

Clinical Article

Prevalence of Disc Degeneration in Asymptomatic Korean Subjects. Part 3 : Cervical and Lumbar Relationship

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Objective : There are many cases in which degenerative changes are prevalent in both the cervical and lumbar spine, and the relation between both spinal degenerative findings of MRI is controversial. The authors analyzed the prevalence of abnormal findings on MRI, and suggested a model to explain the relationship between cervical and lumbar disc in asymptomatic Korean subjects.

Methods : We performed 3 T MRI sagittal scans on 102 asymptomatic subjects (50 men and 52 women) who visited our hospital between the ages of 14 and 82 years (mean age 46.3 years). Scores pertaining to herniation (HN), annular fissure (AF), and nucleus degeneration (ND) were analyzed. The total scores for the cervical and lumbar spine were analyzed using correlation coefficients and multiple linear regression with various predictive parameters, including weight, height, sex, age, smoking, occupation, and sedentary fashion.

Results : The correlation coefficients of HN, AF, and ND were 0.44, 0.50, and 0.59, respectively. We made the best model for relationship by using multiple linear regression.

Conclusion : The results of the current study showed that there was a close relationship between the cervical score (CS) and lumbar score (LS). In addition, the correlation between CS and LS, as well as the LS value itself, can be altered by other explanatory variables. Although not absolute, there was also a linear relationship between degenerative changes of the cervical and lumbar spine. Based on these results, it can be inferred that degenerative changes of the lumbar spine will be useful in predicting the degree of cervical spine degeneration in an actual clinical setting.

Key Words : Degeneration · Cervical disc · Lumbar disc · Magnetic resonance imaging · Relationship.

INTRODUCTION

The use of whole-spine magnetic resonance imaging (MRI) has become increasingly widespread in recent years due to the increased scan speed of MRI, which has led to a higher prevalence of incidental abnormal findings on MRI. Many physicians may experience cases in which cervical spine surgery was considered for patients who visited the outpatient clinic with the chief complaint of lumbar pain because lesions of the cervical spine tend to be more severe than those of the lumbar spine. This is because the symptoms of lumbar spine lesions are accentuated in cases in which dual lesions are present in the cervical and lumbar spines.

Based on our experience, there are many cases in which degenerative changes are prevalent in both the cervical and lumbar spine, and the relation between both spinal degenerative findings of MRI is controversial. However, little quantitative study has reported the degree of degenerative change involved in the relationship between the cervical and lumbar spine. If correlations among the degenerative changes of the cervical and lumbar spine could be accurately reported in a quantitative study, the results would serve as a guideline for preventing spinal diseases.

Given this background, we analyzed the degenerative changes in the cervical and lumbar spine using 3.0-Tesla (3T) MRI to identify the correlation between both changes in asymptomatic Korean subjects.

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MATERIALS AND METHODS

Study population

From December 2007 to March 2008, a total of 102 asymptomatic subjects (50 men and 52 women) who visited our hospital between the ages of 14 and 82 years (mean age 46.3 years) were selected for participation in this study. The study was approved by the hospital Institutional Review Board. Healthy subjects were recruited from asymptomatic visitors of the Health Screening Center by history-taking. We used this selection method in order to exclude any bias as completely as possible.

Written informed consent was obtained from all subjects. The subjects were carefully screened using a modified low back and neck pain questionnaire and history taking. Individuals were enrolled only if they had never experienced relevant pain in the low back and neck area, shoulder, elbow joint, hip joint, and knee joint, never undergone radiation at the upper and lower extremities and never had any neurological deficits.

The absence of relevant symptoms in these areas was defined as never having seen a physician, physiotherapist, chiropractor, acupuncture, oriental herb medication, or other such health care professional, and never having missed workday due to these symptoms. The rationale for these criteria was the notion that episodes of transient back or neck pain are very common and less likely to be recalled after spontaneous regression². Cases in which hospitalization treatment was administered for trauma due to a traffic accident were also excluded. Because we thought that trauma required hospitalization may have undetected cervical and lumbar diseases.

