

Otrzymano: 2007.06.29  
Zaakceptowano: 2007.04.20

## Analysis of CT and MRI investigations of patients with lumbar discopathy treated conservatively or surgically

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### Summary

**Background:**

Imaging investigations (radiculography, X-ray, CT, MRI) constitute an integral part of the therapeutic process in the treatment of patients suffering from lumbar discopathy. The results obtained with the imaging techniques provide the crucial data concerning the stage of disease development; assist the choice of optimal therapy method and the evaluation of the therapeutic actions efficiency.

The aim of the study was to analyze the results of CT and MRI investigations carried out on patients suffering from lumbar discopathy, who had been treated with conservative or surgical methods.

**Material/Methods:**

665 patients aged between 16 and 76 years with discopathy at L4-L5, L5-S1 levels were enrolled to the study. In the analyzed group, 348 patients received only conservative therapy whereas 317 patients underwent surgical procedures. CT and MRI investigations were applied at the beginning of the observation (W), after three years (III) and after ten years (X) since the operation (or exclusively conservative treatment). The results obtained with imaging techniques were divided into three categories: intradiscal, peridiscal and disc-related changes caused by herniation of vertebral discs.

**Results:**

During the subsequent periods of inspection, the rising number of degenerative changes was found. The progression of the imaging technique results concerned both the L4-L5, L5-S1 spaces, which showed distortion initially, and the L3-L4, L2-L3 levels, which were not degenerated in the preliminary examination. The remote examination showed that the number of degenerations in the two examined groups was substantially higher than it had been during the preliminary examination. The total number of degenerative changes among the patients operated on was higher than among the patients in conservative treatment.

**Conclusions:**

The number of degenerative changes of the spine grows from level L2-L3 to level L5-S1. The stage of spinal degenerative changes rises along with the duration of the disease. The patients operated on show more degenerative changes than those in conservative treatment.

**Key words:**

lumbar discopathy • CT • MRI of spine • lumbar discopathy treatment

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### Background

Most spinal pathologies are associated with loss of the physiological function of the intervertebral discs, due to chronic overload, traumas, or congenital vertebral abnor-

malities. Such conditions result in hypotonia of the spinal ligaments, leading to destabilization of intervertebral spaces and displacement of the elements of intervertebral joints. Weakened posterior portion of the annulus fibrosus is susceptible to damage and ruptures allowing

displacement of degenerated intervertebral disc fragments. Nucleus pulposus prolapse involves bulging of these fragments at the sites of longitudinal ligament defects.

The process of intervertebral disc degeneration progresses through three phases: nucleus pulposus degeneration, nucleus pulposus displacement and intervertebral disc fibrosis. Disc herniation may take the following forms: disc protrusion into the canal (protrusio – 23%), disc prolapse involving partial displacement into the canal (prolapsus – 61,5%) or disc sequestration (sequestratio – 15,5%) [1].

The underlying condition for discopathy is physiological aging, involving remodeling of the nucleus pulposus towards a structure similar to that of the anulus fibrosus, and concentric cracking of the individual lamina of the anulus fibrosus. The aforementioned symptoms are observed as early as at 10 years of age [2]. Intervertebral disc degeneration is best visualized by MRI, with the most common findings including: reduction of space between the vertebral bodies, erosion of the adjacent structures, narrowing of the spinal canal and cracking of the anulus fibrosus. Pain intensity correlates better with the extent of anulus fibrosus damage than with the severity of disc degeneration [3].

Kirkaldy-Willis divided the disc degeneration process into three periods. During the first one, painful reaction is associated predominantly with acute pain due to the trauma. The second period is characterized by disturbance of segmental stability. In the third one, the painful symptoms subside because of improvement of segmental stability as a result of natural repair processes and depletion of intradiscal protein inflammatory factors (phospholipase A, prostaglandins, nitric oxide and other proinflammatory substances, not identified to date) [4, 5, 6, 7].

In discopathy, imaging studies provide the most reliable data concerning the stage of the disease, often determining the choice of management methods, and are also used as a primary criterion in assessment of efficacy of the therapeutic measures.

