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ORIGINAL ARTICLE

The influence of endplate (Modic) changes on clinical outcomes in lumbar spinal stenosis surgery: a Swiss prospective multicenter cohort study

Nils H. Ulrich[1,5] · Jakob M. Burgstaller[1] · Isaac Gravestock[1] · Sebastian Winklhofer[2] · François Porchet[3] · Giuseppe Pichierri[1] · Maria M. Wertli[1,4] · Johann Steurer[1] · Mazda Farshad[5] on behalf of the LSOS Study Group

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Abstract

Purpose To investigate if the presence or absence of preoperative endplate Modic changes (MC) is predictive for clinical outcomes in degenerative lumbar spinal stenosis (DLSS) patients undergoing decompression-alone or decompression with instrumented fusion surgery.

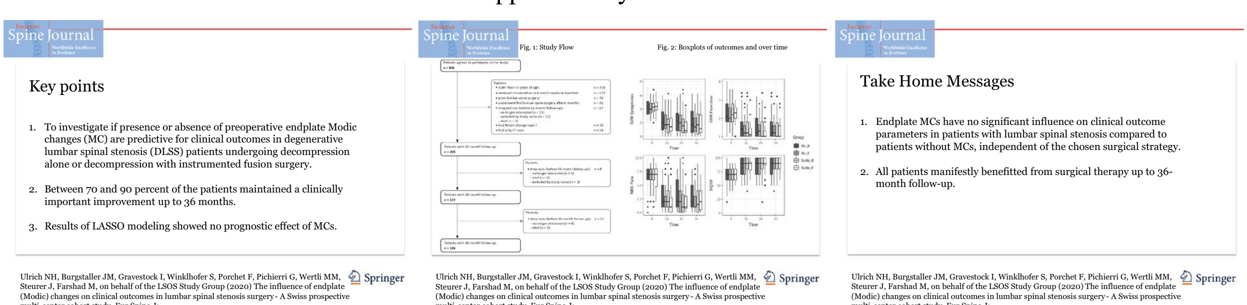
Methods Two hundred five patients were included and categorized into four groups; 102 patients into the decompression-alone group with MCs, 41 patients into the fusion group with MCs, 46 patients into the decompression-alone group without MCs, and 16 patients into the fusion group without MCs. Clinical outcome was quantified with changes in spinal stenosis measure (SSM) symptoms, SSM function, NRS pain, and EQ-5D-3L sum score over time (measured at baseline, 12-, 24-, and 36-month follow-up) and minimal clinically important difference (MCID) in SSM symptoms, SSM function, and NRS pain from baseline to 36-month follow-up. To investigate if possible effects of MCs had been modified or hidden by confounding variables, we used the group LASSO method to search for good prognostic models.

Results There were no obvious differences in any of the clinical outcome measures between groups at baseline. At 12 months, most patients have improved in all outcomes and maintained improved conditions over time (no significant group differences). Between 70 and 90 percent of the patients maintained a clinically important improvement up to 36 months.

Conclusions Endplate MCs have no significant influence on clinical outcome parameters in patients with lumbar spinal stenosis compared to patients without MCs, independent of the chosen surgical strategy. All patients benefitted from surgical therapy up to 36-month follow-up.

Graphic abstract

These slides can be retrieved under Electronic Supplementary Material.



Keywords Modic changes · Endplate · Decompression · Degenerative lumbar spinal stenosis · Fusion

Nils H. Ulrich and Jakob M. Burgstaller have contributed equally to this work.

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Extended author information available on the last page of the article

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Abbreviations

DLSS Degenerative lumbar spinal stenosis
LSOS Lumbar Stenosis Outcome Study

Introduction

Changes in signal intensity in vertebral endplates and subchondral bone marrow on magnetic resonance imaging (MRI) were first described in 1987 [1] and one year later formally classified by Modic et al. [2, 3]. Modic changes (MCs) are a frequent phenomenon in patients with degenerative spinal diseases [4, 5] and may be associated with non-specific low back pain (LBP) [6–8]. Based on their appearance in MRI images, MCs are classified into three types: edema-like changes (MC1), fat-like changes (MC2), and sclerosis-like changes (MC3); this last type is believed to be a late-stage manifestation [2, 3]. MCs are regarded as a sequel of degenerative disc disease (DDD) and as an indirect marker of segmental instability [1, 9]. There appears to be wide acceptance of the concept that there is a "developmental pathway" for particular types of MC, whereby MC2 evolves into mixed MC1/2 or MC3 [10, 11].