Magnetic resonance imaging methods

From C2 to T1 and T12 to S1, magnetic resonance (MR) scans were performed with a 3.0-Tesla imager (Achieva 3.0 T X-series, Philips Medical Systems, Netherlands) with a dedicated receive-only spine coil. The protocol included sagittal T2 weighted (T2W) [2593/120 (repetition time msec/echo time msec)] turbo spin-echo imaging of the entire cervical spine with the following sequence parameters: matrix, 516×256; field of view, 270 mm; section thickness, 3 mm; intersection gap, 0.3 mm; and echo train lengths of 16 for T2 weighted images (T2WIs). And the protocol included sagittal T2W [2500/100 (repetition time msec/echo time msec)] turbo spin-echo imaging of the entire lumbar spine with the following sequence parameters: matrix, 724×256; field of view, 240 mm; section thickness, 4 mm; intersection gap, 0.4 mm; and echo train lengths of 16 for T2WIs.

All images were sent to the in-hospital picture archive and communication system (PACS; Infinitt PACS, invented by Infinitt Co., Seoul, Korea) and reviewed using a 21.3-inch, 5-megapixel medical flat grayscale display (MFGD 5421, Barco, Tortrijk, Belgium) on a HP xw4400 workstation base unit (Hewlett-Packard Co., CA, USA). The monitor has a 2048×2560 resolution, 0.165 mm pixel pitch, 422.4×337.9 mm active screen area, 800:1 dark room contrast, and 700 cd/m² luminance.

Though an axial sequence is also necessary to differentiate differences in disc pathology, the authors used only sagittal imaging for convenience sake.

Image analysis

The imaging studies in all 102 asymptomatic subjects were read independently by three of the authors (two neurosurgeons and one neuroradiologist) who were not given any information about the subjects. To eliminate potential reading bias, the images of 30 random symptomatic patients were mixed with the asymptomatic subject's images. We did not analyze the random 30 patients' results in final analysis. There was no case of blocked vertebra or fusion. Twelve cervical and lumbar disc levels were examined in each subject, and a total of 1224 discs were examined.

Degree of degeneration

To establish the criteria for determining disc abnormality, we classified the three measurement categories: herniation (HN), annular fissure (AF), and nucleus degeneration (ND). There are many classifications for disc herniation and degeneration, we used the most prevalent terms⁵ for HN and modified Pfirrmann's classification⁴ for ND. The reason for the selection of the three categories is that they are abnormal findings with a high prevalence in normal healthy subjects.

Herniation

Disc herniation was classified as local protrusion in the intervertebral space (Table 1). The following terms were used to describe disc abnormalities: normal, bulging, protrusion, extrusion, and sequestration^{3,9}. Disc was considered to be normal when it did not reach beyond the borders of the adjacent vertebral bodies. Bulging was defined as a circumferential, symmetric disc extension around the vertebral border. Protrusion was defined as a focal or asymmetric extension of the disc beyond the vertebral border, with the disc origin broader than any other dimension of the protrusion. Extrusion was defined as a more extreme extension of the disc beyond the vertebral border, with the base against the disc of origin narrower than the diameter of the extruding material and a connection between the material and the disc of origin. Sequestration was defined as a free disc fragment that was distinct from the parent disc and had an increased signal intensity on T2WIs.

Annular fissure and high-signal intensity zone

AF was defined as a high signal at the fibrous ring of an intervertebral disc on T2WIs. In addition, high-signal intensity zone (HIZ) is a high-intensity signal (bright white) located in the substance of the annulus fibrosus, clearly dissociated from the signal of the nucleus pulposus. It is surrounded superiorly, inferiorly, posteriorly and anteriorly by the low-intensity (black) signal of the annulus fibrosus and is appreciably brighter than that of the nucleus pulposus. HIZ probably corresponds to annular tears¹. AF was graded according to fissure site of the disc

at the most clearly lesion from entire disc midsagittal T2WI. And the prevalence of HIZ was analyzed (Table 1).