The aim of the study was to analyze the results of CT and MRI of patients with lumbar discopathy treated surgically or conservatively.

## Materials and methods

The study included 665 patients (301 females and 364 males) aged 16-76 years with discopathy at the L4-L5, L5-S1 levels, treated in the 10<sup>th</sup> Clinical Army Hospital in Bydgoszcz in the period from 1985 to 2004. The patients were in similar clinical condition, with history of the pathology no longer than 6 months. In the analyzed group, 348 patients (160 women and 188 men) received only conservative treatment, whereas, 317 (141 women and 176 men) were operated on. Imaging investigations (CT, MR) were performed at the beginning of the observation (W) three years (III) and 10 years (X) after the surgery (or conservative treatment). The initial moment of the observation was the period of the first hospitalization in the Clinic, during which the diagnosis was established. The assessment done at that time was recorded as the baseline examina-

tion. The results of imaging were classified as belonging to three categories of abnormalities: intradiscal (affecting the intervertebral disc itself), peridiscal (affecting the spinal segment at the level of discopathy) and disc-related (affecting the structures of the vertebral canal).

The correlations of these categories of imaging results with the selected indexes of the patients' clinical condition were analyzed: pain, assessment of Lasague sign, physical fitness, quality of life. Assessment of radicular symptoms was carried out according to the criteria of Japanese Orthopedic Association Low Back Pain Score [8]. Quality of life was assessed on the basis of Oswestry Low Back Pain Disability Questionnaire [9]. Intensity of painful symptoms and physical fitness scores were based on Low Back Pain Rating Scale [10].

Comparative analysis concerning different periods of the study utilized an improvement/progression index, calculated according to the following formula:

$$\frac{\text{current examination result} - \text{baseline examination result}}{\text{maximum value} - \text{baseline examination result}} \times 100\%$$

The following statistical methods were used in the study: Kruskal-Wallis test and Friedman test, Mann-Whitney U test, Spearman's and Kendall's rank coefficients (assessment of strength of the correlation between the analyzed variables expressed as a correlation coefficient – r). Using the aforementioned non-parametric tests, the borderline value of significance level was adopted at p=0.01. Below that value, the result was considered to be statistically significant.

## Results

The most common spinal degenerative changes seen in CT affected the L4-L5 and L5-S1 segments, both in the groups treated conservatively and surgically, and both in the baseline examination and distant follow-up.

The incidence of most of the reported abnormalities was observed to increase with the duration of the disease. The progression of vacuum sign in distant follow-up in the groups treated conservatively and surgically was: L5-S1 – 16% and 16%, L4-L5 – 16% and 17%, L3-L4 – 9% and 16%, L2-L3 – 5% and 10%, respectively. Increase in the development of vertebral body margin osteophytes in 10-year observation in the groups treated conservatively and surgically was as follows: L5-S1 – 9% and 12%, L4-L5 – 16% and 18%, L3-L4 – 22% and 35%, L2-L3 – 14% and 18%. Narrowing of the intervertebral spaces in both groups was observed with similar frequency. Signs of decreased stability of the mobile segments were more frequent in the patients after surgical treatment. In distant follow-up, vertebral body subluxation was seen in 20% of scans at L5-S1 level and in 13% at L4-L5 level. In the group after conservative treatment, vertebral body subluxation was also most common in the L5-S1 (6%) and L4-L5 (6%) segments. Reduced fluid reserve at the baseline was more frequently observed in the patients qualified for surgery – in 23% of scans at L5-S1 level and in 13% at L4-L5. In the group qualified for conservative treatment, fluid reserve

**Table 1.** Incidence of particular degenerative changes in CT investigation in patients treated conservatively or surgically (n – the number of investigations).