The etiology of MCs is to a large extent still a mystery, although the current consensus is that disc degeneration causes higher levels of axial loading with an increase in mechanical stress on the vertebral body endplate [3, 5], which causes edema and inflammation (MC1) [5]. Some research proposes a different hypothesis, namely that MCs is a result of bacterial infection, generally Propionibacterium acnes [12, 13].

There is some debate as to whether preoperative MCs are associated with clinical outcomes after decompression or instrumented fusion surgery in patients with lumbar spine diseases [14–16].

Intervertebral disc pathologies like DDD are strongly linked to MCs development and, in the long term, to the progress into degenerative lumbar spinal stenosis (DLSS) [5, 17, 18]. There is a valid discussion to be had about the appropriate form of surgical procedure for DLSS patients with preoperative MCs (simple decompression or instrumented fusion surgery), as the type selected may have a bearing on the outcome [14, 15, 19]. In addition, there is a lack of studies that have evaluated the relationship between surgically treated DLSS patients with MCs and patient outcomes. Anecdotally, some surgeons indicate an additional instrumented fusion to a decompression surgery if MCs are present, assuming that the degree of segment degeneration must be advanced and low back pain would occur more likely with a decompression-alone surgical strategy.

The aim of this study was to investigate if the presence or absence of endplate MCs would affect clinical outcomes in DLSS patients undergoing decompression-alone versus instrumented fusion surgery.

Methods

Study design

For this retrospective analysis, we used data from the prospective multicenter cohort Lumbar Stenosis Outcome Study (LSOS). The LSOS is conducted as a prospective cohort study at eight medical centers (with approximately two million inhabitants in the over regional area) covered by Rheumatology and Spine Surgery Units in Switzerland. Patients with a history of neurogenic claudication and lumbar spinal stenosis verified by magnetic resonance imaging (MRI) were eligible. Additional information about LSOS is available in previous publications [20–23].

Inclusion and exclusion criteria

All patients who met the inclusion criteria (> 50 years of age, history of neurogenic claudication and lumbar spinal stenosis verified by MRI, no evidence of stenosis caused by tumor, fracture, infection, or significant deformity) underwent surgery without or with MCs (MC1 or MC2) at the height of the operated level(s) and had at least a 12-month follow-up which were eligible.

Excluded were patients who were older than 75 years of age, who had previous lumbar spine surgery, whose lumbar spine surgery was more than six months after study enrolment, and who had MC3. (Such endplate changes are known to be less likely associated with lower back pain or who received only conservative care and/or epidural injection.)

Surgical technique and approach

All patients underwent either decompression surgery alone or decompression with instrumented fusion surgery. Decompression surgery consisted of a standard open or microscopic posterior lumbar decompression of the affected level(s). Fusion surgery consisted of decompression surgery and the additional implantation of pedicle screws with rods, plus intersomatic fusion and cage(s) at the affected level(s) if indicated. The surgeon had discretion to add fusion and to proceed with single- versus multi-level procedures.

Radiological classification

The MRI of each patient was evaluated by two senior radiologists. The radiologist categorized the endplate and bone marrow abnormalities (MC) into normal (no changes), MC1 (decreased signal intensity on T1-weighted spin-echo images and increased signal intensity on T2-weighted images), MC2 (increased signal intensity on T1-weighted images and isointense or slightly increased signal intensity on T2-weighted images), and MC3 (low intensity on both T1- and T2-weighted images) [2].

Outcome measures

Spinal Stenosis Measure (SSM): The SSM, an instrument specifically developed and validated for spinal stenosis patients by Stucki et al. [24], aims to measure severity of symptoms and quantifies disability. Minimal clinically important difference (MCID) in SSM symptoms is defined as an improvement (decrease) by at least 0.48 points and in SSM function by at least 0.52 points [25].

EQ-5D-3L: The EQ-5D-3L is an assessment tool to measure health-related quality of life in five dimensions (*mobility, self-care, usual activities, pain/discomfort and anxiety/depression*) which can be calculated as a sum score (score range 0–100, worst–best) [26].

Numeric Rating Scale (NRS) pain: General assessment of pain intensity in the back and in the legs during the previous seven days (score range 0–10, best–worst). MCID is defined as an improvement (decrease) by at least 2 points [27].

Outcome

To find potential differences between groups in regard to clinical outcome, changes in SSM symptoms, SSM function, NRS pain, and EQ-5D-3L sum score over time (measured at baseline, 12-month, 24-month, and 36-month follow-up), and MCID in SSM symptoms, SSM function, and NRS pain from baseline to 36-month follow-up were evaluated.

Statistical analyses

Patients were categorized into four groups: MC/Decompression, MC/Fusion, No MC/Decompression, and No MC/Fusion.

Patient characteristics, radiological parameters, and surgery details were summarized in tables, stratified into four groups. Means and standard deviations or counts and percentages are given as appropriate. Differences between the groups were tested with F-tests and Fisher tests.

