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MRI Assessment of the Multifidus Muscle in Patients Undergoing Microdiscectomy or Physiotherapy: A Retrospective Analysis

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MRI Assessment of the Multifidus Muscle in Patients Undergoing Microdiscectomy or Physiotherapy: A Retrospective Analysis

Abstract

Objective:

A retrospective assessment of changes in the cross-section of the multifidus muscle on MRI in a group of patients surgically treated for lumbar discopathy (microdiscectomy) compared to conservatively treated patients and a control group without symptoms. The study also analyzes pain levels and disability before surgery, 3 months, and 1 year after the procedure. All patients underwent a uniform rehabilitation protocol for one year.

Methods:

The study included 50 patients aged 18-40 years with discopathy at the L4/L5 or L5/S1 levels, confirmed by MRI. Patients were divided into an operated group (31 individuals), a conservatively treated group (10 individuals), and a control group (10 healthy individuals without symptoms of discopathy). MRI evaluation included measurements of the cross-section of the multifidus muscle at the L4-L5 and L5-S1 levels, assessing total cross-sectional area (TCSA), muscle fiber cross-sectional area (MCSA), and fat cross-sectional area (FCSA) within the muscle, as well as calculating the percentage shares of fat and muscle. In the operated group, measurements were taken before surgery, 3 months, and 12 months after the procedure. Participants also completed pain and disability assessments (VAS, ODI).

Results:

In the operated group, a slight but statistically significant increase in MCSA was observed after 12 months (an average increase of 0.6 cm^2), while TCSA did not show significant changes. No significant differences were found between the operated group and the conservatively treated group or the healthy group. FCSA showed ambiguous changes, with fat levels in the muscle not being statistically significantly higher in the postoperative group compared to the other groups. The %FCSA rate significantly decreased after 3 months in the operated group at the L4-L5 level. After 12 months post-surgery, a significant reduction in perceived pain and disability levels was observed ($p<0.001$).

Conclusions:

Microdiscectomy does not cause significant atrophy of the multifidus muscle. Patients treated surgically show improved muscle function, volume, and pain reduction one year after the

procedure, suggesting that appropriate postoperative rehabilitation may support muscle regeneration and improve quality of life.

Introduction

Low back pain (LBP) is one of the most common health problems in the modern world. Approximately 60 - 80% of the human population experience 'sacroiliac' pain during their lifetime. About 2-8% of them suffer from chronic onset leading to long-term or permanent physical disability and reduced quality of life. Yearly, 3-4% of the population is temporarily and more than 1% is permanently incapacitated because of this condition (1,2).

The paraspinal muscles play a crucial role in lumbar spine stabilization, with approximately 80% of stability attributed to the function of the multifidus muscle (MF). It is the most medially located and largest muscle of this section of the spine. By its segmental structure, the MF controls the displacement of the individual lumbar vertebrae and can adapt the individual segments to the loads acting on them and provide stabilization of the L/S region (3). Assessment of the MF dysfunction yields the basis for creating effective rehabilitation programs, which focuse on restoring normal muscle and fascial function and minimising the forces affecting the lumbar region during any physical activity.(4)

Changes in the paravertebral muscles in the course of osteoarthritis have been the subject of many papers. It has been found that LBP is accompanied by asymmetry in the cross-sectional area of the paraspinal muscles and increased fat infiltration (5–8). To date, no studies assessing the condition of the multifidus muscle in a group of patients after microdiscectomy and injection of autologous chondrocytes in place of the damaged disc, in whom rehabilitation began 48 hours after surgery were performed.

The aim of this study is to retrospectively evaluate changes in the multifidus muscle on MRI in a homogeneous group of patients treated surgically for lumbar discopathy, by means of microdiscectomy with autologous chondrocytes, compared to patients with discopathy treated conservatively in relation to an asymptomatic control group. In addition, the aim is to analyze the pain and degree of disability before surgery, 3 months and 1 year after surgery.

Materials and methods

5.1. Patients characteristics

Fifty subjects aged 18 to 40 years, diagnosed with single-level lumbar disc herniation at the L4/L5 or L5/S1 level, were included in the study based on clinical examination and MRI findings. The inclusion criteria were: symptomatic disc herniation confirmed by MRI, qualification for either surgical or conservative treatment, and a body mass index (BMI) below

28. Inclusion criteria for the control group were: patients without symptoms suggestive of discopathy who underwent abdominal MRI.

Exclusion criteria: patient's lack of consent to treatment, previous surgery performed in the lumbar spine, multilevel lesions (discopathy at more than one level), spondylodiscitis, Modic type I and II vertebral body lesions, internal medicine comorbidities. Additional exclusion criteria for the surgery group were: failed cell culture and failed cell administration. A flow chart presenting the detailed patient selection process is shown in Figure 1.

