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MAGNETIC RESONANCE IMAGING OF THE LUMBAR SPINE IN PEOPLE WITHOUT BACK PAIN

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Abstract *Background.* The relation between abnormalities in the lumbar spine and low back pain is controversial. We examined the prevalence of abnormal findings on magnetic resonance imaging (MRI) scans of the lumbar spine in people without back pain.

Methods. We performed MRI examinations on 98 asymptomatic people. The scans were read independently by two neuroradiologists who did not know the clinical status of the subjects. To reduce the possibility of bias in interpreting the studies, abnormal MRI scans from 27 people with back pain were mixed randomly with the scans from the asymptomatic people. We used the following standardized terms to classify the five intervertebral disks in the lumbosacral spine: normal, bulge (circumferential symmetric extension of the disk beyond the interspace), protrusion (focal or asymmetric extension of the disk beyond the interspace), and extrusion (more extreme extension of the disk beyond the interspace). Nonintervertebral disk abnormalities, such as facet arthropathy, were also documented.

Results. Thirty-six percent of the 98 asymptomatic subjects had normal disks at all levels. With the results of the two readings averaged, 52 percent of the subjects had a bulge at at least one level, 27 percent had a protrusion, and 1 percent had an extrusion. Thirty-eight percent had an abnormality of more than one intervertebral disk. The prevalence of bulges, but not of protrusions, increased with age. The most common nonintervertebral disk abnormalities were Schmorl's nodes (herniation of the disk into the vertebral-body end plate), found in 19 percent of the subjects; annular defects (disruption of the outer fibrous ring of the disk), in 14 percent; and facet arthropathy (degenerative disease of the posterior articular processes of the vertebrae), in 8 percent. The findings were similar in men and women.

Conclusions. On MRI examination of the lumbar spine, many people without back pain have disk bulges or protrusions but not extrusions. Given the high prevalence of these findings and of back pain, the discovery by MRI of bulges or protrusions in people with low back pain may frequently be coincidental. (N Engl J Med 1994;331:69-73.)

THE lifetime prevalence of low back pain is approximately 80 percent; 31 million Americans have low back pain at any given time.[1] In the United States, low back pain is second only to the common cold as the reason patients cite for seeking medical care. The estimated cost of medical care for patients with low back pain exceeds $8 billion annually.[2] Although there has been no increase in the incidence of this problem, over the past 30 years the rate of disability claims related to low back pain has increased by 14 times the rate of population growth.[1]

The relation between abnormalities in the lumbar spine and low back pain is controversial. Previous autopsy studies, as well as myelography, computerized tomography (CT), and magnetic resonance imaging (MRI), have shown abnormalities in a substantial number of people without back pain.[3-8] A recent study using MRI reported a high prevalence of disk herniation in people without symptoms and urged caution in relating symptoms to such lesions,[6] although the nomenclature was not precise. The term "herniation" can be used to describe a wide spectrum of abnormalities involving disk extension beyond the interspace, from a bulge to a frank extrusion; therefore, the reported data on the prevalence of herniation can be misleading. Well-defined morphologic terms may be more useful in describing this abnormality and may correlate better with symptoms.

Using a well-defined morphologic nomenclature, we examined the prevalence of abnormal disks as well as other findings in MRI examinations of the lumbosacral spine in people without back pain. In addition, we correlated the level of physical activity by the study participants with disk abnormalities.

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METHODS

We studied 98 people (50 men and 48 women) without symptoms of back pain, from 20 to 80 years old (mean age, 42.3 years). Volunteers were recruited by distributing flyers in the hospital, mailing

Table 1. Prevalence of Bulges, Protrusions, and Extrusions on MRI Scans in 98 Asymptomatic Subjects and 27 Symptomatic Subjects.*

	Bulge	Protrusion	Extrusion
	no. of subjects (%)		
Evaluator 1			
Asymptomatic subjects	52 (53)	30 (31)	2 (2)
Symptomatic subjects	23 (85)	14 (52)	8 (30)
Evaluator 2			
Asymptomatic subjects	50 (51)	23 (23)	0
Symptomatic subjects	18 (67)	15 (56)	6 (22)
Average of the two evaluators			
Asymptomatic subjects	51 (52)	26.5 (27)	1 (1)
Symptomatic subjects	20.5 (76)	14.5 (54)	7 (26)

*Bulge, protrusion, and extrusion are defined in the Methods section.

an announcement to all staff physicians, and advertising in the hospital newspaper. Participants did not need to be affiliated with the hospital. Applicants completed a consent form approved by the Investigational Review Board and were interviewed by one of us. Those with a history of back pain lasting more than 48 hours or any lumbosacral radiculopathy were excluded (about 20 patients). To reduce bias in the interpretation of the MRI scans, abnormal scans from 27 people with back pain were selected and mixed randomly with the scans from the 98 people without symptoms.