Box plots were used to compare the change in outcome scores from baseline after 12 and 36 months between the four groups.

To further investigate if possible effects of MCs had been modified or hidden by confounding variables, we used the group LASSO method for linear regression to search for good prognostic models. LASSO is a method which combines variable selection and covariate shrinkage to select a model with good predictive performance. The method is based on a fitting a series of models with increasingly strong penalty on coefficient estimates to keep only those with strong effects and then choosing the best model among these. The "group" variant of LASSO allows for the proper handling of categorical variables. We fit the LASSO linear models with the *gglasso* package [28] and use cross-validation to select the optimal model. The cross-validation on multiple subsets of the data to determine the LASSO penalty parameter was performed separately for each outcome model. This procedure helps select the best model while avoiding the overestimation of the effects of covariates and therefore the reporting of spurious results. Models were fitted for the outcomes SSM symptoms, SSM function, NRS pain, and EQ-5D-3L sum score, The model selection procedure considered the following variables: baseline scores of SSM symptoms, SSM function, NRS pain, and EQ-5D-3L sum score, type of MC, fusion surgery, comorbidities (Cumulative Illness Rating Scale, CIRS), age, sex, smoking status, low back pain, buttocks pain, gonarthrosis, coxarthrosis duration of symptoms, number of segments decompressed, and presence of spondylolisthesis.

All analyses are conducted with R for Windows.

Ethics

The study was approved by the independent Ethics Committee of the Canton Zurich (KEK-ZH-NR: 2010-0395/0).

Results

Baseline characteristics

Figure 1 shows the patient flow of 841 patients who agreed to participate between December 2010 and December 2015 into the multicenter lumbar spinal stenosis cohort study. For this analysis, 205 patients met the inclusion criteria.

Table 1 presents the baseline characteristics. In the MC group ($n = 143$), mean age was 67.4 years, 66 (46.2%) were female, 102 underwent decompression-alone surgery, and 41 underwent fusion surgery. MC1 were present in 22 (15.4%), MC1 and MC2 in 28 (19.6%), and MC2 in 93 (65.0%) patients. In the No MC group, mean age was 65.6 years, 30 (48.4%) were female, 46 patients underwent decompression-alone surgery, and 16 underwent fusion surgery. None of the differences apart of the CIRS were statistically significant.

Operated levels, radiological parameters, complications, and reoperations

Table 2 provides details about the operated levels and the radiological parameters. The most commonly involved operated level was L4/5. Most levels had a severe central stenosis radiologically.

A dura lesion during surgery occurred in ten patients (9.8%) in the MC/Decompression group, in one patient (2.4%) in the MC/Fusion group, in five patients (10.9%) in the No MC/Decompression group, and in no patient in the No MC/Fusion group (Table 2).

Reoperations were necessary in eleven patients (10.8%, decompression alone) and in eight patients (7.8%, decompression with fusion surgery) in the MC/Decompression group, further in one patient (2.4%, decompression with fusion surgery) in the MC/Fusion group, and in two patients (4.3%, decompression with fusion surgery) in the No MC/Decompression group (Table 2). Median days until reoperation were 94, 356, 25, and 202 days, respectively.

Patient baseline and changes

No obvious difference in patients' SSM scores, NRS pain, or quality of life was documentable at baseline (Fig. 2). At 12 months, most patients had improved in all outcomes. At 24 and 36 months, most patients had maintained improved conditions. There was a slight trend for patients who had fusion surgery for more improvement, but a Kruskal–Wallis test of the outcome score changes between the groups did not give any evidence for a difference (p values between 0.390 and 0.964). Table 3 shows the number and percentage of patients who have a clinically important improvement from baseline in symptoms,