Nucleus degeneration

The extent of intervertebral disc ND was graded on midsagittal T2WI according to the criteria of modified Pfirrmann classification⁴⁾ (Table 1, 2). This grading correlates with the extent and loss of proteoglycans in the nucleus pulposus of the intervertebral disc. Intervertebral disc narrowing was diagnosed in cases in which decrease of more than 33.3% in the intervertebral disc space was present. The seven findings in the lumbosacral intervertebral disc were : bright (homogeneous hyperintense nucleus), bright-band (nucleus clear distinction with horizontal dark band), bright-narrow (nucleus clear with disc height decreased), dim (nucleus unclear distinction with normal height), dim-slight (nucleus unclear with slightly decreased), dim-moderate (nucleus unclear with moderately decreased), dim-collapsed (nucleus unclear with collapsed). For the purpose of this investigation, grade 0-2 were grouped together and grade 3-6 were the more advanced grades of ND (Table 1).

Affecting risk factors

We investigated about the risk factors which have the possibility of degeneration effect in disc. We selected variables below 10 among numerous risk factors, because baseline subjects are 102 people. We also selected variables which are easily obtained by history taking and do not have any collinearity. Finally, factors are 7 kinds, such as age, sex, smoking, weight, height, occupation, and sedentary fashion (SF) (Table 3).

We divided three groups for smoking as non-smoker, ex-smoker, and current smoker. Non-smoker group defined in the group who did not smoke the tobacco before. Ex-smoker group defined in the group who had been smoked tobacco but stops smoking for 1 or more years. Occupation was divided into 4 groups as student, white-collar, housewife, and blue-collar. Student defined in the group which does not have any occupation before, and other groups defined in the case of 5 or more years with respective job. We introduced SF and graded from 0 to 10. SF grade 0 is always use chair when sitting and SF grade 10 is never use chair when sitting.

Statistical analysis

The prevalence of each abnormality

assessed was calculated by averaging the scores given by three readers. Scores pertaining to HN, AF, and ND were analyzed. Scores for HN were obtained using the ratio of normal : bulging : protrusion : extrusion=0 : 1 : 2 : 3 (Table 1). For AF, a grade of 0-7 was converted to a score based on the number of fissures and HIZ. For ND, each grade (0-6) was converted to a score at a ratio of 1 : 1 and then summed for each subject. The total scores for the cervical and lumbar spine were analyzed using Pearson's correlation coefficient (Table 4). Multiple linear regression analysis was used to analyze the correlation between degenerative changes in the cervical and lumbar spine and various predictive parameters, including weight, height, sex, age, smoking, occupation, and SF.

Both explanatory and response variables (or independent and dependent variables) are frequently found to be continuous when regression analysis is performed. However, our parameters corresponding to the explanatory variables belong to the categorical (scattered, discontinuous) data, and thus dummy variables were used. For dummy variables, new variables were created to have a number in the range of variable-1. Then, 1 was entered into the value corresponding to each category, and 0 was entered for other cases.

Table 1. Degree of disc degeneration

Grade	Herniation*	Annular fissure**	Nucleus degeneration
0	Normal	Normal	Bright
1	Diffuse bulging	Annular fissure-P	Bright-band
2	Protrusion	Annular fissure-A	Bright-narrow
3	Extrusion	Annular fissure-B	Dim
4	Sequestration		Dim-slight
5			Dim-moderate
6			Dim-collapsed

*Herniation : Disc finding on the sequential sagittal view. 1) Diffuse bulging : Nonfocal, non-osseous material extending beyond the normal disc space in a circumferential manner on the sequential sagittal view, 2) Protrusion : Nucleus pulposus contained in the annulus fibrosus but with contour abnormality, 3) Extrusion : Nucleus pulposus extending through the annulus fibrosus but still contiguous with the host nucleus, 4) Sequestration : Free fragment migration of herniated fragment away from the disc space. **Annular fissure : Nucleus signal. 0) Normal : No annular fissure or high-signal intensity zone, 1) Annular fissure-P : Annular fissure at posterior or posterolateral site, 2) Annular fissure-A : Annular fissure at anterior site, 3) Annular fissure-B : Annular fissure at both anterior and posterior site