Group I – Patients referred for operation (Surgery)

Group I of patients with symptomatic herniation at the L4-L5 and L5-S1 levels consisted of 31 patients, including 13 women and 18 men (the mean age of women was 34.1 ± 5.0 years, while that of men was 28.9±6.2) qualified for surgical microdiscectomy. The group consisted of patients with unilateral (26 patients) and central or bilateral (5 patients) symptoms. The group could be divided by the level of L4-L5 surgery (7 patients) L5-S1 (24 patients). Statistical analysis supported the inclusion of operated patients with averaged parameters measured on both the symptomatic and asymptomatic sides, as well as those presenting with central or bilateral symptoms.

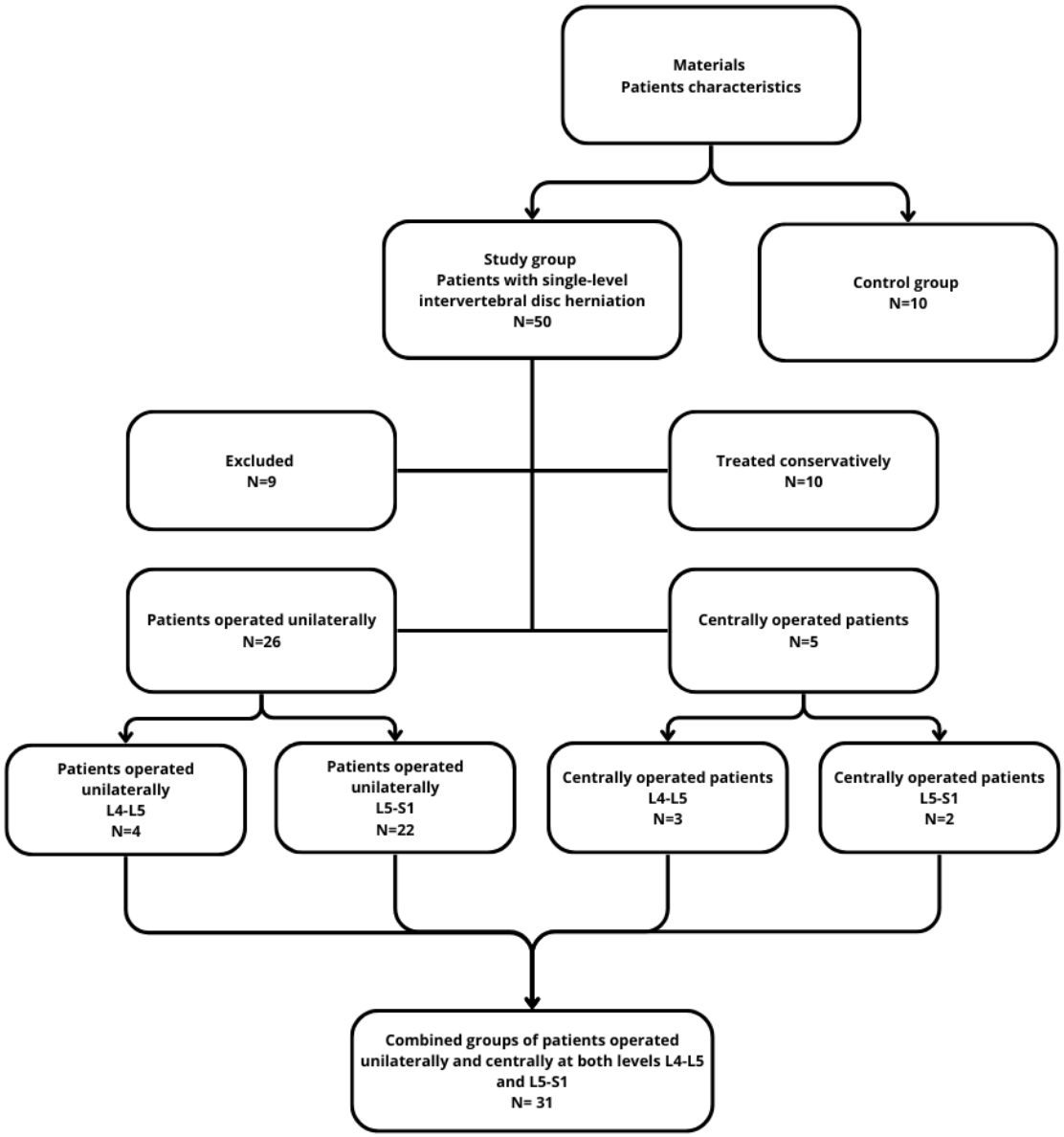
Group II – patients treated only conservatively (Conservative)

Group II comprised patients with a symptomatic L-S hernia at the L4- L5 or L5-S1 level not qualified for surgery, treated conservatively - 10 patients, including five women and five men aged between 30 and 39 years (mean age of women 36.2 ± 3.6 years, men 35.2±3.0),

Control group

The healthy control group comprised 10 asymptomatic subjects, including five women and five men aged between 20 and 35 years ((mean age of women was 30.8 ± 3.8 years, men 24.6±6.0), without lumbar or lower limb pain symptoms, who had no herniated discs in the L/S spine on MR radiological assessment.