Fig. 1 Study flow

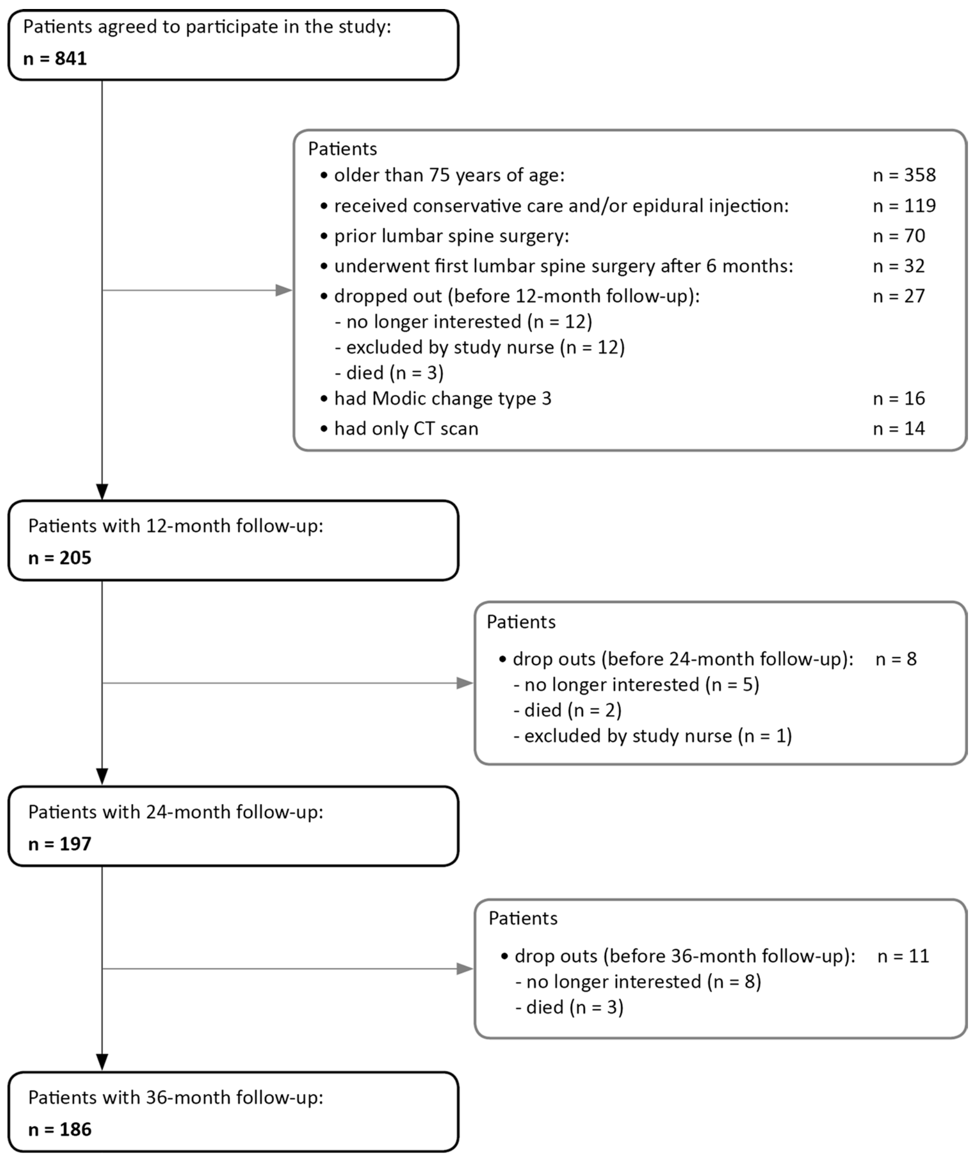

Table 1 Patient characteristics at baseline

Group	MC with decompression alone	MC with fusion surgery	No MC with decompression alone	No MC with fusion surgery	*P*
n	102	41	46	16	
Age, mean (SD)	67.90 (6.19)	66.02 (6.39)	65.59 (6.15)	65.50 (7.43)	0.111
Female, *n* (%)	45 (44.1)	21 (51.2)	25 (54.3)	5 (31.2)	0.359
BMI, mean (SD), kg/m^2	28.14 (4.83)	28.16 (4.31)	27.10 (5.15)	26.85 (3.71)	0.493
Smoker, *n* (%)	15 (14.7)	11 (26.8)	10 (21.7)	4 (25.0)	0.341
Education (compulsory school only), *n* (%)	23 (22.5)	7 (17.1)	13 (28.3)	3 (18.8)	0.637
Social risk*, *n* (%)	26 (25.5)	9 (22.0)	12 (26.1)	2 (12.5)	0.684
CIRS, mean (SD)	9.71 (3.83)	8.78 (3.35)	7.74 (4.17)	8.12 (3.58)	0.025
Gonarthrosis, *n* (%)	24 (24.2)	11 (27.5)	9 (19.6)	4 (25.0)	0.855
Coxarthrosis, *n* (%)	19 (19.2)	8 (20.0)	4 (8.7)	3 (18.8)	0.410
Low back pain, *n* (%)	92 (90.2)	37 (90.2)	37 (84.1)	13 (81.2)	0.571
Pain in buttocks, *n* (%)	80 (78.4)	32 (78.0)	37 (80.4)	11 (68.8)	0.809
Pain in upper leg, *n* (%)	82 (80.4)	34 (82.9)	39 (86.7)	11 (68.8)	0.450
Pain in leg only, *n* (%)	10 (9.8)	4 (9.8)	5 (11.4)	3 (18.8)	0.750
Low back pain only, *n* (%)	5 (4.9)	1 (2.4)	0 (0.0)	0 (0.0)	0.347
Duration of symptoms, *n* (%)					0.142
< 3 months	11 (10.8)	2 (4.9)	3 (6.5)	1 (6.2)	
3–6 months	15 (14.7)	2 (4.9)	5 (10.9)	0 (0.0)	
6–12 months	15 (14.7)	10 (24.4)	13 (28.3)	1 (6.2)	
> 12 months	61 (59.8)	27 (65.9)	25 (54.3)	14 (87.5)	
NRS pain, mean (SD)	6.44 (2.30)	6.56 (1.55)	6.59 (2.11)	6.31 (2.21)	0.959
EQ-5D-3L sum score, mean (SD)	67.94 (16.25)	69.02 (12.81)	70.00 (13.66)	68.12 (12.23)	0.881
SSM function score, mean (SD)	2.27 (0.70)	2.14 (0.54)	2.25 (0.70)	2.23 (0.63)	0.763
SSM symptoms score, mean (SD)	3.17 (0.62)	3.06 (0.47)	3.16 (0.56)	3.21 (0.62)	0.708
Modic type, *n* (%)					**< 0.001**
No changes	NA	NA	46 (100.0)	16 (100.0)	
Type 1	15 (14.7)	7 (17.1)	NA	NA	
Type 1/2	18 (17.6)	10 (24.4)	NA	NA	
Type 2	69 (67.6)	24 (58.5)	NA	NA	

