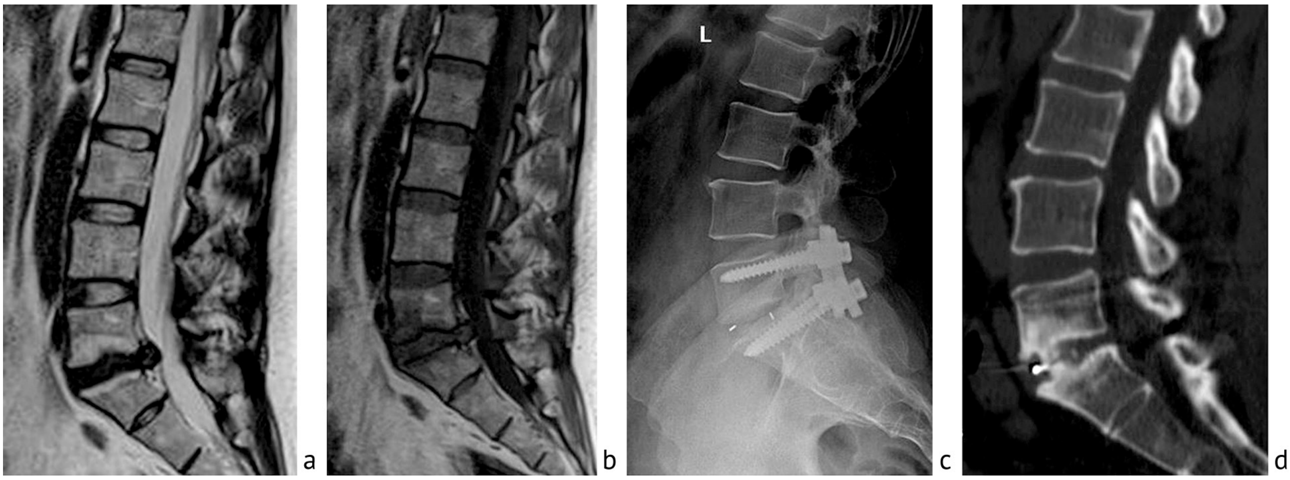

Fig. 2 A 48-year-old patient N. underwent surgical treatment for vertebrogenic pain syndrome with compression of the S1 root on the left caused by disc herniation at the L5-S1 level, segmental instability of L5-S1. MRI (a and b) showed signs of Modic I changes in the endplates and red bone marrow of the type. Transpedicular and interbody fixation at the L5-S1 level was performed. Rg (c) and MSCT (d) demonstrated consistent metal fixation with no migration of the interbody implant, no implant subsidence with interbody fusion identified at 12 months (Tan type 2)