Figure 1 – Patient selection process.



Methods

Physiotherapy protocol

Physiotherapy began on the second day after surgery to improve lumbar-pelvic stability and mobility. Initially, patients performed low-intensity exercises to activate deep core muscles with controlled breathing. As recovery progressed, exercises focused on muscle coordination

in functional positions and later on maintaining control during dynamic movements. Prone lying and sciatic nerve mobilization were also introduced early in the recovery. (FIG. 2)

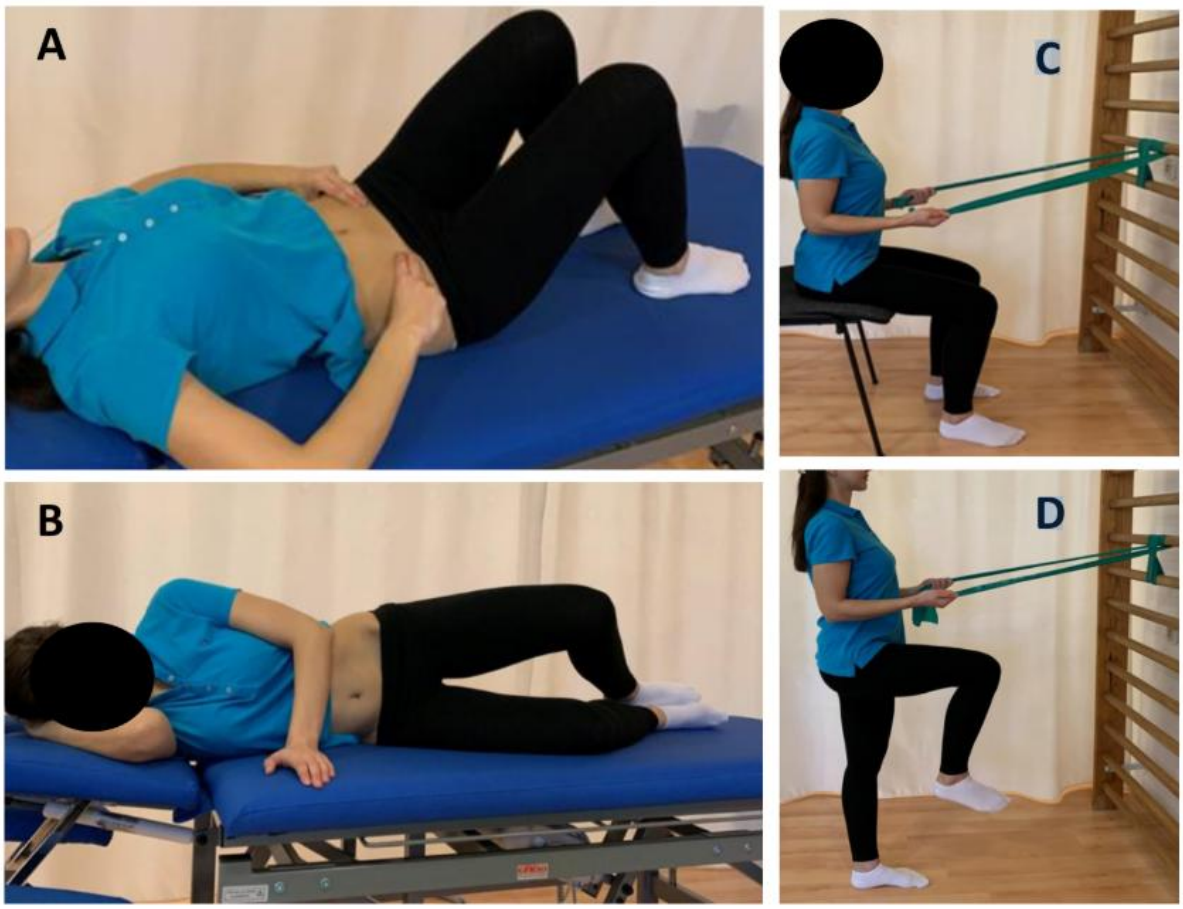


FIG.2 A. The patient activates the deep muscles, independently controlling the tension of the transverse abdominis. **B.** Stage II. While engaging the deep muscles, the patient performs a movement with the lower limb. **C.** The patient, in a seated position, activates the deep muscles and performs movements with the upper limbs. **D.** Stage III. Standing position, activation of deep muscles, the patient performs flexion of the lower limb.

MR protocol and evaluation

MRI scans were performed using a 1.5T system. Imaging included T2-weighted spin echo sequences in the transverse plane at the L4/L5 and L5/S1 disc levels, aligned parallel to the intervertebral discs, as well as sagittal T2-weighted and STIR sequences.

