

# Analysis of the clinical picture in patients with osteoarthritis of the spine depending on the type and severity of lesions on magnetic resonance imaging

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## Abstract

**Objectives:** Spondyloarthritis is the most common pathological change in the spine. In a significant number of cases, it leads to compression of the nervous structures of the spinal canal, causing pain and neurological symptoms. Intervertebral disc pathology is a common cause of root deficits in neurological examination of all types of degenerative changes of the spine structures. Disc herniation is pathologically divided into 4 stages of herniated nucleus pulposus: 1) bulging, 2) protrusion, 3) extrusion, 4) sequestration. The aim of this study is to analyze the correlation between the type and severity of degenerative changes in the spine and the incidence of neurological deficits.

**Material and methods:** The study included 100 patients: 74 men and 26 women aged  $50.2 \pm 10.43$  years with pain of the spine in the cervical and/or lumbosacral segments and with degenerative changes in the plain radiographs. The mean value of body mass index (BMI) was  $27.8 \pm 3.95$  kg/m<sup>2</sup>. Each patient underwent neurological examinations and 1.5 T magnetic resonance imaging MRI of the cervical and/or lumbar spine.

**Results:** Every patient was diagnosed with herniated nucleus pulposus affecting on average  $4 \pm 2$  segments of the spine. The most frequently observed degree of severity of disc herniation was the second (protrusion, 71.9% of all disc disease in 89 patients). Much less frequently found was the third degree (extrusion, 45 patients, 20.1% slipped disc), the first (bulging, 14 patients, 6.3% slipped disc), and least often only a small percentage of fourth degree (sequestration, 4 patients, 1.7% slipped disc). Neurological symptoms (deficits) were observed in 34 patients. They were accompanied by disc herniations in 23.7% of patients. In remaining patients with neurological deficits there was spinal stenosis. No correlation was observed between neurological deficits and stage 1 of disc herniation.

**Conclusions:** The incidence rate of neurological deficits is correlated with the degree of changes in the spine, as visualized by MRI.

**Key words:** spine, intervertebral disc herniation, magnetic resonance imaging.

## Introduction

Spondyloarthritis is the most common pathological change in the spine. In a significant number of cases it leads to compression of the nervous structures of the spinal canal, causing pain and neurological symptoms. Depending on the clinical symptoms there are two ba-

sic pathological syndromes: spondylosis (changes relate mainly to the intervertebral disc and bone structures of vertebrae) and myelopathy (spinal cord injury caused by compression). The first diagnostic test for spondyloarthritis is a standard plain radiograph, followed by computed tomography (CT) and magnetic resonance

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Submitted: 10.07.2015; Accepted: 17.08.2015

imaging (MRI) in patients with persistent pain and neurological symptoms.

Spondylosis usually begins with disc pathology. As a result of changes in the disc anatomy and the spinal mobility the degenerative process gradually includes other structures of the vertebral bodies, intervertebral joints, yellow ligaments and longitudinal ligaments. The degenerative changes of the intervertebral discs are the results of repetitive overload of the spine and increased spinal mobility. Congenital abnormalities such as scoliosis or trauma also influence disc degeneration. The progression of disc degeneration is expressed by the progressive loss of water (dehydration) and the formation of cracks within the annulus, as well as the formation of clusters of gas (symptom vacuum). This leads to the reduction of the mass of the intervertebral disc, and in some cases to herniation of the nucleus pulposus (this is a general displacement of the disc material structures beyond the intervertebral space) [1].

There are 4 stages of herniation of the nucleus pulposus [2]:

1. Disc bulging – it is a symmetric flattening of the disc in all directions. Cracks are already present within the annulus, but without interrupting outer limit of the annulus. The MRI signal disc in T2-weighted images is reduced.
2. Protruded nucleus pulposus (protrusion) – a bulging of the nucleus pulposus to the annulus, but the outer part of the fiber ring of the annulus is not interrupted.
3. Herniated nucleus pulposus (extrusion) – it is the complete interruption of the annulus fibrosus. Fragments of the nucleus pulposus bulge out beyond the outline of the fiber ring. Computed tomography and MRI images in the second and the third stage of this disease are often similar.
4. Prolapse of the nucleus pulposus (sequestration, free fragment). In this stage, the fragments of the nucleus pulposus and the annulus fibrosus are detached from the disc.