Table 2. Degree of nucleus degeneration

Nucleus degeneration	Nucleus/Annulus distinction	Nucleus signal	Disc height
Bright	Clear	Hyperintense, homogeneous	Normal
Bright-band	Clear	Hyperintense w/ horizontal dark band	Normal
Bright-narrow	Clear	Hyperintense w/ or w/o horizontal dark band	Decreased
Dim	Unclear	Decreased, slightly or heterogeneous irregularity	Normal
Dim-slight	Unclear	Decreased, slightly or heterogeneous irregularity	Slightly decreased (<1/3)
Dim-moderate	Lost	Decreased, moderately	Moderately decreased (1/3-2/3)
Dim-collapsed	Lost	Decreased, severely	Collapsed (>2/3)

Among the explanatory variables encountered in the regression analysis, only variables that significantly affected the response variables were selected for the analysis. There are three methods

that can be used to select effective variables : forward selection, backward elimination, and stepwise selection. Forward selection is a method in which the most influential variable is selected first, followed by the next influential variable and so on. Forward selection is disadvantageous because a variable will remain until the end of the model once it has been selected. Backward elimination is an alternative method to forward selection in which the least influential variables are removed from the overall model one-by-one to create the final model. Backward elimination is disadvantageous in that a variable cannot be chosen for the final model once it has been removed. Stepwise selection is a method that compensates for the demerits of forward selection and backward elimination. It basically involves both forward selection and backward elimination. In our series, all three methods were used, while the cervical score (CS) and lumbar score (LS) were compared in each subject. The results were then compared.

Table 3. Predictor variables obtained by history taking for risk factors affecting to disc degeneration

Variable	Simplified parameter	Scale
Demography		
Age	Age	Years
Sex	Sex	Male/Female
Habit		
Smoking	T0/T1/T2	0-2 (non-smoker : 0, ex-smoker : 1, current smoker : 2)
Anthropometry		
Weight	Wt	kg
Height	Ht	cm
Physical characteristics		
Occupation	OC0-OC3	0-3 (student : 0, white-collar : 1, housewife : 2, blue-collar : 3)
Sedentary fashion	SF0-SF10	0-10 (always chair sitting : 0, always cross-legged sitting : 10)
MRI finding		
Herniation	HN	0-4 (refer to Table 1)
Annular fissure	AF	0-3 (refer to Table 1)
Nucleus degeneration	ND	0-6 (refer to Table 1, 2)

SF : sedentary fashion, HN : herniation, AF : annular fissure, ND : nucleus degeneration

Table 4. Cervical & lumbar score, weight, height and age correlation coefficient (Pearson's method)

Variable	HN-CS	HN-LS	AF-CS	AF-LS	ND-CS	ND-LS	Weight	Height	Age
HN-CS	1.00000	0.44431 19.7% <0.0001	0.77448 60.0% <0.0001	0.43621 19.0% <0.0001	0.66818 44.6% <0.0001	0.44152 19.5% <0.0001	-0.00258 0.0% 0.9870	-0.16549 2.7% 0.0925	0.44612 19.9% <0.0001
HN-LS		1.00000	0.48956 24.0% <0.0001	0.88816 78.9% <0.0001	0.51448 26.5% <0.0001	0.88904 79.0% <0.0001	-0.16249 2.6% 0.1027	-0.36206 13.1% 0.0002	0.67040 44.9% <0.0001
AF-CS			1.00000	0.49810 24.8% <0.0001	0.62153 38.6% <0.0001	0.47597 22.7% <0.0001	-0.14319 2.1% 0.1511	-0.16529 2.7% 0.0969	0.53631 28.8% <0.0001
AF-LS				1.00000	0.55829 31.2% <0.0001	0.87968 77.4% <0.0001	-0.17712 3.1% 0.0749	-0.39057 15.3% <0.0001	0.74682 55.8% <0.0001
ND-CS					1.00000	0.58844 34.6% <0.0001	-0.04276 0.2% 0.6696	-0.24742 6.1% 0.0122	0.69117 47.8% <0.0001
ND-LS						1.00000	-0.17793 3.2% 0.0736	-0.46159 21.3% <0.0001	0.77213 59.6% <0.0001
Weight							1.00000	0.62995 39.7% <0.0001	-0.13077 1.7% 0.1902
Height								1.00000	-0.44682 20.0% <0.0001
Age									1.00000