Measurements of the multifidus muscle were taken by a senior radiologist on transverse T2-weighted magnetic resonance images. Cross-sectional area measurements were taken using a dedicated tool on the screen of the workstation, plotting the region of interest (ROI) freehand.

The following measurements were taken at the L4-L5 and L5-S1 levels (at the levels of the upper L5 and S1 border plates):

- TCSA - Total cross sectional area
- MCSA - Muscle cross sectional area
- FCSA - Fat cross sectional area
- %MCSA = [MCSA/(FCSA+MCSA)]x100% - percentage of muscle tissue in ROI
- %FCSA] =[FCSA/(MCSA+FCSA)]x100% - percentage of fatty tissue in ROI

The measurements were taken three times - before the surgery (I), three (II) and twelve months after the surgery (III) in the Surgery group. In Conservative and Control groups the measurement was taken only once at admission.

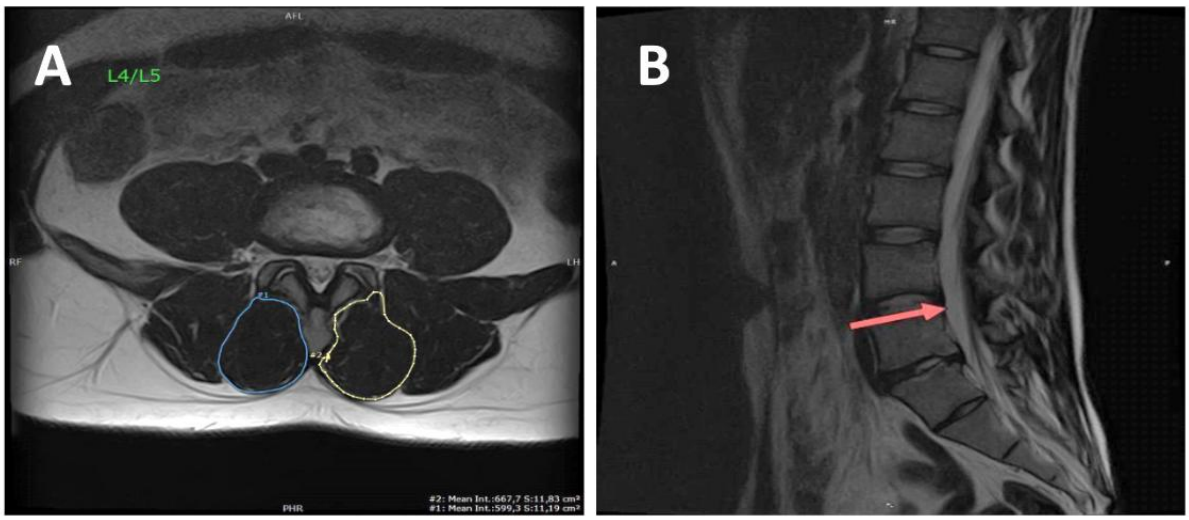


FIG. A. Image of the total cross-sectional area of the multifidus muscle (TCSA) in an asymptomatic individual, MRI, axial plane, T2-weighted sequence. **B**. Level of multifidus muscle assessment at L4-L5 – upper endplate of the L5 vertebra on the sagittal image (red line).

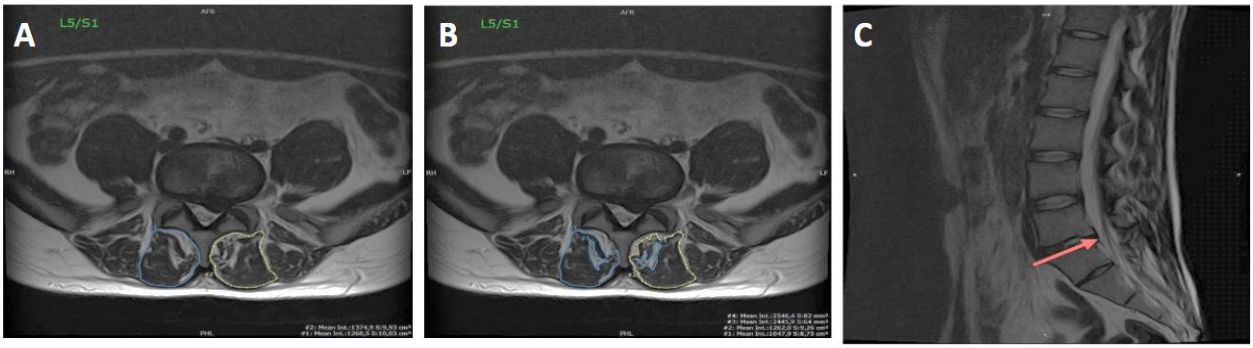


FIG. A. MRI of the multifidus muscle at the L5-S1 level in a patient with low back pain and disc herniation – TCSA of the multifidus muscle marked using ROI bilaterally. **B.** MRI of the multifidus muscle at the L5-S1 level in a patient with spinal pain. Areas of fatty tissue (FCSA) and muscular tissue within the muscle (MCSA) are delineated using ROI. **C.** Level of multifidus muscle assessment at L5-S1 – upper endplate of the S1 vertebra on the sagittal image (red line).