Hernias in the third and fourth stage can still be divided into subligamentous (without interrupting the continuity of the longitudinal ligament) and extraligamentous types (with longitudinal ligament rupture). Herniation of the nucleus can occur in all directions. The most common and most important is the intrathecal hernia (medial-lateral). Radiologically their picture is the same as a picture of the Schmorl nodules in the course of Scheuermann disease [3]. The degeneration of the disc results in changes in other structures of the spine: vertebral bodies, intervertebral joints, yellow ligaments, longitudinal ligaments. The changes involving these elements are called spondylosis. Degenerative changes of the vertebral bodies can take many forms. In the initial period they cover mainly the plate. Later

the formation of osteophytes is observed. The degeneration of the yellow ligaments is expressed by their hypertrophy and thickening. The longitudinal ligaments decrease in flexibility and increase in extensibility. The above changes can lead to stenosis of the spinal canal and the intervertebral foramina. Changes in the longitudinal ligaments, however, can also be the cause of degenerative spondylolisthesis, which in turn can result in narrowing of the spinal canal. Spinal stenosis may affect the central part of the spinal canal (central spinal stenosis) or the lateral recesses and the lateral intervertebral foramina (lateral spinal stenosis). All the degenerative processes which lead to narrowing of the spinal canal or intervertebral foramina can lead to spinal pain syndromes and neurological root deficits. The occurrence of the clinical symptoms, however, is not synonymous with the existence of a hernia of the nucleus pulposus and the discopathies that correspond to intervertebral disc degeneration.

The most common degenerative processes occur in the lumbosacral and cervical spine; they are much rarer in the thoracic part. In the cervical spine segments from C5 to C7 are affected most often. In the lumbar spine the hernia is usually seen in segments L4–L5 and L5–S1. This suggests that the pathological changes depend partly on traffic-related injuries and age-related degeneration.

The aim of the study is to analyze the correlation between the type and severity of degenerative changes in the intervertebral disc in comparison with the incidence of neurological symptoms.

## Material and methods

The study included 100 patients, 74 men and 26 women aged  $50.2 \pm 10.43$  years with pain of the spine in the cervical and/or lumbosacral segments and with degenerative changes in the plain radiographs. Mean value of body mass index (BMI) was  $27.8 \pm 3.95$  kg/m<sup>2</sup>. Each patient underwent neurological examinations and 1.5 T MRI of the cervical and/or lumbar spine.

The patients were admitted to the Outpatient Neurological Policlinic between November 2014 and July 2015. Each patient underwent neurological examination and neuroimaging study by magnetic resonance 1.5 T.

All participants of the study had degenerative changes in the C and/or L–S spine, shown previously in standard radiological studies, and the presence of prior, periodic or current pain in one or both sections of the spine. The primary indication for the past or present magnetic resonance imaging was the occurrence of pain in one or both sections of the spine and/or neurological deficits.

The trial was approved by the Bioethics Committee of the Central Clinical Hospital of the Ministry of Internal Affairs in Warsaw, N. 127/2014, 05.11.2014, according to the guidelines of the ICH – GCP.

## Results

Every patient was diagnosed with herniated nucleus pulposus affecting on average  $4 \pm 2$  segments of the spine. The most frequently observed degree of severity of disc herniation was the second (protrusion, 71.9% of all disc disease in 89 patients). Much less frequently found was the third degree (extrusion, 45 patients, 20.1% slipped disc), the first (bulging, 14 patients, 6.3% slipped disc), and least often only a small percentage of fourth degree (sequestration, 4 patients, 1.7% slipped disc) (Table I).