Three numbers in each cell represent correlation coefficient (r), r²%, and p-value in order. CS : cervical score, LS : lumbar score, ND : nucleus degeneration, AF : annular fissure, HN : herniation

Statistical procedures were performed using SPSS-PC, Version 9.0. The level of statistical significance was set at 0.05. Multiple linear regression analysis confirmed that the HN, AF, and ND scores followed a normal distribution.

Table 5. Cervical & lumbar score correlation coefficients (Pearson's method)

Correlation list	Criteria	r	r ² %	p-value
Herniation	HN	0.4443	19.7	<0.0001
Annular fissure	AF	0.4981	24.8	<0.0001
Nucleus degeneration	G3-6	0.5884	34.6	<0.0001

AF : annular fissure, HN : herniation, r : correlation coefficient

RESULTS

Degree of degeneration

There was a linear correlation between CS and LS in all three parameters, HN, AF, and ND ($p < 0.05$).

As shown in Table 5, there was a linear relationship between degenerative changes of the cervical spine and those of the lumbar spine. That is, a linear relationship could be found at a rate of approximately 19.7% for HN, 24.8% for AF, and 34.6% for ND.

Multiple linear regression analysis

Multiple linear regression analysis was used to evaluate the correlation between degenerative changes of the cervical and lumbar spine and predictive parameters such as weight, height, sex, age, smoking, occupation, and SF.

Herniation

A model was established by using only the variables that were determined to be significant by univariate analysis.

$$\text{HN-CS} = 0.44 + 0.22 (\text{HN-LS}) + 0.04 (\text{age}) + [0.32 (\text{OC1}) - 0.23 (\text{OC2}) + 0.43 (\text{OC3})]$$

The final model was also established using a stepwise regression analysis. Forward selection showed the same results.

$$\text{HN-CS} = 0.75 + 0.24 (\text{HN-LS}) + 0.03 (\text{age}) + 1.01 (\text{T1})$$

The results of cases in which backward elimination was used were as follows :

$$\text{HN-CS} = 1.59 + 0.34 (\text{HN-LS}) + 1.38 (\text{T1})$$

According to a model established using a stepwise method, a significant correlation between CS and LS for herniation was affected by age and smoking as well as LS. As shown for ND, advanced age was associated with an increased degree of cervical spine herniation. Advanced age was the only variable to show this proportional relationship. In normal healthy individuals, the CS increased by 2.4 points when the LS was increased by 10 points, and the CS increased by 0.3 points when age was increased by 10 years. In subjects with a previous history of smoking, the scores increased by 3.4 and 1.3 points, respectively.

Results of the analysis using backward elimination showed that LS and a previous history of smoking were the more influential parameters and that age did not have an effect.

Annular fissure

A model was established by using only the variables that were determined to be significant by univariate analysis.

$$\text{AF-CS} = 2.45 + 0.26 (\text{AF-LS}) - 0.01 (\text{Ht}) + 0.09 (\text{age}) - 0.09 (\text{CLS}) + [-0.64 (\text{OC1}) - 2.32 (\text{OC2}) - 1.22 (\text{OC3})]$$

The final model was also established by using a stepwise regression analysis. Forward selection showed the same results.

$$\text{AF-CS} = 3.43 + 0.31 (\text{AF-LS}) - 0.05 (\text{Wt}) + 0.08 (\text{age}) + [-2.52 (\text{OC2}) - 1.38 (\text{OC3})]$$

The results of cases in which backward elimination was used were as follows :

$$\text{AF-CS} = 0.21 + 0.22 (\text{AF-LS}) + 0.08 (\text{age}) - 1.39 (\text{OC2})$$

Based on the above model, the significant correlation between CS and LS for AF was affected by age and occupation as well as LS. As shown for ND, advanced age was associated with an increased degree of cervical spine fissure. However, the degree of cervical spine fissure was decreased in subjects with an increased weight, housewives and manufacturing workers. Advanced age was eventually associated with an increased CS and LS. However, because LS was greatly affected by weight, CS was increased to a greater extent than LS. Regarding occupations, as shown in the above results, housewives and manufacturing workers affected CS, but they did not have a further increasing effect.