The level of physical activity was scored as follows: 0, no exercise; 1, occasional exercise (less than weekly); 2, weekend exercise; 3, workouts three or four times a week; and 4, workouts five or more times a week or regular workouts that included strenuous activity such as weightlifting or horseback riding.

All MRI scans were obtained at Hoag Memorial Hospital with 1.5-T imagers (Signa, General Electric, Milwaukee; and Magnetom SP4000, Siemens Medical Systems, Iselin, N.J.). The studies consisted of four spin–echo sequences: a coronal localizer with a repetition time and echo time (TR/TE) of 400/15 msec, a sagittal view with a TR/TE of 300–600/11–23 msec, an axial view with a TR/TE of 700–900/11–15 msec, and a sagittal view with a TR/TE (dual-echo sequence) of 2500–2600/16–21 and 90–105 msec. Technical specifications included a slice thickness of 3 and 4 mm for sagittal and axial sequences, respectively; a field of view of 26 and 20 cm for the sagittal and axial images, respectively; and a matrix of 192 by 256. The T_1-weighted axial sequences were stacked slices extending from the inferior aspect of L3 through the inferior aspect of S1. There were two excitations for the T_1-weighted axial and sagittal images, with one excitation for the T_2-weighted sagittal images.

All studies were read at the Cleveland Clinic by two experienced neuroradiologists familiar with the MRI imagers used. The readers did not know the clinical status of the subjects. All identifying information and dates were obscured. Readings were carried out in groups of 9 to 11 studies per session, which included 1 to 4 studies from people with symptoms. The readers independently evaluated the status of the 5 intervertebral disks in the lumbosacral spine in all 125 subjects (a total of 625 disks).

The terms used to classify disks were defined as follows: normal, no disk extension beyond the interspace; bulge, circumferential symmetric extension of the disk beyond the interspace (around the end plates); protrusion, focal or asymmetric extension of the disk beyond the interspace, with the base against the disk of origin broader than any other dimension of the protrusion; and extrusion, more extreme extension of the disk beyond the interspace, with the base against the disk of origin narrower than the diameter of the extruding material itself or with no connection between the material and the disk of origin. This terminology was selected on the basis of the findings of a companion study that evaluated interobserver and intraobserver variability when different nomenclatures were used to describe disk abnormalities in the same 125 MRI studies. In that study, all scans were read independently at least twice by the two neuroradiologists (evaluator 1 and evaluator 2), with a minimum of two weeks between the readings. The data in the current study are based on the second reading in the companion study, in which the terms we selected (normal, bulge, protrusion, and extrusion) were used for the first time. With these definitions, an interobserver agreement of 80 percent (for all 125 subjects) was found (kappa = 0.59).[9]

Table 2. Number of Subjects with Bulges, According to the Age of the Subject and the Location of the Bulge.*

Age (yr)	Location of Bulge					Bulge at Least at One Level
	L1–2	L2–3	L3–4	L4–5	L5–S1	
	no. of subjects					*no. of subjects (%)*
20–29 (n = 20)	0/0	0/0	4/0	5/2	4/2	7/4 (35/20)
30–39 (n = 28)	2/1	1/1	4/1	6/8	4/3	11/9 (39/32)
40–49 (n = 23)	1/0	1/2	3/8	7/10	5/8	13/15 (57/65)
50–59 (n = 17)	3/3	5/4	10/8	9/6	12/9	13/14 (76/82)
≥60 (n = 10)	0/1	1/4	4/5	5/6	4/5	8/8 (80/80)
Total (n = 98)	6/5	8/11	25/22	32/32	29/27	52/50 (53/51)

*For each pair of data, the first number refers to the first evaluator's result, and the second number to the second evaluator's result.