Statistical analysis showed that the occurrence of the second stage of the disease (protrusion) was sig-

nificantly more frequent than the occurrence of other grades (compared to bulging, extrusion and sequestration, significance  $p < 0.0001$ ). In addition, the presence of 3 stages was significantly more frequent than the first ( $p < 0.0001$ ) and fourth ( $p < 0.0001$ ), and additionally the fourth stage (sequestration) was significantly less frequent ( $p = 0.0135$ ) than the first.

As shown in Table II, discopathy was most frequently observed in the lumbar spine: L5–S1 (73 patients), L4–L5 (72 patients), and L3–L4 (50 patients). The least often observed was cervical pathology: C2–C3 (3 patients), C7–Th1 (5 patients), Th12–L1 (6 patients). As a result of the statistical analysis, statistically significant differences in the incidence of disc herniation were found in the following sections: C2–C3 to L2–L3, and L3–L4, L4–L5 and L5–S1 ( $p < 0.01$  to  $p < 0.0001$ ).

The first stage of herniation (bulging) occurred most frequently in the lumbar-sacral section at the L3–L4 seg-

**Table I.** Prevalence of different stages of herniated nucleus pulposus in studied patients

Stage	Number of patients ( <i>n</i> = 100)	Number of discs ( <i>n</i> = 363)	Number of discs in relation to patient with discopathy
Bulging	14	23 (6.3%)	1.6
Protrusion	89	261 (71.9%)	2.9
Extrusion	45	73 (20.1%)	1.6
Sequestration	4	6 (1.7%)	1.5
<i>p</i>	< 0.0001	< 0.0001	–

**Table II.** Hernia nucleus pulposus stage and segments of the spine – number of disc hernias

Stage	Normal	Number of hernias	Bulging	Protrusion	Extrusion	Sequestration	<i>p</i>
C2–C3	97	3	0	2	1	0	0.6222
C3–C4	80	20	3	15	2	0	< 0.0001
C4–C5	76	24	1	20	3	0	< 0.0001
C5–C6	67	33	1	24	8	0	< 0.0001
C6–C7	72	28	0	23	5	0	< 0.0001
C7–Th1	95	5	1	3	1	0	0.4087
Th12–L1	94	6	1	4	0	1	0.1744
L1–L2	85	15	2	12	1	0	< 0.0001
L2–L3	66	34	3	26	4	1	< 0.0001
L3–L4	50	50	8	30	10	2	< 0.0001
L4–L5	28	72	2	52	18	0	< 0.0001
L5–S1	27	73	1	50	20	2	< 0.0001
All	837	363	23	261	73	6	< 0.0001
% of the total number of hernias (363)			6.3	71.9	20.1	1.7	

ment (8 patients). The presence of a herniated disc in the second stage (protrusion) was observed most often in the lumbo-sacral spine: L4–L5 (52% or more than half of patients) and L5–S1 (50% of patients), less in L3–L4 (30% of patients) and L2–L3 (26% of patients). In the cervical spine, the second stage of disc hernia was most common (C5–C6 in 24% of patients, C6–C7 in 23% of patients, C4–C5 in 20% of patients).

Most cases of herniated grade 3 disease (extrusion) occurred also in the lumbo-sacral segment L5–S1 (20% of patients) and L4–L5 (18% of patients). In the cervical spine degree 3 occurred only in isolated cases. No patient was found to have the fourth stage of herniation in the cervical spine.

Comparison of four different types of disc herniation distribution between different levels of the spine showed that segment Th12–L1 was significantly less common than the other levels (C2–C7, C7–Th1 and L1–S1) in 3-stage herniation – extrusion (0% vs 20.1%  $p = 0.0409$ ). No statistically significant changes in other segments or stages were observed (Table III).

The mean age and BMI of patients with symptoms of neurological deficits were  $52.2 \pm 8.6$  years and  $27.8 \pm 4.6$  kg/m<sup>2</sup> and did not differ significantly from age and BMI in patients without symptoms ( $49.1 \pm 11.2$  years,  $p = 0.17$ , and  $27.7 \pm 4.6$  kg/m<sup>2</sup>,  $p = 0.92$ ).

Neurological symptoms (deficits) were observed in 34 patients (Table IV). They were accompanied by disc herniations in 23.7% of patients (86/363). In the remaining patients with neurological deficits there was spinal stenosis.