Nucleus degeneration

A model was established by using only the variables that were determined to be significant by univariate analysis.

$$\text{ND-CS} = -4.44 + 0.22 (\text{ND-LS}) + 0.03 (\text{Ht}) + 0.13 (\text{age}) - 0.25 (\text{SF}) + [0.89 (\text{T1}) + 1.16 (\text{T2})] + [3.92 (\text{OC1}) + 3.25 (\text{OC2}) + 4.96 (\text{OC3})]$$

The final model was also established by using a stepwise regression analysis. Forward selection and backward elimination showed the same results.

$$\text{ND-CS} = 1.64 + 0.24 (\text{ND-LS}) + 0.14 (\text{age}) + [3.04 (\text{OC1}) + 2.59 (\text{OC3})]$$

Based on the above model, a significant correlation between CS and LS for ND was affected by age, occupation, and LS.

Table 6. Model of multiple linear regression for disc degeneration scores and risk factors

Correlation list	Variable selection	Linear model	Related variable
Herniation	FS, SS	HN-CS=0.75+0.24 (HN-LS)+0.03 (age)+1.01 (T1)	Age, smoking
	BE	HN-CS=1.59+0.34 (HN-LS)+1.38 (T1)	Smoking
Annular fissure	FS, SS	AF-CS=3.43+0.31 (AF-LS)-0.05 (Wt)+0.08 (age)+[-2.52 (OC2)-1.38 (OC3)]	Age, Wt, OC
	BE	AF-CS=0.21+0.22 (AF-LS)+0.08 (age)-1.39 (OC2)	Age, OC
Nucleus degeneration	FS, BE, SS	ND-CS=1.64+0.24 (ND-LS)+0.14 (age)+[3.04 (OC1)+2.59 (OC3)]	Age, OC

FS : forward selection, BE : backward elimination, SS : stepwise selection, HN : herniation, AF : annular fissure, ND : nucleus degeneration, CS : cervical score, LS : lumbar score, OC : occupation, OC1 : white-collar occupation, OC2 : housewife, OC3 : blue-collar occupation, T1 : ex-smoker, Wt : weight

Older age and certain occupations, including manufacturer and office worker, were correlated with a higher degree of degenerative change in the cervical spine. On the other hand, in normal healthy individuals who had an equivalent level of CS, advanced age was correlated with a lower LS. Eventually, advanced age becomes associated with increased CS and LS, but the difference between CS and LS gradually increases. In normal healthy individuals, the CS increased by 2.4 points when the LS was increased by 10 points, and the CS increased by 1.4 points when age was increased by 10 years. In case of office and manufacturing workers, the scores more increased by 3.0 and 2.6 points than those of student, respectively.

Results of multiple linear regression are summarized in Table 6. The shaded model is made by stepwise selection. CS was affected by LS and age in all disc degeneration (HN, AF, and ND). Smoking was related factor in HN. And occupation was related factor in AF and ND. Other factors (sex, height, and SF) had not significant relations.

DISCUSSION

In 1969, Sim and Janes¹⁰ reported the surgical outcomes of 31 patients who underwent alternate surgeries on the cervical and lumbar spine, and they reported a relationship between the cervical and lumbar spine. Jacobs et al.⁶ conducted a study to identify the concurrent prevalence of cervical and lumbar disc diseases in 200 patients. According to these authors, 21 of 60 patients with a single level cervical disc disease underwent lumbar spine surgery, and 39 presented with abnormal findings on myelography. They also noted that 40 of 140 patients with a multilevel disc disease underwent lumbar spine surgery, 139 presented with abnormal findings on myelography, and only one showed a normal finding. As described in the present report, a few studies have been conducted to examine the degenerative changes of the cervical and lumbar spine. However, it can be inferred that the concurrent presence of degenerative changes of the cervical and lumbar spine deserves special attention.