Bold value indicates the level of significance was set to 5%

CIRS cumulative illness rating scale, *MC* Modic change, *NA* not applicable, *NRS* numeric rating scale, *SSM* spinal stenosis measure

EQ-5D-3L sum score range 0–100 (worst–best); NRS range 0–10 (worst–best); SSM symptoms score range 1–5 (best–worst); SSM function: score range 1–4 (best–worst)

*Living alone, or single/divorced/widowed and living in a nursing/residential home

function, and pain at 36 months. There is no evidence for differences among the groups for any of these outcomes.

LASSO model results

The result of model selection process for predicting SSM symptoms at 36 months is visualized with a trace plot (Fig. 3) showing the coefficients of increasingly penalized models. The best model chosen by cross-validation is marked with the vertical dashed line on the trace plot. The chosen model includes the variables whose paths have not shrunken to the zero line. The model selection depicted for SSM symptoms is similar to that of the models for SSM function, NRS pain, and EQ-5D-3L sum score. Neither MCs nor fusion surgery was found to have any prognostic value in the results of our modeling (Table 4). The patients' baseline health status (especially CIRS and NRS pain), age, and spondylolisthesis were the best prognostic indicators of patient outcomes, while the number of decompressed levels was found to have very weak effect on SSM function only. The resulting models (Table 4) predict that older patients with worse baseline health and many comorbidities will have worse outcomes. As MCs were not included in the LASSO models, there was no evidence for effects due to MCs or any effects were hidden or modified by confounding variables.

Table 2 Operated levels, radiological parameters, complications, and reoperations

Group	MC with decompression alone	MC with fusion surgery	No MC with decompression alone	No MC with fusion surgery	*P*
n	102	41	46	16	
Levels operated, *n* (%)					**< 0.001**
1	29 (28.4)	18 (43.9)	32 (69.6)	14 (87.5)	
2	51 (50.0)	19 (46.3)	13 (28.3)	2 (12.5)	
3	22 (21.6)	4 (9.8)	1 (2.2)	0 (0.0)	
Operated level, *n* (%)					
L1/L2	2 (2.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.564
L2/L3	25 (24.5)	5 (12.2)	6 (13.0)	0 (0.0)	**0.041**
L3/L4	62 (60.8)	22 (53.7)	23 (50.0)	2 (12.5)	**0.004**
L4/L5	88 (86.3)	33 (80.5)	30 (65.2)	14 (87.5)	**0.023**
L5/S1	20 (19.6)	8 (19.5)	2 (4.3)	2 (12.5)	0.100
Central stenosis grade of operated levels, *n* (%)					0.787
No	1 (0.5)	1 (1.5)	1 (1.6)	0 (0.0)	
Mild	27 (13.7)	4 (5.9)	6 (9.8)	1 (5.6)	
Moderate	62 (31.5)	23 (33.8)	18 (29.5)	5 (27.8)	
Severe	107 (54.3)	40 (58.8)	36 (59.0)	12 (66.7)	
Meyerding listhesis grade of operated levels, *n* (%)					**< 0.001**
0	144 (73.1)	29 (42.6)	47 (77.0)	3 (16.7)	
I	51 (25.9)	31 (45.6)	14 (23.0)	10 (55.6)	
II	2 (1.0)	8 (11.8)	0 (0.0)	5 (27.8)	
Intraoperative complications, *n* (%)					
Epidural venous bleeding	0 (0.0)	0 (0.0)	1 (2.2)	0 (0.0)	0.324
Durotomy	10 (9.8)	1 (2.4)	5 (10.9)	0 (0.0)	0.245
Postoperative complications, *n* (%)					
Wound infection	1 (1.0)	1 (2.4)	0 (0.0)	0 (0.0)	0.678
Osseous infection	1 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.798
Other*	10 (9.8)	2 (4.9)	1 (2.2)	1 (6.2)	0.356
Postoperative mortality (within 3 months of operation), *n* (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	NA
Reop, indication for 2nd op, *n* (%)					
Restenosis (reop: decompression alone)	11 (10.8)	0 (0.0)	0 (0.0)	0 (0.0)	**< 0.001**
Median days until reoperation	94	NA	NA	NA	
Restenosis (reop: decompression + fusion)	8 (7.8)	1 (2.4)	2 (4.3)	0 (0.0)	**0.002**
Median days until reoperation	356	25	202	NA	
Respondylodesis	NA	2 (4.9)	NA	2 (12.5)	NA
Median days until reoperation	NA	33	NA	485.5	