Operative protocol

All patients in the operated group underwent a standard microdiscectomy procedure. In the majority of patients, it was possible to determine the symptomatic side (pain to the buttock, leg on the right or left side, neurological symptoms). Therefore, surgery was performed from the side of symptom onset.

The duration of the surgical procedure was 30-90 minutes (mean approx. 60min), while the duration of the muscle retraction did not exceed 40 minutes. The distance of muscle retraction from the spinous process was approximately 2- 2.5 cm.

Patient reported Outcome Measures (PROMs)

Each patient in the surgery group completed the Oswestry Disability Index (ODI)(9) and Numeric Rating Scale (NRS) (0-10; 0 – no pain, 10 – worst pain imaginable) assessments before surgery (I), three months after surgery (II), and twelve months after surgery (III) to evaluate changes in disability and pain intensity over time.

Statistical analysis and bioethical committee

Due to its retrospective design, the study was exempt from local Bioethics Committee approval (decision attached). The Wilcoxon test was used to compare radiographic muscle measurements between sides and across time points (I, II, III), with Bonferroni correction

applied (adjusted p = 0.016). The Kruskal-Wallis test compared the Surgery, Conservative, and Control groups. The Mann-Whitney test with Bonferroni correction (adjusted p = 0.0167) was used for pairwise group comparisons. Analyses were performed using Statistica v.9 [StatSoft, Inc., 2012].

Results

The multifidus muscle total cross-sectional area (TCSA) measured in examination I, II, III in the group of operated patients changes slightly. The TCSA values in the operated group showed only slight changes across the three time points. The TCSA parameter at the L4-L5 level in the full group of 31 people showed a small increase between the I and II measurement (9.6 vs. 10.1cm2, p <0.009) and an increase between the I and III measurement study (9.6 vs. 10.4cm2, p <0.0006). Patients operated on the L5-S1 level in the combined group showed a small, statistically insignificant increase between the I and II measurement (10.8 vs. 11.4 cm2 and also a small but statistically significant increase between the I and III measurements). – the III study (10.8 vs. 11.5cm2, p <0.01). There was also no statistically significant difference in the TCSA parameter between the operated group and the group treated conservatively and in healthy subjects. The presented differences between the group of operated patients selected according to the level of surgery and the group treated conservatively are visible, but not significant. (FIG 3)

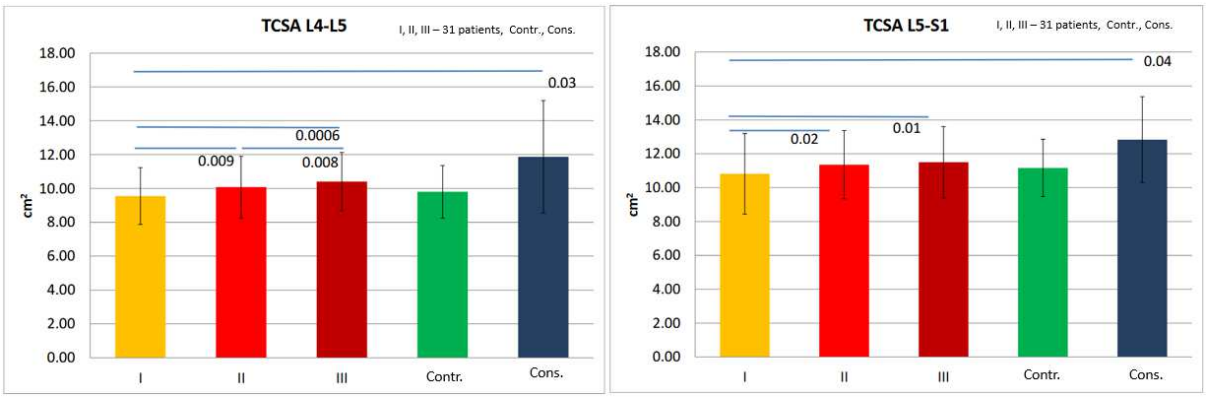


FIG.3 *Measurement of the TCSA parameter in the operated group (before surgery – I, 3 months – II, and 12 months – III), as well as in the healthy group – Healthy and the conservatively treated group – Conservative.*

Left chart: Patients operated on the L4-L5 level.

Right chart: Patients operated on the L5-S1 level.