Table 3. Number of Subjects with Protrusions, According to the Age of the Subject and the Location of the Protrusion.*

Age (yr)	Location of Protrusion					Protrusion at Least at One Level
	L1–2	L2–3	L3–4	L4–5	L5–S1	
	no. of subjects					*no. of subjects (%)*
20–29 (n = 20)	0/0	0/0	0/0	3/2	2/1	5/3 (25/15)
30–39 (n = 28)	1/1	1/1	1/1	5/2	2/2	6/6 (21/21)
40–49 (n = 23)	0/1	0/0	1/0	5/3	4/4	8/7 (35/30)
50–59 (n = 17)	0/0	1/1	2/1	2/4	0/0	5/5 (29/29)
≥60 (n = 10)	0/0	2/1	1/0	4/0	3/1	6/2 (60/20)
Total (n = 98)	1/2	4/3	5/2	19/11	11/8	30/23 (31/23)

*For each pair of data, the first number refers to the first evaluator's result, and the second number to the second evaluator's result.

Nonintervertebral disk abnormalities were assessed on the basis of a consensus by two other readers at Hoag Memorial Hospital. The following abnormalities were recorded: Schmorl's nodes, facet arthropathy, spondylolysis, spondylolisthesis, annular defects, and stenosis of the central canal or neural foramen. The criteria for stenosis of the central canal and neural foramen were obliteration of the epidural fat with flattening of the thecal sac and obliteration of the perineural fat, respectively.[10]

For statistical analyses, the prevalence of disk abnormalities observed by the two readers was determined according to the subjects' sex, age, and physical-activity score, with the use of a generalized linear model for correlated binary data.[11] All tests of significance were two-tailed.

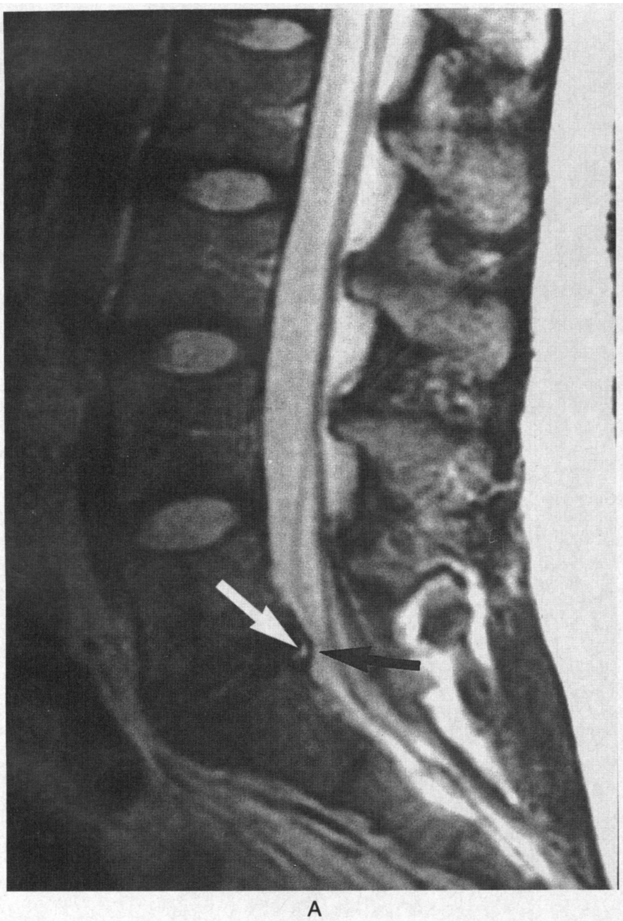
Results

Table 1 summarizes the prevalence of disk bulges, protrusions, and extrusions in the MRI studies. With the results of the two readings averaged, 52 percent of people without symptoms had a bulge at at least one intervertebral disk, 27 percent had a protrusion, and 1 percent had an extrusion. Thus, 64 percent of these people without back pain had an intervertebral disk abnormality, and 38 percent had an abnormality at more than one level.

The prevalence of bulges and protrusions according to the age of the subjects and the location of the abnormalities in the intervertebral disk space are presented in Tables 2 and 3. The prevalence of bulges and protrusions was highest at L4–5 and L5–S1; there were few abnormalities at L1–2. The MRI scan of an asymptomatic subject with a disk protrusion and its schematic representation are shown in Figure 1. No significant relation was found between sex and the prevalence of bulges (data not shown) or between age and the prevalence of protrusions (Table 3). The prevalence of disk bulges increased with age ($P<0.001$) (Table 2), and this trend was present for each disk level. Figure 2 shows a circumferential disk bulge. Age was also significantly associated with the presence of more than one disk abnormality. Sixty-seven percent of the 27 people who were 50 years of age or older had multiple abnormalities, as compared with 27 percent of the 71 younger participants (evaluator 1, 20 of 27 older subjects vs. 21 of 71 younger subjects; evaluator 2, 16 of 27 vs. 18 of 71; $P<0.001$).