LESION CATEGORY	STUDY PHASE					
	Preliminary		After 3 years		After 10 years	
	Treatment method		Treatment method		Treatment method	
	Surg. n=156	Conserv. n=186	Surg. n=104	Conserv. n=108	Surg. n=106	Conserv. n=111
Vacuum sign						
L2/L3			2	2	11	6
L3/L4			9	3	17	11
L4/L5	39	30	30	29	45	36
L5/S1	45	41	31	30	48	42
Marginal osteophytes of the vertebral bodies						
L2/L3			11	8	19	16
L3/L4			17	9	37	24
L4/L5	46	44	45	38	50	45
L5/S1	64	69	52	45	57	51
Narrowing of the intervertebral spaces						
L2/L3			5	5	12	11
L3/L4			11	5	19	14
L4/L5	71	81	60	61	61	62
L5/S1	84	98	61	62	63	65
Subluxation of the vertebral bodies						
L2/L3						
L3/L4			3	1	4	3
L4/L5			11	3	14	6
L5/S1			14	4	21	7
Fluid reserve decrease						
L2/L3					6	2
L3/L4	21	16	2	6	17	13
L4/L5	36	18	12	19	15	21
L5/S1			17	22	19	28

reduction occurred with similar frequencies at L5-S1 and L4-L5 levels (9% in both cases). In distant follow-up, the incidence of dural sac compression and fluid reserve decrease at L5-S1 and L4-L5 levels was reduced (ca. 5%) in the surgical treatment arm, whereas in the conservative treatment arm an increase was noted (ca. 25%).

In MR, like in CT, degenerative changes were detected most frequently in the L4-L5 and L5-S1 in both the studied groups. Their incidence was observed to increase with the duration of the disease. Intervertebral disc signal attenuation correlated with the incidence of intervertebral space reduction ( $p < 0.01$ ) at all the analyzed time points. The presence of scars and adhesions within the spinal canal was observed in 37% of patients 3 years after the surgery. The changes were present at the L5-S1 level in 26% of patients, and at the L4-L5 in 24%.

In distant follow-up after 10 years of treatment, the incidence of scar-like lesions did not change significantly. The incidence of marginal osteophytes of the vertebral bodies increased more significantly in the surgical treatment group than in the conservative treatment arm, and more significantly at the L2-L3 and L3-L4 than at the L4-L5 and L5-S1 levels. The increase in the number of osteophytes

was 23.3%, in the surgical treatment group and 15.5% in the conservative treatment group. The occurrence of osteophytes at the L2-L3 and L3-L4 levels increased by 22.6%, and at the L4-L5 and L5-S1 by 15.8%. Instability signs were two-fold more frequent after surgical treatment (19% after 3 years, 32% after 10 years) than after conservative treatment (10% after 3 years, 14% after 10 years).

In baseline examinations, protrusion type discopathies were diagnosed in 35.7% of patients qualified for conservative treatment (13.9% at L4-L5 and 21.8% at L5-S1 level) and in 20.6% of those qualified for surgery (9.6% at L4-L5 and 11.0% at L5-S1 level). Intervertebral disc herniation was observed in 54.3% of the conservative treatment arm (24.4% at L4-L5 and 29.9% at L5-S1 level) and in 63.0% of the surgical treatment arm (28.9% at L4-L5 and 34.1% at L5-S1). Displacement of a fragment of the nucleus pulposus to the spinal canal was diagnosed in 8.9% of patients receiving conservative treatment (3.8% at L4-L5 and 5.1% at L5-S1) and in 15.4% of patients qualified for surgery (7.2% at L4-L5 and 9.2% at L5-S1).

In investigations performed 3 years after the surgery, herniation and prolapse type discopathy at the L4-L5 and L5-S1 levels was reduced (by 43.5% and 3.1%, respectively),

**Table 2.** Incidence of particular degenerative changes in MRI investigation in patients treated conservatively or surgically (n - the number of investigations).