Bold values indicate the level of significance was set to 5%

MC Modic change, *NA* not applicable

*For example, urosepsis, hemorrhage, wound healing deficit

Discussion

The aim of the current study was to identify the extent to which there is a relationship between the presence or absence of preoperative endplate MCs and the clinical outcomes that are observed among DLSS patients who are subjected to decompression surgery alone or decompression with instrumented fusion surgery. The outputs of the research revealed that all four groups of patients (MC/Decompression, MC/Fusion, No MC/Decompression, and No MC/Fusion) manifestly benefited from having undergone surgical management, even at the 36-month follow-up point. Furthermore, regardless of the MCs or type of surgery performed, there was no significant disparity in terms of outcome parameters. In addition, we also developed prognostic models for patient outcomes using group LASSO

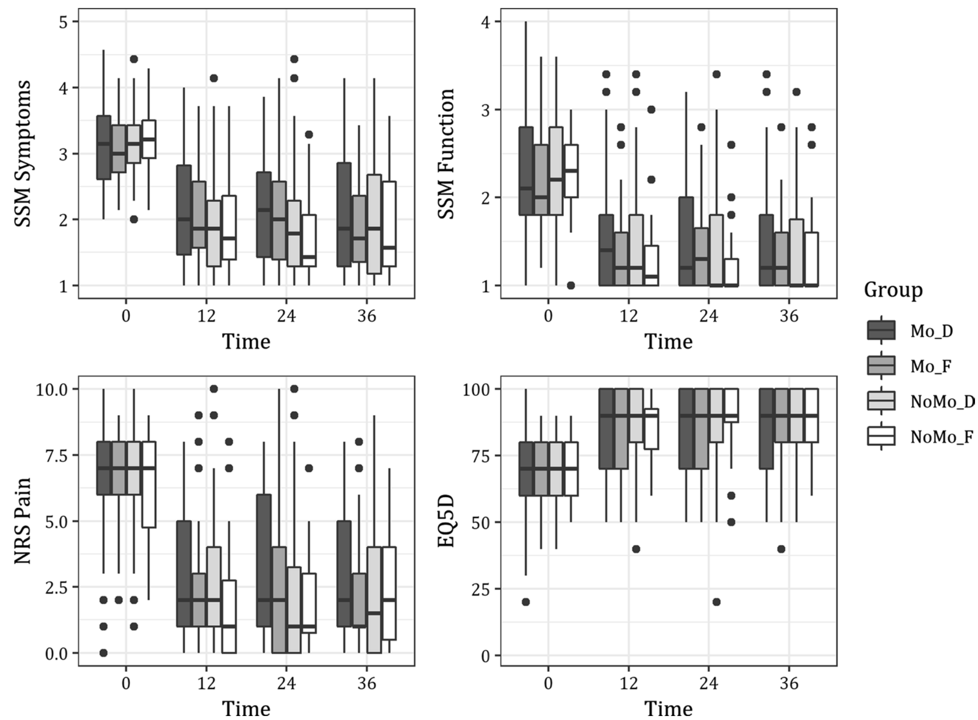

Fig. 2 Boxplots of the outcomes over time. The boxplots show that there is no obvious difference in patients' SSM scores, NRS pain, or quality of life at baseline. At 12 months, most patients have improved in all outcomes. At 24 and 36 months, the boxplots show that most patients have maintained improved conditions