The most common were sensory deficits in dermatomal distribution, which occurred in 33 patients (23.4% hernia); less common were motor deficits (18% of respondents, 10.5% of hernias) and muscle atrophy (13%, 7.4% of hernias).

Neurological symptoms (deficits) were found in patients with stage-4 hernia sequestration (66.7% of cases) (Table V). The third stage of herniation (extrusion) was found in 13.7% to 38.4% of the cases, the second (protrusion) in 5% to 29.6%. No neurological deficits were observed in the first stage.

Table VI shows the frequency of different stages of hernia with the selected neurological deficits.

## Discussion

Symptoms of disc herniation depend not only on the size and location of the slipped disc, but also on the dimensions and construction of the spinal canal. The key role is played by the anterior-posterior dimension and side of the spinal canal and intervertebral foramina. In the case of narrowing of the spinal canal by osteoarticular changes, even a small disc can cause nerve root compression. In the spinal canal with the correct dimensions the severity of symptoms depends mainly on the direction and extent of the disc prolapse. Interruption of the intervertebral disc occurs frequently, especially between the 4<sup>th</sup> and 6<sup>th</sup> decade of life. This disorder is rarely found in people under 25 years of age or after 60 years of age.

Disc herniation in the cervical spinal may affect the spinal cord depending on the volume of the spinal ca-

**Table III.** Number and type of disc disease in segments of the spine – comparison between different levels: cervical segment, C7–Th1, Th12–L1 and lumbar-sacral segment L1–S1

Spine section	All	Bulging <i>n</i> = 23 (6.3%)	Protrusion <i>n</i> = 261 (71.9%)	Extrusion <i>n</i> = 73 (20.1%)	Sequestration <i>n</i> = 6 (1.7%)	<i>p</i>
Cervical C2–C7	108	5 (4.6%)	84 (77.8%)	19 (17.6%)	0 (0%)	0.2593
C7–Th1	5	1 (20%)	3 (60%)	1 (20%)	0 (0%)	0.3893
Th12–L1	6	1 (16.7%)	4 (66.7%)	<b>0 (0%)</b>	1 (16.7%)	<b>0.0409</b>
Lumbar-sacral L1–S1	244	16 (6.6%)	170 (69.7%)	53 (21.7%)	5 (2.1%)	0.5743

**Table IV.** Neurological symptoms observed in studied patients

Neurological symptoms	Hernias ( <i>n</i> = 363)		Patients ( <i>n</i> = 100)	
	number of changes	% hernias	number of patients	% of patients
Neurological deficits	86	23.7%	34	34%
Root motor deficit (on Lovett scale)	38	10.5%	18	18%
Muscular atrophy	27	7.4%	13	13%
Root sensory deficit	85	23.4%	33	33%

**Table V.** Neurological deficits and stage of herniated nucleus pulposus – number and percentage of symptoms for a given stage of hernia

Neurological symptoms	Stage of hernia (hernia total <i>n</i> = 363)			
	bulging 23 (6.3%)	protrusion 261 (71.9%)	extrusion 73 (20.1%)	sequestration 6 (1.7%)
Neurological deficits	0	54 (20.6%)	28 (38.4%)	4 (66.7%)
Root motor deficit (on Lovett scale)	0	20 (7.7%)	14 (19.2%)	4 (66.7%)
Muscular atrophy	0	13 (5.0%)	10 (13.7%)	4 (66.7%)
Root sensory deficit	0	53 (20.3%)	28 (38.4%)	4 (66.7%)