At first glance, the estimated parameters we analyzed using multiple linear regression analysis may appear very small. Because we performed our calculations using the sum of scores based on a 6-level grading system, the scores would actually correspond to six times the value of the estimated parameters, if the levels at which lesions frequently occur are restricted to one

or two (i.e., C4/5, C5/6). For instance, AF, which was determined to be the most simple parameter, showed a formula of AF-CS=0.14+0.05 (age). It was also shown that the CS was increased by 0.5 points when age was increased by 10 years. In an actual clinical setting, patients in their teens were found to have a CS of approximately 0.64 points, and those in their twenties had a CS of 1.14 points. Based on the consideration that lesions are mostly restricted to 1 or 2 levels in patients in their teens and twenties, AF scores corresponding to C4/5 and C5/6 are six times greater than each score, and they can be calculated as 3.8 and 6.8, respectively (of course, this is a very extreme case).

In the current study, we scored the MR images and then compared the scores of the cervical spine and lumbar spine based on the sum of each subject^{7,8}. Although a linear relationship based on a scoring system ranging from 0 to 7 points cannot be accepted, it is assumed that the discrepancy in the linear relationship caused by applying the same scoring system to the cervical and lumbar spine would be resolved to a greater extent. Rather than taking digital measurements based on the signal intensity of the MR image, we graded the MRI findings in accordance with the guidelines established for interpretation by specialists in radiology and neurosurgery. This was based on the assumption that the current analysis would be performed in the same manner as that used in an actual clinical setting.

In our series, though there was a slight degree of discrepancy between the CS and LS values, there was a close relationship between the two parameters. Besides, such a correlation can also be altered by other explanatory variables as well as the LS itself. Of course, it cannot be accepted that the changes in MRI findings are not proportional to the severity of the diseases. However, it is highly probable that they can be indicative of the predictive changes in disease progression.

Pearson's correlation analysis revealed a significant correlation among nearly all of the variables. Weight was the only variable that did not show a significant correlation with any of the other variables. It is generally known that lumbar disc degeneration is closely associated with weight. However, the variation in the results of the current study does not mean that there was not a significant correlation between weight and degenerative disc changes, but that a well-controlled body weight is an essential factor for recruiting healthy asymptomatic people as subjects. Only six of 102 patients had an abnormal weight of >body mass index (BMI) 3, and the remaining 96 (98%) had a normal

weight, with a BMI in the range of 1-2. Similarly, there was a significant correlation between height and LS, but not CS. Based on these results, it can be inferred that the LS would be significantly correlated with height and weight because weight was the only factor that had a significant relationship with height.

In addition to several parameters that were established as explanatory variables in the current study, hematologic profile, genetic factors affecting the vertebrae, differences in residency, ethnicity, dietary habits, amount of regular exercise, and sleeping patterns can also be considered. However, there are many limitations that make it impossible to evaluate all of these parameters in an actual clinical setting. Therefore, in our series, the model was established by using only parameters that could be considered most fundamentally and easily (e.g., height, weight, sex, and occupation).

The results of the current study must be interpreted with caution because the study was conducted based on the scoring of abnormal findings on MRI. It can therefore be inferred that the clinical application of our results must be done according to the clinical symptoms of the patients. We hope that our results will provide the baseline data for an analysis of clinical symptoms, including MRI scans, with the additional use of a scoring system.

CONCLUSION

The results of the current study show that although there was a slight difference in the degree of degeneration between the CS and LS, there was a close relationship between the cervical and lumbar spine. Besides, the correlation between CS and LS, as well as the LS value itself, can be altered by other explanatory variables. Although not absolute, there is a linear relationship between degenerative changes of the cervical and lumbar spine. Based on these results, it can be inferred that degenerative changes of the lumbar spine will be useful in predicting the de-

gree of cervical spine degeneration in an actual clinical setting.

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