The surface area of the muscle tissue in the multifidus muscle (MCSA): practically does not increase in the group of full patients in the period before surgery (I) to 3 months after the operation (II). The difference at the L4-L5 levels is insignificant, and at the L5-S1 levels it is too small to meet the Bonferroni criterion. MCSA grows little in the group of full patients in the period of examination before surgery (I) and 12 months after surgery (II). The difference at the L4-L5 and L5-S1 levels is 0.6cm2, $p < 0.004$ and $p < 0.007$, respectively. The conservative group has a higher MCSA value compared to the patients before surgery. Differences in different selections of the operated group and in different ones levels are relatively high in absolute terms (max. 3 cm2), however, statistically significant ($p < 0.01$) are only at the L5-S1 level in the full group of patients operated on.

Smaller differences in MCSA values occurred between the Surgery group in examination I and healthy patients, only at the L5-S1 level (in the complete operation group) this difference was statistically significant ($p < 0.004$). (Fig. 4)

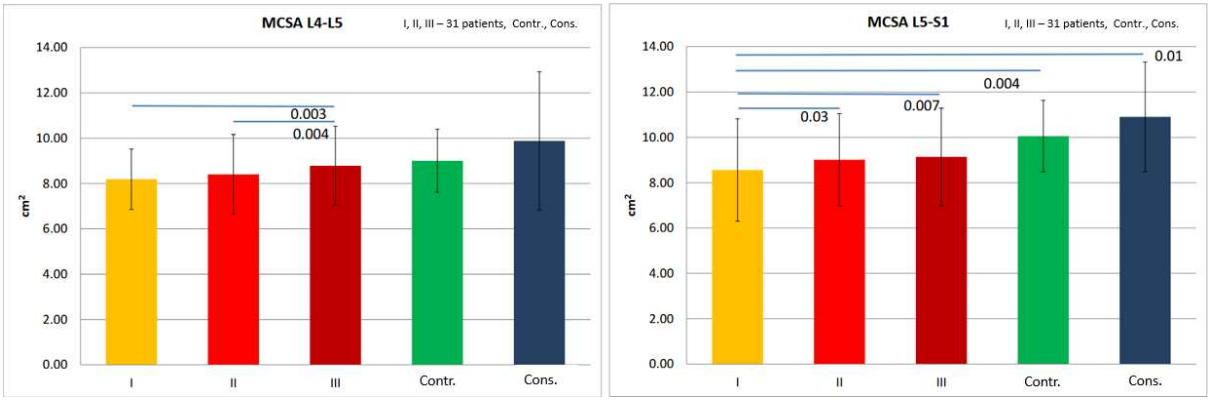


FIG.4 *Measurement of the MCSA parameter in the operated group (before surgery – I, 3 months – II, and 12 months – III), as well as in the healthy group – Healthy and the conservatively treated group – Conservative.*
Left chart: Patients operated on the L4-L5 level.
Right chart: Patients operated on the L5-S1 level.

FCSA shows ambiguous changes in examinations I, II and III depending on the method of selecting the Surgery group. The difference between the first and second examination is statistically significant ($p < 0.002$ for 31 people). The difference of examination I and III was insignificant due to the Bonferroni correction. It should be noted, that the FCSA in the third examination is not higher than in the I and II examinations, and at the level of L4-L5 is slightly

lower, though statistically insignificant. In healthy subjects, the content of adipose tissue in multisection muscle was lower compared to the operated group and patients with discopathy treated conservatively, however both insignificant statistically. (Fig.5)

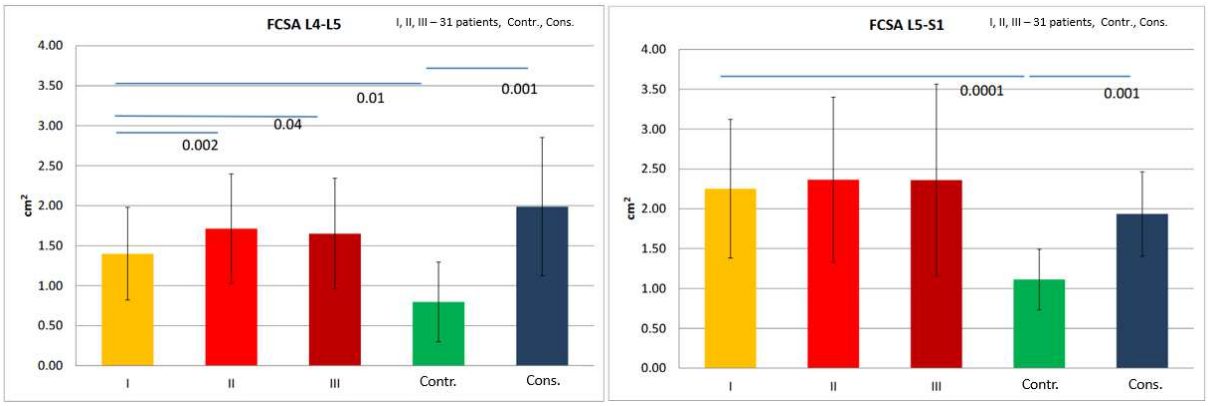


FIG. 5 *Measurement of the FCSA parameter in the operated group (before surgery – I, 3 months – II, and 12 months – III), as well as in the healthy group – Healthy and the conservatively treated group – Conservative.*
Left chart: Patients operated on the L4-L5 level.
Right chart: Patients operated on the L5-S1 level.