LESION CATEGORY	STUDY PHASE					
	Preliminary		After 3 years		After 10 years	
	Treatment method		Treatment method		Treatment method	
	Surg. n=123	Conserv. n=117	Surg. n=105	Conserv. n=96	Surg. n=107	Conserv. n=99
Intervertebral disc signal hypointensity						
L2/L3			4	2	13	7
L3/L4			11	4	19	11
L4/L5	52	48	51	41	59	54
L5/S1	57	56	57	52	62	57
Scars and adhesions in the spinal canal						
L2/L3						
L3/L4					4	
L4/L5			25		27	
L5/S1			27		31	
Thickening of the posterior longitudinal or arcuate ligament						
L2/L3			5		6	4
L3/L4			13	9	15	8
L4/L5	14	9	21	16	21	15
L5/S1	17	11	27	18	29	19
Marginal osteophytes of the vertebral bodies						
L2/L3			10	8	21	15
L3/L4			17	9	35	23
L4/L5	41	32	56	37	59	40
L5/S1	48	38	59	43	62	42
Narrowing of the intervertebral spaces						
L2/L3			7	5	14	9
L3/L4			11	7	19	14
L4/L5	58	51	63	45	65	61
L5/S1	68	61	62	51	66	62
Subluxation of the vertebral bodies						
L2/L3						
L3/L4			1		6	1
L4/L5			8	4	12	5
L5/S1			13	6	17	8
Fluid reserve decrease						
L2/L3					8	11
L3/L4	26	14	9	4	19	12
L4/L5	33	21	14	24	23	25
L5/S1			22	27	24	29

whereas the number of protrusion-type discopathies increased (by 17.2%). Assessment of the L4-L5 and L5-S1 intervertebral spaces in the conservative treatment group demonstrated increased incidence of protrusions by 8.5%, sequesters number increase by 5.2% and reduction of the number of herniations by 3.3%. Intervertebral disc damage at the L2-L3 and L3-L4 levels was more frequently observed in patients after the surgery: the incidence of protrusion was increased by 11.7%, herniation by 4.2% and sequestration was two-fold more frequent.

In distant follow-up (after 10 years), signs of intervertebral disc damage at the L4-L5 and L5-S1 levels were more frequent in the conservative treatment group. The differences

in incidence of the observed discopathy types were as follows: protrusion – 15.2%, herniation – 18.1%, prolapse – 5.0%. signs of intervertebral disc damage in the L2-L3 and L3-L4 segments were more frequent in patients after surgery. The differences in incidence of the observed discopathy types were as follows: protrusion – 8.3%, herniation – 9.0%, prolapse – 1.4%.

In distant follow-up, the number of degenerative changes observed in both treatment groups was significantly higher than in the baseline examination ( $p < 0.01$ ). The total number of degenerative changes in the patients after surgery was higher than in the conservative treatment group ( $p < 0.05$ ).

**Table 3.** Types of intervertebral disc injury in CT and MRI investigations (n - the number of investigations)

LESION TYPE	STUDY PHASE					
	Preliminary		After 3 years		After 10 years	
	Treatment method		Treatment method		Treatment method	
	Surg. n=279)	conserv. n=303)	Surg. n=209)	Conserv. n=204	Surg. n=213	Conserv. n=210
<b>Protrusion</b>						
L2/L3			5	4	12	9
L3/L4			28	4	27	13
L4/L5	21	59	34	51	39	57
L5/S1	35	67	44	49	41	53
<b>Herniation</b>						
L2/L3			7	6	14	8
L3/L4			14	6	16	9
L4/L5	98	93	33	51	34	50
L5/S1	114	105	32	56	37	58
<b>Prolapse</b>						
L2/L3					2	1
L3/L4			4	2	8	6
L4/L5	19	11	9	12	14	17
L5/S1	23	13	15	15	19	22