The prevalence of disk abnormalities varied little with the physical-activity score. However, among the 48 people who exercised regularly (a score of 3 or 4), the prevalence of protrusions at L5–S1 was 16 percent, as compared with 4 percent among the 50 people who were more sedentary (evaluator 1, 8 of 48 people who exercised regularly vs. 3 of 50 who were more sedentary; evaluator 2, 7 of 48 vs. 1 of 50; $P = 0.05$).

The most common nonintervertebral disk abnormalities in people without symptoms were Schmorl's nodes (herniation of the disk into the vertebral-body end plate), in 19 percent of the subjects; annular de-



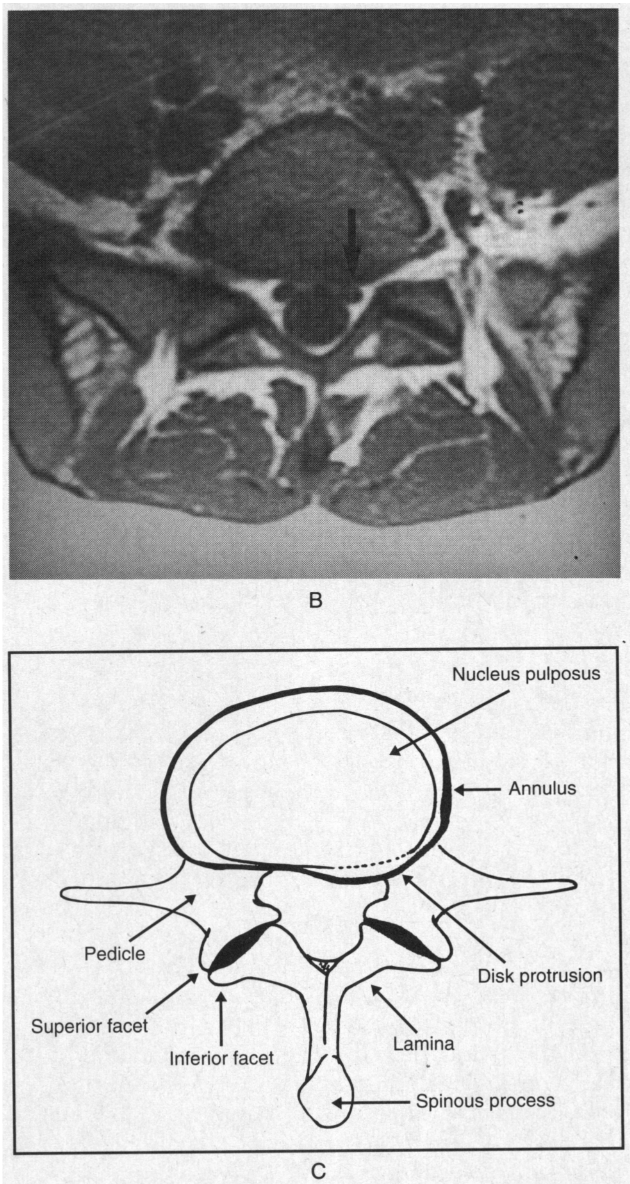


Figure 1. A Disk Protrusion in a 24-Year-Old Woman without Back Pain.

The T_2-weighted sagittal image (TR/TE, 2500/102 msec) (Panel A) shows an L5–S1 protrusion (black arrow) with a small annular defect, as evidenced by the focus of high signal intensity at the posterior disk margin (white arrow). The T_1-weighted axial image (TR/TE, 800/11 msec) (Panel B) shows the left paracentral disk protrusion, with subtle posterior displacement of the left S1 nerve root (arrow). A schematic axial representation (Panel C) depicts the left paracentral disk protrusion.