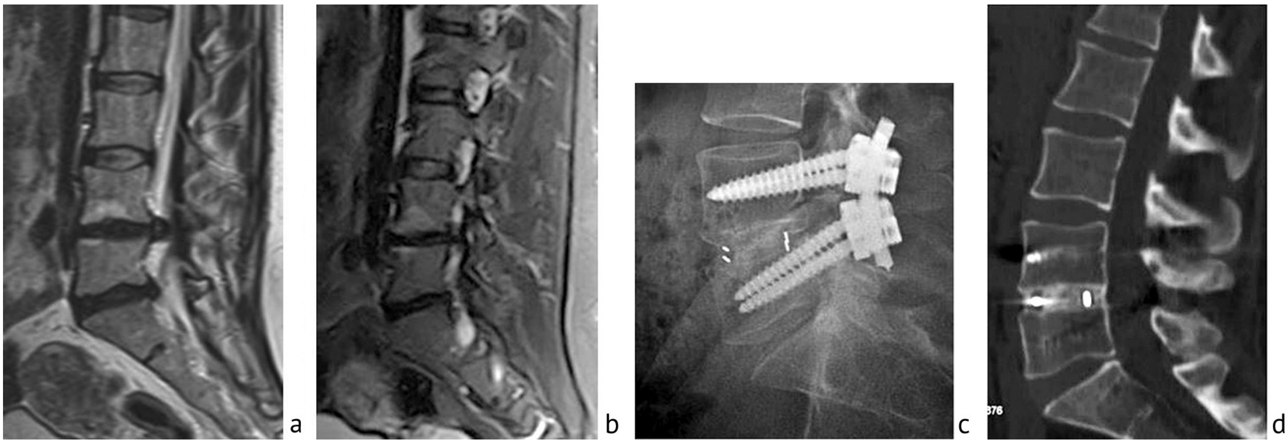

Fig. 3 A 44-year-old patient N. underwent surgical treatment for vertebrogenic pain syndrome with compression of the L5 root on the left due to disc herniation at the L4-L5 level, segmental instability of L4-L5. MRI (a and b) showed signs of Modic II changes in the endplates and red bone marrow. Transpedicular and interbody fixation at the L4-L5 level was performed. Rg (c) and MSCT (d) demonstrated the intact metal construct, no migration of the interbody implant, no implant subsidence with interbody fusion identified at 15 months (Tan type 1)

DISCUSSION

Spinal fusion is a technology commonly used in the practice of a spine surgeon. The goal is to provide segmental stability and correct segmental relationships. The endplates of the bodies of adjacent vertebrae and the bone portion that remains after removal of hyaline cartilage during curettage have a significant role. Dudli S. et al. reported specific morphological and pathophysiological changes occur in the endplates and adjacent red bone marrow due to Modic disorders that can affect the biological properties of the bone. Mechanical stress resistance is responsible for maintaining the interbody correction achieved. For instance, erosive defects can affect the stability of the endplate and implant interface.

In 1988, Modic et al. described 3 types of changes in the endplates and adjacent bone marrow of adjacent vertebral bodies in patients with chronic low back pain. Modic I changes were characterized by the destruction and cracks in the endplate with areas of degeneration and regeneration of vascular granulation tissue, a higher expression of pro-inflammatory cytokines as compared to other types and changes in the activity of osteoblasts and osteoclasts. This indicates to Modic I changes reflecting an active inflammatory process in the endplates and adjacent red bone marrow. The process can last as long as 3 years. Modic II changes are characterized by an identical histological pattern of Modic I changes in the endplates (fissures, vascular granulation tissue, increased activity of pro-inflammatory cytokines). However, there is a significant depletion of hematopoietic components that are replaced by yellow adipose tissue in the adjacent red bone marrow. Modic III changes reflect sclerotic changes in the endplates and red bone marrow. Analyzing the literature focusing on the role of

Modic changes in surgical practice, two main clinical and radiological aspects can be identified with the dynamics in grade change in stages of Modic changes, formation of bone fusion, subsidence.

The clinical significance of Modic changes can be confirmed by the following: the prevalence is higher in patients with pain in the lumbar spine; episodes of pain syndrome are much more frequent and longer, in Modic I patients, in particular; the size of the endplate lesion correlates with pain intensity. A number of studies have shown the dependence of the clinical success of spinal fusion in patients with different types of Modic changes. Pinson H et al. examined ALIF patients and reported a more significant improvement in clinical outcomes (VAS back) in Modic I patients as compared to other types, in the first 3 months, in particular. Similar results were reported by Esposito P et al. in a study of 60 patients who underwent posterior interbody or posterolateral fusion. They reported a more significant improvement in patients with Modic I or II changes than those with Modic 0. Kwon Y.-M. et al. reported a significantly worse clinical outcome in Modic III patients in a retrospective analysis of 597 patients who underwent posterior interbody fusion without pedicle screw fixation. Laustsen AF et al., performed a systematic review of the literature, and concluded that the evidence is insufficient due to a paucity of studies and the low quality to allow convincing conclusions about the clinical role of Modic changes after spinal fusion. Although they revealed a trend towards a negative correlation of clinical improvement after discectomy and a potential of positive outcomes with use of artificial discs.

Segment fixation can speed up the transition from one Modic stage to another. We found two original articles that investigated such dynamics with rigid stabilization without interbody fixation. Ohtori S. et al. reported 21 Modic I patients after posterolateral fusion in a 12-month study with a transition to Modic II detected in 9 cases, to Modic 0 in 2 cases and with no changes in 10 cases. Of the 12 Modic II patients, only in 2 made a transition to Modic 0, with no changes in the rest of the cases. JM Vital reported 4 individuals could transit to Modic 0 and 13 to Modic II out of 17 Modic I patients who underwent posterolateral fusion at 6 months. The parameter was not evaluated in our series because it was not a goal.