The %FCSA on Patients operated on level L4-L5 in the combined group is lower in the I assessment than in II with statistical significance $p<0.007$. No difference was observed in %FCSA in patients operated at L5-S1 level between I, II, and III examinations.

In comparison to the Healthy group, the L4-L5 patients have statistically significant higher %FCSA ($p=0.005$). This finding also applies to the patients operated on L5-S1 level ($p<0.00002$). In both the Conservative and Surgery group do not differ in terms of %FCSA (Fig.6). Full information regarding the analysis is available in Table 1.

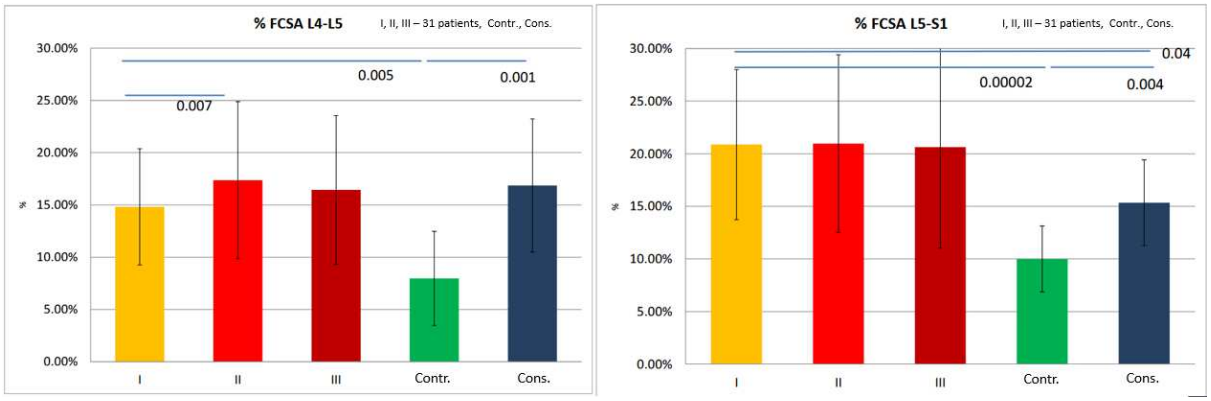


FIG. 6 *Measurement of the %FCSA parameter in the operated group (before surgery – I, 3 months – II, and 12 months – III), as well as in the healthy group – Healthy and the*

conservatively treated group – Conservative.

Left chart: Patients operated on the L4-L5 level.

Right chart: Patients operated on the L5-S1 level.

Table 1. Detailed analysis information.

Segment	Parameter	Study I	Study II	Study III	Timepoint Comparison	P (Anova KW)	Surgery I study (n=31)	Healthy (n=10)	Conservative (n=10)	Sur-Healthy	Sur-conservative	Healthy-Conservative
L4–L5	TCSA	9.6 ± 2.5	10.1 ± 2.3	10.4 ± 2.3	I-II 0.009 I-III 0.0006 II-III 0.008	n.s.	9.6 ± 2.5	9.8 ± 1.5	11.9 ± 3.4	n.s.	0.03	n.s.
	MCSA	8.2 ± 2.4	8.4 ± 2.3	8.8 ± 2.5	I-II n.s. I-III 0.003 II-III 0.004	n.s.	8.2 ± 2.4	9.0 ± 1.4	9.9 ± 3.1	n.s.	n.s.	n.s.
	FCSA	1.4 ± 0.8	1.7 ± 0.9	1.7 ± 0.9	I-II 0.002 I-III 0.04 II-III n.s.	0.002	1.4 ± 0.8	0.8 ± 0.4	2.0 ± 0.8	0.01	n.s.	0.001
	%MCSA	85.2% ± 7.2%	82.6% ± 8.7%	83.5% ± 8.4%	I-II 0.007 I-III n.s. II-III n.s.	0.004	85.2% ± 7.2%	92.0% ± 1.5%	83.1% ± 5.9%	0.005	n.s.	0.001
	%FCSA	14.8% ± 7.2%	17.4% ± 8.7%	16.4% ± 8.5%	I-II 0.007 I-III n.s. II-III n.s.	0.004	14.8% ± 7.2%	8.0% ± 3.7%	16.9% ± 5.9%	0.005	n.s.	0.001
L5–S1	TCSA	10.8 ± 2.4	11.4 ± 1.9	11.5 ± 2.0	I-II 0.02 I-III 0.01 II-III n.s.	n.s.	10.8 ± 2.4	11.2 ± 1.7	12.8 ± 2.5	n.s.	0.04	n.s.
	MCSA	8.6 ± 2.2	9.0 ± 1.9	9.1 ± 2.0	I-II 0.03 I-III 0.007 II-III n.s.	0.01	8.6 ± 2.2	10.2 ± 1.5	10.9 ± 2.4	0.004	0.01	n.s.
	FCSA	2.3 ± 0.9	2.4 ± 0.9	2.4 ± 1.1	I-II n.s. I-III n.s. II-III n.s.	0.0003	2.3 ± 0.9	1.0 ± 0.2	1.9 ± 0.5	0.0001	n.s.	0.001
	%MCSA	79.1% ± 7.2%	79.0% ± 7.1%	79.6% ± 8.8%	I-II n.s. I-III n.s. II-III n.s.	0.0000	79.1% ± 7.7%	90.0% ± 1.9%	84.7% ± 3.6%	0.00002	0.04	0.004
	%FCSA	20.9% ± 7.2%	21.0% ± 7.1%	20.6% ± 8.8%	I-II n.s. I-III n.s. II-III n.s.	0.0000	20.9% ± 7.7%	10.0% ± 1.9%	15.3% ± 3.6%	0.00002	0.04	0.004