**Table VI.** Frequencies of different stages of herniated discs for selected neurological deficits

Neurological symptoms	Stage of hernia (hernia total <i>n</i> = 363)				<i>p</i>
	bulging 23 (6.3%)	protrusion 261 (71.9%)	extrusion 73 (20.1%)	sequestration 6 (1.7%)	
Neurological deficits	0	54 (62.8%)	28 (32.6%)	4 (4.6%)	< 0.001
Root motor deficit (on Lovett scale)	0	20 (52.6%)	14 (36.8%)	4 (10.5%)	< 0.001
Muscular atrophy	0	13 (48.1%)	10 (37.0%)	4 (14.8%)	< 0.001
Root sensory deficit	0	53 (62.3%)	28 (32.9%)	4 (4.7%)	< 0.001

nal and size. Spinal stenosis is rare except with a narrow spinal canal, or a massive falling out of the nucleus pulposus. The most common place of the hernia is the level of C5–C6 and C6–C7 segments, while C4–C5 and C7–Th1 are less common. Intervertebral disc disease in the cervical spine causes symptoms such as stiff neck and headache. In more advanced stages of disease, root pain and paresthesias occur [4, 5].

Movements of the head and neck worsen. In order to reduce the symptoms, patients often take a position with the arm raised and bending of their head. In the case of persistent compression discrete signs of root damage appear. C5 damage causes pain in the arm, weakness of the superficial sensation in the corresponding dermatome and weakness and atrophy of the deltoid muscle. C6 damage causes paresthesia in the thumb and weakness of the biceps. The lesions may involve C7 with paresthesia of the index and middle fingers, the thumb, weakness and atrophy of the triceps, wrist extensor muscles, pectoral muscles and weakening of the corresponding reflexes. C8 supplies the muscles of internal mobility and sensory hand the fourth and fifth fingers.

Root symptoms in intervertebral disc disease in the lumbosacral spine are often temporary, so remissions are considered to be characteristic. The Valsalva maneuver (coughing, sneezing, or straining during defecation abdominal pressure) increases the pain. The pain may be limited to the back or radiate to one or both legs. Lower back pain may be increased by weight bearing or

twisting of the spine. Characteristic is the reduction of pain in the supine position. Some patients, however, experience relief in a seated position. Often one can see the curvature of the spine with subsequent lateral tilting of the patient and the iliac crest elevation on one side. The range of motion in the lumbar spine is severely limited due to the protective paraspinal muscle tension, with severe pain. Passive straight lower limb lifting is limited, causing leg pain and lower back pain (Lasègue symptom) [4]. Muscular atrophy may appear with weakness, tenderness and pain in the path of the sciatic nerve. Common is hyperalgesia in the supply of the nerve root. Typical symptoms of nerve root compression are lumbar muscle weakening (tibialis anterior, the rectifier hallux, gastrocnemius, plantar flexors of the foot, quadriceps) and disorders of knee and ankle reflexes [4, 5].

The presence of neurological deficits depends on the severity of degenerative disc disease, but a significant effect on their appearance can be exerted by other factors, such as: buildup on the edges of vertebral bone (marginal osteophytosis), degenerative changes in the intervertebral joints, congenital spinal canal width, synovial cysts in the intervertebral joints, periradicular cysts, or the degree of dehydration of the intervertebral disc.

Analysis of the clinical picture, including primarily neurological status of the patients, in correlation with the results of neuroimaging studies in magnetic resonance imaging in a group of 100 persons showed that the incidence of neurological deficits was primarily as-

sociated with stage 4 of herniated nucleus pulposus of the intervertebral disc (prolapse, sequestration), and with spinal canal stenosis at the level of disc herniation. Herniated nucleus pulposus in stage 2 (protrusion) and 3 (extrusion) has significantly lower incidence of root cause of neurological deficits, and in stage 1 (bulging) virtually all.

Similar observations are present in the available literature [6–10].

Maus and Aprill [6] observed coincidence between root pain and changes on MRI in stages 3 and 4 of disc herniations. Del Grande et al. [7] noted a correlation between age-related changes in intervertebral discs and radicular pain. Takashima et al. [8] observed the value of MRI examinations in diagnosis of disc herniation connected with neurological symptoms. Heary [9] claimed that neurological symptoms are in correlation with MRI. In young Finnish adults Takatalo et al. [10] observed the association of different changes in the spine with severity of low back symptoms.

## Conclusions

The incidence rate of neurological deficits is correlated with the degree of changes in the spine, as visualized by MRI.

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*The author declares no conflict of interest.*

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