Table 3 Minimal clinically important difference at 36 months

Group	MC with decompression alone	MC with fusion surgery	No MC with decompression alone	No MC with fusion surgery	*P*
n	102	41	46	16	
MCID in NRS pain, *n* (%)	67 (73.6)	28 (80.0)	33 (78.6)	13 (86.7)	0.656
MCID in SSM function score, *n* (%)	65 (71.4)	25 (71.4)	31 (73.8)	11 (73.3)	0.992
MCID in SSM symptoms score, *n* (%)	67 (73.6)	30 (85.7)	29 (69.0)	12 (80.0)	0.355

MC Modic change, *MCID* minimal clinically important difference, *NRS* numeric rating scale, *SSM* spinal stenosis measure

methodology in order to exclude a potential effect due to MCs being obscured or modified by confounding variables. In this regard, the outcomes of the study indicated that MCs did not have a prognostic effect on patient clinical outcomes. Generally, the baseline health covariates (especially CIRS and pain) of the patients were the most important prognostic factors, with the number of decompressed levels and the existence of spondylolisthesis having small effects on the SSM outcome scores.

To our knowledge, this is the first study that investigates a potential association between preoperative MCs and clinical outcomes in DLSS patients undergoing decompression-alone or decompression with instrumented fusion surgery. Our research findings are aligned with previous studies investigating patients with LBP undergoing fusion surgery for various reasons [14–16]. Ghodsi et al. [15] studied a prospective cohort that consisted of 70 patients who reported with a single-level degenerative lumbar instability. They categorized the patients into one of four groups: non-MC, MC1, MC2, and MC3. In contrast, in our study over 60% of the patients who underwent fusion had spondylolisthesis (graded by the Meyerding classification) and we did not include patients with MC3. At the one-year follow-up point, Ghodsi et al. [15] found that there were no differences between the various types of MCs and the outcomes ODI and VAS on LBP, and they subsequently concluded that posterolateral fusion represented an effective treatment method irrespective of the Modic variations. In a different study, Kwon et al. [16] performed a retrospective assessment of the effectiveness of posterior lumbar interbody fusion (PLIF) with threaded fusion cages as a standalone treatment within a population that consisted of 351 patients who reported with degenerative disc disease (DDD) and MC at a mean follow-up time of 60 months. They found that their treatment was effective to reduce LBP in patients who reported with DDD with or without MC1/2. Even though we only included instrumented fusion in our study and did not use standalone cages, our findings were similar to those of

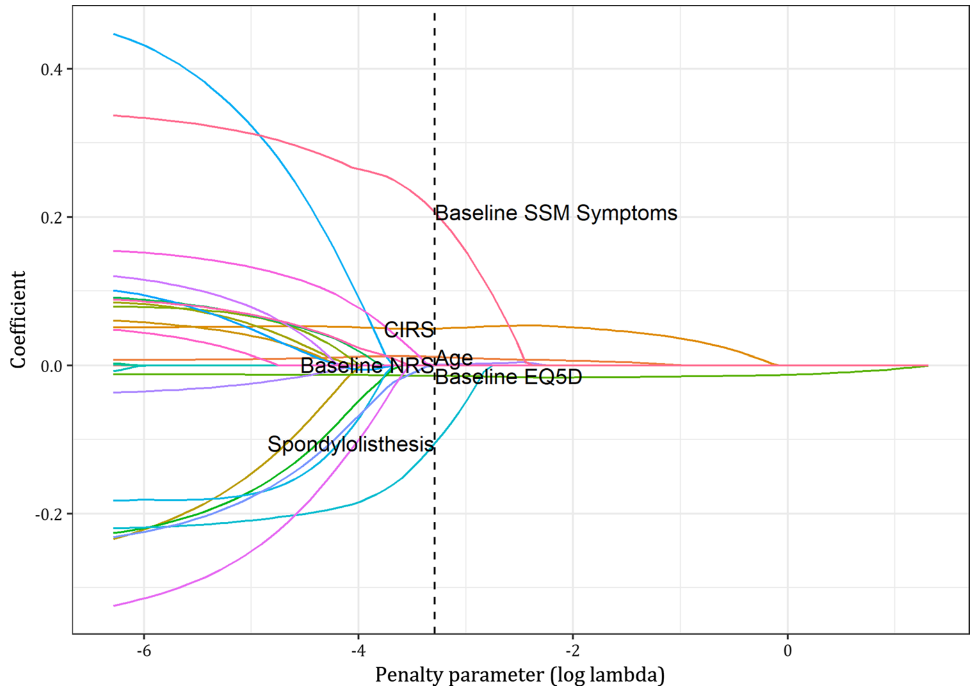

Fig. 3 LASSO trace plot. The trace plot visualizes the result of model selection process for predicting SSM symptoms at 36 months. The best model, chosen by cross-validation, is marked with the vertical dashed line on the trace plot. The chosen model includes the variables labeled, whose paths have not shrunken to the zero line