In the studied group of patients with lumbar discopathy, a significant reduction in pain and disability was found after 12-month follow-up in the surgery group (VAS I:8,4±1,7 III: 0,45±1,18, $p<0.001$; ODI I:0,71±0,17 III:0,04±0,008, $p<0.001$). (Tab. 2)

Table 2 Assessment of pain and disability in surgical patients (at specific time points after surgery) according to VAS scale and ODI questionnaire.

Evaluation in operated patients	**I**	**II**	**III**	**Comparison of measurements at different time points**

NRS (N=31)	8,4±1,7	0,67±0,91	0,45±1,18	I –II 0,000001 I – III 0,00001 II – III 0,00002
ODI (N=31)	0,71±0,17	0,12±0,9	0,04±0,008	I –II 0,000001 I – III 0,00001 II – III n.s.

Discussion

The study aimed to evaluate changes in the multifidus muscle morphology in patients with lumbar discopathy undergoing surgical or conservative treatment, and in healthy controls, with measurements taken at L4–L5 and L5–S1 spinal levels.

In the present study, a slight increase of 0,6 cm2 in MCSA was observed in patients who underwent surgery. Despite, there was no statistically significant increase in the TCSA. These findings may indicate a change in the composition of the MF in favor of the muscle tissue because, while there was an increase in the area of the muscle tissue, no increase in % body fat was observed in study III compared to study I. No increase in TCSA was observed because this is primarily due to the course of the discopathy in which there is atrophy of muscle tissue and an increase in lumbar fat infiltrating muscle tissue (5,10). Moreover, this could be affected by surgery itself, as the intervention may exacerbate the muscular tissue atrophy.(11,12) Additionally some studies have shown that injury to the multifidus muscle increases with the length of time it is pulled back during surgery(13).

This study is contrary to prior findings that microdiscectomy lead to fatty infiltration of paraspinal muscles one year postoperatively. Minimally invasive surgery (MIS) resulted in minimal multifidus atrophy at the index level, with greater fatty infiltration observed caudally. Importantly, greater muscle degeneration correlated with increased postoperative lumbar pain, emphasizing the value of muscle-sparing techniques in improving clinical outcomes (14,15).

Those disparities can be a result of early and aggressive postoperative rehabilitation protocol or stem from reinnervation of the MF muscle after surgery.

Evaluation of the rehabilitation results after surgical treatment of discopathy has been the subject of many publications. The main goal of the rehabilitation exercises was to stabilize the lumbo-pelvic complex, restore simultaneous contraction of the deep muscles, and improve mobility of the lower extremities and trunk. Stabilization exercises have proven efficacy in such clinical scenarios (16,17) and additional reduction in MM atrophy (18).

Speaking of limitations, as this is a pilot study - the small sample size, particularly in the conservative and control groups, limits the generalizability and statistical power of the findings. The inclusion of patients operated at both the L4–L5 and L5–S1 levels within the same surgical group may have introduced a confounding variable, potentially obscuring level-specific effects on multifidus muscle morphology and limiting the precision of the analysis. Moreover, the morphological parameters were assessed by one radiologist what may cause the potential observer bias to the study. Additionally, future studies should assess the MM fatty infiltration in longer follow-up post operatively with functional assessment.

Conclusion

In patients undergoing lumbar microdiscectomy for discopathy, no significant changes were found in the total cross-sectional area (TCSA) of the multifidus muscle at 3 and 12 months post-surgery. However, a slight but statistically significant increase in muscle tissue area (MCSA) was observed at 12 months. Additionally, a significant reduction in pain was noted 12 months after surgery and rehabilitation. These findings imply that microdiscectomy does not provoke multifidus (MF) atrophy and significantly reduces pain after 12 months of follow-up. Moreover, rehabilitation in addition to surgery contributes to an increase in muscle tissue in the MF.

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