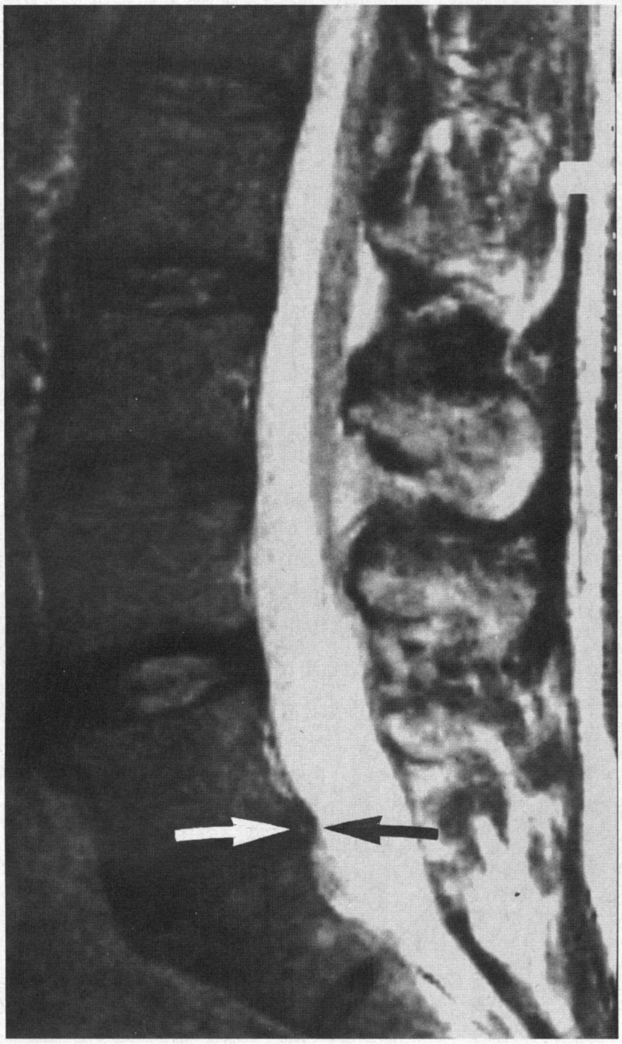


Figure 2. A Disk Bulge in a 21-Year-Old Man without Back Pain. The T_2-weighted (TR/TE, 2500/102 msec) image shows a midline sagittal section through a circumferential disk bulge at L5–S1 (black arrow). In addition, the small focus of high signal intensity at the posterior margin (white arrow) is compatible with a small annular fissure.

fects (disruption of the outer fibrous ring of the disk), in 14 percent; and facet arthropathy (degenerative disease of the posterior articular processes of the vertebrae), in 8 percent. Seven percent of the asymptomatic subjects had spondylolysis, 7 percent had spondylolisthesis, 7 percent had stenosis of the central canal, and 7 percent had stenosis of the neural foramen.

Discussion

We found a high prevalence of abnormalities in the lumbar spine on MRI examination of people without back pain. Only 36 percent of those examined had a normal disk at all levels. About half had a bulge at at least one intervertebral disk, and about a quarter had at least one disk protrusion. Given the high prevalence of back pain in the population, the discovery of a bulge or protrusion on an MRI scan in a patient with low back pain may frequently be coincidental. Therefore, the clinical picture should be correlated with the MRI results. Abnormalities of the lumbar spine by MRI examination can be meaningless if considered in isolation.

Only a small number of the asymptomatic people we studied had disk extrusions on MRI examination. Appropriate statistical comparisons of people with symptoms and those without symptoms cannot be made from our data, because the scans for those with symptoms were selected retrospectively. However, our data are consistent with the hypothesis that the prevalence of extrusions in people with symptoms of back pain may be substantially higher than in people without symptoms. Previous studies using CT and MRI[5,6] did not distinguish between protrusions and extrusions. The term "herniation" may be too generic for clinical relevance. Classification of protrusions and extrusions may be more helpful in characterizing the findings.

The presence of disk abnormalities in the lumbar spine of asymptomatic people is well known. In a study of 33 people presumed to have been free of back pain, postmortem examination of the entire spine showed a 39 percent prevalence of posterior disk protrusions.[4] In another study, 24 percent of 300 myelograms in people without symptoms showed abnormalities of the lumbar disk.[3] Wiesel et al. used CT to examine 52 people without symptoms and found the prevalence of herniated disks to be 19.5 percent in people under the age of 40 years and 26.9 percent in those over the age of 40[5]; however, only the L4–5 and L5–1 intervertebral disks were evaluated.[6] In our study, one third of the participants had disk extensions beyond the interspace at the L1–2, L2–3, or L3–4 levels. Using MRI in 67 people without symptoms, Boden et al. found herniated disks in 20 percent of the people less than 60 years old and in 36 percent of those 60 years of age or older.[6] In another study, MRI examination of 41 women without symptoms showed that 54 percent had a disk bulge or herniation at one or more disk spaces,[8] although only L3–4, L4–5, and L5–1 levels were examined.