There is a paucity of publications that would substantively evaluate the fusion of the vertebrae in various Modic types, and the issue has remained out of focus in the Russian literature. The technology of posterolateral or interbody fusion is described in the studies we analyzed. One article only reported the results of 360° fixation. Lang P. et al. demonstrated the worst results in Modic I patients with 70 % having nonunion at the level of posterolateral fusion reported in one of the early works of the early 1990s. However, the fusion was reported in 84 % of Modic II cases. The authors explained this kind of results by presence of reparative granulation tissue, inflammation, edema in Modic I creating poor conditions for adhesion. On the contrary, Chataigner H. reported 5 nonunions in 29 ALIF patients with 3 Modic II that can be explained by low reparative activity of the adjacent red bone marrow due to fatty degenerative involution. The best results were obtained with Modic I due to favorable pathophysiological conditions for fusion with the interbody autograft. Young-Min Kwon et al. reported the results of surgical treatment using PLIF without posterior screw fixation in a retrospective observational study of 597 patients. They reported fusion in 96.5 % of Modic 0 cases, in 80.8 % of Modic I, 83.6 % of Modic II and 54.5 % of Modic III. Ohtori S. et al. reported no significant difference in vertebral union over 9 months in a study of 21 Modic I and 12 Modic II patients after posterolateral fusion. Wang M.Y. et al. (2019) reported no difference in the frequency of fusion in Modic and non-Modic patients (n = 186) who underwent TLIF with PEEK cages and posterior transpedicular fixation. However, the authors did not explore the parameter depending on Modic types. Our series demonstrated fusion noted in 88.9 % of Modic I cases, in 77.3 % Modic II, in 81.8 % Modic III and in 94.4 % Modic 0. Significant differences in the outcome of interbody fusion were seen between MCII and MC0 ($p = 0.000120$) only.

The endplates take the main load during interbody fusion. The mechanical strength providing primary stability at the contact zone with the cage is a very important aspect. Implant subsidence, loss of interbody space height and segmental correction can be expected with low endplate strength. There is a paucity of works devoted to the study of the effect of altered endplates and adjacent red bone marrow on radiological results at the site of the contact with an interbody implant in the lumbar spine. Wang M.Y. et al. reported subsidence of an interbody implant with various types of endplate changes in patients after transforaminal interbody fusion in combination with transpedicular fixation. The authors reported a significantly higher incidence in Modic I (28.0 %, 7/25), Modic II (24.2 %, 16/66) as compared to Modic 0 patients (11.5 %, 10/87). Chung N.S. et al. evaluated radiographic outcomes of OLIF in two groups of patients with and without Modic changes. The work did not reveal a more significant frequency of subsidence, a decrease in the segmental angle, or disc height in Modic patients. However, the authors did not compare these parameters for different Modic types. Such an assessment was performed in the present study. A decrease in the height of the interbody space and segmental angle was noted in all groups ($p < 0.05$) during the period of postoperative observation and they were the most significant in Modic I. We also noted the highest frequency of subsidence in patients with

Modic type I changes (38.9 %). However, there was no significant correlation between Modic changes and radiological parameters (p < 0.3).

There is controversy regarding the role of changes in the endplates and adjacent red bone marrow in the outcome of decompression stabilization interventions due to the small number of studies, the heterogeneity of the results and lack of multicenter randomized studies. The factors exclude the possibility of unifying approaches to the choice of surgical strategy which dictates the need for studies with a high level of evidence and a large number of patients. Limitations of the study included monocentric, retrospective; observation period of 1-2 years; the role of various osteoinductive materials used for cages, and clinical parameters were not evaluated. The study is the level of evidence "3" according to the OCEBM scale (Oxford Center for Evidence-Based Medicine).

CONCLUSION

The results of monosegmental posterior fusion showed the frequency of interbody fusion Tan types 1 and 2 being the highest for Modic 0 (94.4 %) and the lowest for Modic II (77.3 %). Subsidence of interbody implants occurred more frequently with Modic I (38.9 %) and less frequently with Modic III (9.1 %). Loss of interbody space height and segmental correction in the postoperative period was more common for Modic I. Changes in the endplates and adjacent red bone marrow described by Modic MT should be considered with use of monosegmental posterior interbody fusion in combination with transpedicular fixation.

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