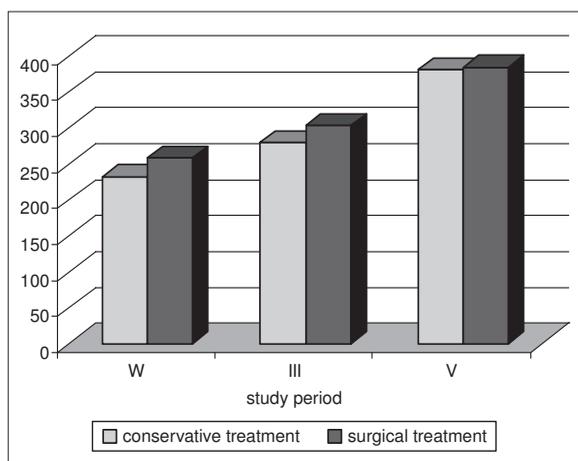
The most commonly observed intradiscal abnormalities included: disc signal attenuation (dehydration of the intervertebral discs), deformation and penetration of the nucleus pulposus, intradiscal gas presence (on CT). The most common peridiscal abnormalities included: reduced intervertebral space, osteophytosis, peripheral sclerotization of the intervertebral bodies, thickening of the posterior longitudinal ligament, thickening of the arcuate ligament, vertebral body subluxation. Disc-related abnormalities, associated with penetration of the spinal canal as a result of disc herniation, involved most frequently modeling of the dural sac surface and reduction of fluid reserve.

On baseline assessment, disc-related and peridiscal changes at L4-L5 and L5-S1 levels were more frequent in the group

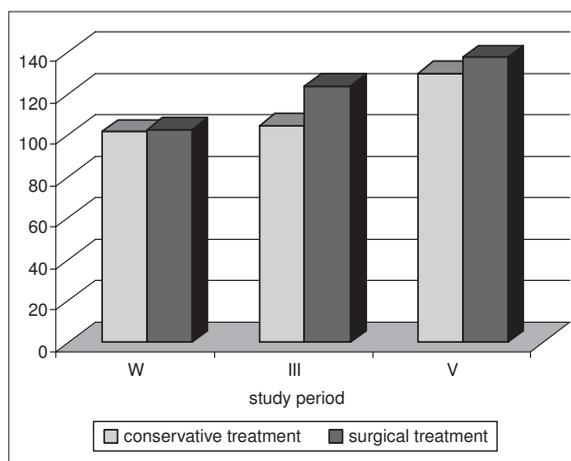
qualified for surgery. The number of disc-related abnormalities was significantly reduced after surgical treatment. At the intermediate and distant observation time points, the number of disc-related and peridiscal changes was higher in the conservative treatment group ( $p < 0.01$ ).

The incidence of peridiscal changes correlated with the assessment of pain intensity ( $r = 0.563$ ), motor activity impairment ( $r = 0.611$ ) and quality of life ( $r = 0.594$ ). The incidence of disc-related changes correlated with the assessment of Lasegue sign ( $r = 0.551$ ).

In the L2-L3 and L3-L4 segments, the number of disc-related and peridiscal degenerative changes was significantly higher in the surgical treatment group than in the conservative treatment group ( $p < 0.01$ ).



**Figure 1.** The incidence of degenerative changes of lumbar spine in the treatment period: preliminary (W), III and V.



**Figure 2.** The incidence of peridiscal changes in lumbar spine in the treatment period: preliminary (W), III and V.

**Table 4.** Types of degenerative changes in the CT and MRI investigations of patients treated conservatively or surgically (incidence rates in %)

LESION CATEGORY	STUDY PHASE					
	Preliminary		After 3 years		After 10 years	
	Treatment method		Treatment method		Treatment method	
	Surg.	Conserv.	Surg.	Conserv.	Surg.	Conserv.
<b>Intradiscal:</b>						
L5-S1	53	52	56	55	61	58
L4-L5	44	42	53	44	64	61
L3-L4			11	4	19	12
L2-L3			3	2	13	7
<b>Peridiscal:</b>						
L5-S1	55	57	59	58	66	61
L4-L5	48	45	65	47	72	69
L3-L4			17	9	39	24
L2-L3			11	8	27	15
<b>Disc-related</b>						
L5-S1	55	52	22	50	28	54
L4-L5	45	35	26	34	33	36
L3-L4			15	6	26	17
L2-L3			9	4	15	11