In our study, the prevalence of disk bulges, but not protrusions, increased with age. Since protrusions are less common than bulges, a larger study might have demonstrated a similar association between age and protrusions.

Annular "tears" may be painful, possibly because of leakage of the contents of the nucleus pulposus into the epidural space, with related nerve irritation.[12] Annular defects have been demonstrated by MRI.[13] The 14 percent prevalence of annular defects in our study may be an underestimate. The reported prevalence of posterior radial tears at autopsy in asymptomatic people is 40 percent for those between the ages of 50 and 60 years and 75 percent for those between 60 and 70.[14] Annular tears may lead to disk degeneration.[15] In our study, all the disks with annular fissures also had a decreased signal on the T_2-weighted image, and all but one had an associated bulge or protrusion. These findings support the contentions that annular defects are generally associated with disk degeneration and that such defects are frequently asymptomatic.

Abnormalities other than disk disease, such as facet arthropathy, have been cited as an important and often overlooked source of low back pain and sciatica. Abnormal facets can be injected with corticosteroids. Our study underscores the difficulty of establishing facet disease as the source of pain, since 8 percent of our subjects without back pain had facet arthropathy.

In conclusion, on MRI examination of the lumbar spine, many people without back pain have disk bulges or protrusions but not extrusions. Because bulges and protrusions on MRI scans in people with low back pain or even radiculopathy may be coincidental, a patient's clinical situation must be carefully evaluated in conjunction with the results of MRI studies.

References

1. Robertson JT. The rape of the spine. Surg Neurol 1993;39:5-12.
2. Deyo RA, Tsui-Wu Y-J. Descriptive epidemiology of low-back pain and its related medical care in the United States. Spine 1987;12:264-8.
3. Hitselberger WE, Witten RM. Abnormal myelograms in asymptomatic patients. J Neurosurg 1968;28:204-6.
4. McRae DL. Asymptomatic intervertebral disc protrusions. Acta Radiol 1956;46:9-27.
5. Wiesel SW, Tsourmas N, Feffer HL, Citrin CM, Patronas N. A study of computer-assisted tomography. I. The incidence of positive CAT scans in an asymptomatic group of patients. Spine 1984;9:549-51.
6. Boden SD, Davis DO, Dina TS, Patronas NJ, Wiesel SW. Abnormal magnetic-resonance scans of the lumbar spine in asymptomatic subjects: a prospective investigation. J Bone Joint Surg [Am] 1990;72:403-8.
7. Powell MC, Wilson M, Szypryt P, Symonds EM, Worthington BS. Prevalence of lumbar disc degeneration observed by magnetic resonance in symptomless women. Lancet 1986;2:1366-7.
8. Weinreb JC, Wolbarsht LB, Cohen JM, Brown CEL, Maravilla KR. Prevalence of lumbosacral intervertebral disk abnormalities on MR images in pregnant and asymptomatic nonpregnant women. Radiology 1989;170:125-8.
9. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159-74.
10. Helms CA. CT of the lumbar spine — stenosis and arthrosis. Comput Radiol 1982;6:359-69.
11. Liang K-Y, Zeger SL, Qaqish B. Multivariate regression analysis for categorical data. J R Stat Soc [B] 1992;54:3-40.
12. McCarron RF, Wimpee MW, Hudkins PG, Laros GS. The inflammatory effect of nucleus pulposus: a possible element in the pathogenesis of low-back pain. Spine 1987;12:760-4.
13. Yu SW, Sether LA, Ho PSP, Wagner M, Haughton VM. Tears of the anulus fibrosus: correlation between MR and pathologic findings in cadavers. AJNR Am J Neuroradiol 1988;9:367-70.
14. Hirsch C, Schajowicz F. Studies on structural changes in the lumbar annulus fibrosus. Acta Orthop Scand 1952;22:184-231.
15. Yu S, Haughton VM, Sether LA, Ho K-C, Wagner M. Criteria for classifying normal and degenerated lumbar intervertebral disks. Radiology 1989;170:523-6.