Table 4 LASSO prediction model results for patient outcomes at 36-month follow-up

Variable	NRS	SSM function score	SSM symptoms score	EQ-5D-3L sum score
(Intercept)	3.120	0.955	1.190	70.200
Age*		0.00563	0.0115	
CIRS*	0.148	0.0275	0.0493	−0.867
NRS pain*	0.103	0.00283	0.000912	
SSM function score*		0.210		
SSM symptoms score*			0.207	
EQ-5D-3L sum score*	−0.035	−0.00806	−0.0141	0.336
Operated levels		−0.020		
Spondylolisthesis		−0.0390	−0.105	

CIRS cumulative illness rating scale, *NRS* numeric rating scale, *SSM* spinal stenosis measure

*At baseline

Kwon et al. [16]. Further, Cao et al. [14] examined simple discectomy and instrumented PLIF caused by lumbar disc herniation (LDH) within a retrospective study that involved 91 patients who had MC type 1 or 2. At the 18-month follow-up point, the results indicated that Japanese Orthopaedic Association Score (JOAS) was significantly higher and VAS for LBP was significantly lower in patients who were treated with instrumented PLIF than in those who underwent simple discectomy.

The focus of this study was on DLSS patients who—compared to LDH patients—are consistently found to exhibit a reduction in low back pain as well as in claudication symptoms. The lack of association between the outcome and MCs could be attributed to the fact that MCs represent just one finding among many others within the progressive series of events; specifically, osteophyte formation, facet joint and ligamentum flavum hypertrophy, and disc degeneration all have a role to play and, in this regard, MCs seem not consistently identified as the primary or sole contributor to pain.

This study is promising for a number of reasons. First, to the best of our knowledge, it represents the largest retrospective analysis of a prospective, multicenter cohort study that examined the possible relationship between preoperative MCs and clinical outcomes in DLSS patients who undergo decompression-alone or fusion surgery. Second, we use modern statistical methods for model selection to find robust estimates of prognostic indicators and to avoid the difficulties caused by p values in this context.

One major limitation of the study is that the LSOS was not originally designed to investigate preoperative MCs with outcome parameters in DLSS patients. Unfortunately, the LSOS did not distinguish between low back pain and buttocks pain separately in the follow-up questionnaires. Furthermore, the working hypothesis was delineated retrospectively and as a post hoc study, no meaningful power analysis could be performed. A further limitation is that the surgeries were performed in different settings by different surgeons; as such, it is not possible to trace the outcomes back to a single facility or surgeon's performance. Consequently, we should not completely exclude the risk of confounding because of facilities or specialists. Further, as documented in Table 2, there was clear difference in factors between the groups which influenced the chosen treatment strategy, namely the number of operated level or the presence or absence of spondylolisthesis. A potential way to overcome such limitations and inhomogeneities would be the performance of a well-designed RCT, which, however, would introduce other challenges.

This retrospective evaluation of a multicenter study corroborates the view that surgery outcome is independent of both preoperative MCs and whether the surgical strategy employed instrumented fusion or decompression alone. There is a requirement for further studies (especially prospective observational patient registries) that place an emphasis on a larger patient population.

Conclusion

The presence or absence of endplate MCs seems not to have any significant influence on clinical outcome parameters in patients with lumbar spinal stenosis undergoing surgical treatment, independent of the chosen surgical strategy. Further, all patients manifestly benefitted from the surgical therapy up to 36-month follow-up.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Affiliations

Nils H. Ulrich[1,5] · Jakob M. Burgstaller[1] · Isaac Gravestock[1] · Sebastian Winklhofer[2] · François Porchet[3] · Giuseppe Pichierri[1] · Maria M. Wertli[1,4] · Johann Steurer[1] · Mazda Farshad[5] on behalf of the LSOS Study Group

✉ Nils H. Ulrich
nils.hb.ulrich@gmail.com

1 Horten Centre for Patient Oriented Research and Knowledge Transfer, University of Zurich, Zurich, Switzerland

2 Institute of Diagnostic and Interventional Radiology, University Hospital Zurich, University of Zurich, Zurich, Switzerland

3 Department of Orthopedics and Neurosurgery, Spine Center, Schulthess Clinic, Zurich, Switzerland

4 Division of General Internal Medicine, Bern University Hospital, Bern University, Bern, Switzerland

5 University Spine Centre Zurich, Balgrist University Hospital, University of Zurich, Zurich, Switzerland