**Discussion**

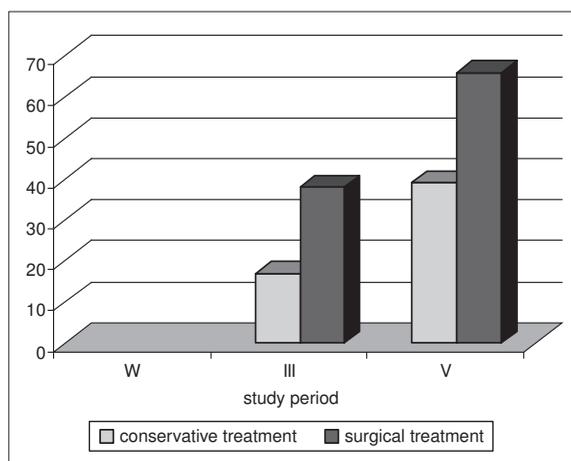
Longer duration of the disease was associated with an increasing number of degenerative changes observed in the lumbar segments of the vertebral column. The progression was seen both in the L4-L5, L5-S1 spaces, found to be involved in the baseline examination, and the L3-L4, L2-L3 levels, unaffected at the baseline. In distant follow-up, the number of degenerative changes was significantly higher than at the baseline. Additionally, the total number of degenerative changes was higher in the surgical treatment group than in the conservative treatment group. Lower spinal segments were found to be more susceptible to degenerative changes. The number of discopathy-related abnormalities increased from the L2-L3 to the L5-S1 level. At the L4-L5 and L5-S1, the signs of disc damage were predominant over the presence of osteophytes, whereas in the L2-L3 and L3-L4 segments, the presence of osteophytes was observed more frequently. The increase in incidence of osteophytes was significantly higher in the group treated surgically than in patients receiving conservative treatment, and higher at the L2-L3, L3-L4 than at the L4-L5, L5-S1 levels. Instability signs were twice more frequent in the group of patients after surgery.

At the baseline, protrusion type discopathy was more often observed in patients qualified for conservative treatment than in those qualified for surgery, whereas herniation and prolapse type discopathy was more common among surgically treated patients. Three years later, the number of herniation and prolapse type abnormalities in L4-L5 and L5-S1 intervertebral spaces was found to be reduced in the group which had undergone surgical treatment, and increased in the conservative treatment group. After 10 years, the signs of disc damage at the L4-L5 and L5-S1 were more frequently observed in conservatively treated patients. Signs

of intervertebral disc damage at the L2-L3 and L3-L4 levels were observed in both groups, but they were significantly more frequent in the patients after surgical treatment. The number of discopathies at all levels was increasing with the duration of the disease, more significantly with respect to protrusion and prolapse, than with respect to herniation.

The increase of changes developing at the levels proximal to the site of surgical correction has been confirmed by numerous authors [7, 11, 12, 13, 14, 15, 16]. On the other hand, the results demonstrating no effect of surgical treatment on progression or further course of spinal degenerative changes have been reported [17, 18].

Analysis of the investigated structures may indicate a correlation between the level of discopathy and the patient's



**Figure 3.** The incidence of peridiscal changes in segments L2-L3, L3-L4, in the treatment period: preliminary (W), III and V.

age. In young patients, the L5-S1 segment was most frequently affected by degenerative changes. Upper lumbar spinal segments were more frequently involved in older patients. Dammers demonstrated in his studies that the mean age of patients with L5-S1, L4-L5 discopathy is significantly lower than among those with L3-L4 and L2-L3 discopathy [7]. The mean age of patients with two-level discopathy was higher than of those with one-level discopathy. The above observations are consistent with reports by other authors [7, 19, 20, 21, 22, 23].

The number of degenerative changes increased from the L2-L3 to L5-S1 level, with is probably associated with higher loads to be borne by the lower spinal segments. The degenerative changes affected more frequently the L5-S1 level than the L4-L5 one. The results of imaging investigations are not always consistent with the clinical condition of the patient. In the presented study, these

results also correlated only with some clinical condition parameters: assessment of pain, physical fitness and quality of life.

## Conclusions

1. The number of degenerative changes of the spine grows from level L2-L3 to level L5-S1.
2. The stage of spinal degenerative changes rises along with the duration of the disease.
3. The patients operated on show more degenerative changes in distant follow-up than those in conservative treatment.
4. Patients with discopathies of herniation and prolapse type are more frequently referred for surgical treatment.

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