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The Correlations between Lumbar Lordosis, L_{4-5} Disc Angle, L_{4-5} Disc Height, and the Lumbosacral Angle in L_{4-5} HNP Patients

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Abstract. [Purpose] This study was conducted to examine the degree of lumbar lordosis, L_{4-5} disc angle, L_{4-5} disc height and the lumbosacral angle in L_{4-5} herniated nucleus pulposus (HNP) patients and analyze the correlations between these variables to examine the relationship between HNP and abnormal sagittal spinal alignment. [Subjects] The study subjects were 15 lumbar spine 4-5 (L_{4-5}) HNP patients; the control group comprised 15 normal adults. [Methods] Both groups' magnetic resonance imaging scans were compared and analyzed. [Results] The HNP group showed a significantly smaller degree of lumbar lordosis, L_{4-5} disc angle, L_{4-5} disc height, and lumbosacral angle ($p<0.05$). I was also shown that as the degree of lumbar lordosis decreased, the disc angle, disc height, and lumbosacral angle decreased. [Conclusion] We found that L_{4-5} HNP patients have abnormal sagittal spinal alignments.
Key words: Lumbar lordosis, Magnetic resonance imaging, Spinal alignments

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INTRODUCTION

Compared with other spines, the human lumbar spine receives the largest tension and pressure involved in supporting body weight. it is subject to a high risk of damage because its range of motion is large and the frequency of occurrence of herniated nucleus pulposus (HNP) in the lumbar spine is also high. Around 95% of lumbar spinal HNP cases occur in L4-5 or L5-S1. The peak incidence of HNP is between 30 and 55 years of age and the majority of herniated discs occur in a posterolateral direction[1)].

In measuring lumbar lordosis, magnetic resonance imaging (MRI) showed higher reliability between measurers than radiography and its reliability within each measurer was close to zero[2)]. Methods to diagnose lumbar spinal HNP include myelography, computed tomography, and MRI. Of them, MRIing enables analyses of the anatomical structure of the spine, nucleus pulposus displacement, anterior and posterior longitudinal ligament rupture, and the normal structure of the lumbar spine[3)]. Because the lumbar curvature is believed to be an important consideration in lumbar spinal HNP patients, studies of lumbar lordosis, lumbar spinal angles, disc heights, or sacral gradients in lumbar spinal HNP patients are being conducted. Previous studies using radiography included those using radiography conducted on the lumbar lordosis of normal persons or back pain patients[4)], lumbar lordosis of pregnant women[5)], lumbar lordosis in relation to the height of shoe heels[6)], lumbar lordosis before and after exercises

for stabilizing the lumbar region. Previous studies using MRI are limited to a study on lumbar lordosis and the lumbosacral angle before and after disc surgery[7], and a study on L4-5 lumbar angle and disc height[8].

In this respect, this study compared and analyzed lumbar lordosis, L4-5 disc angles, L4-5 disc heights, and lumbosacral angles in the L4-5 HNP group with a control group. In additional, this study analyzed the correlationship between lumbar lordosis, L4-5 disc angles, L4-5 disc heights, and lumbosacral angles in order to examine the relationship between L4-5 HNP and abnormal sagittal spinal alignments.

SUBJECTS AND METHODS

This study was conducted by specialists in radiology and specialists in neurosurgery on 15 L_{4-5} HNP patients diagnosed by MRI (IASSC 1.5, Caie Company, Korea) among patients who visited S Hospital located in Daejon Metropolitan City in Korea and 15 normal adults as a control group. The research subjects in this study were aged between 25 and 45 years old, with an average age of 33.45 ± 4.56 (mean ± SD). The average height was 166.50 ± 7.32 cm and the average weight 61.10 ± 10.12 kg. As for gender, men and women were 15 each, giving equal proportion. The chi-squared tests for gender, age, height, and weight revealed statistically insignificant differences between the L_{4-5} HNP group and the control group.

The MRIs of the 30 study subjects were used to analyze lumbar lordosis, L4-5 disc angles, L4-5 disc heights, and lumbosacral angles. Patients with a history of surgical treatment of the lumbar area, systematic diseases (cancer patients), rheumatic diseases, back pain accompanied by compression fracture, disorders found in the nervous system and those born with abnormal sagittal spinal alignments were excluded from the comparative analyses of MRIs. The intention of this study and the content of the overall experiment were sufficiently explained to those subjects who participated in the comparative analyses of MRIs and their voluntary agreements to participation were received. In this study, the MRIs of L4-5 HNP patients and normal adults were used to monitor changes in lumbar lordosis, L4-5 disc angles, L4-5 disc heights, and lumbosacral angles with a full Picture Archiving and Communications (PACS) system. During MRI

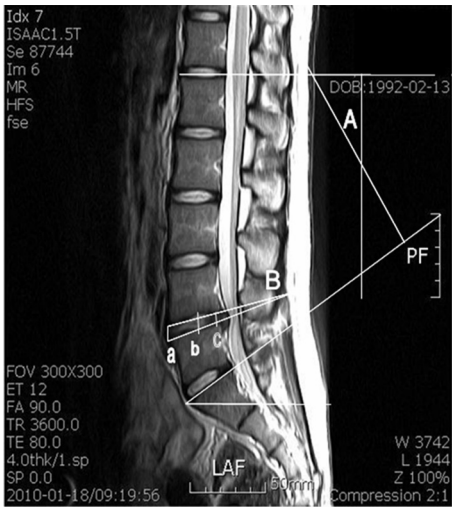

Fig. 1. Lumbar lordosis (A), L_{4-5} disc angle (B), lumbosacral angle (C), L4-5 disc height (a+b+c)/3. In a T_2 weighted sagittal image.

examination, the subjects were fixed in the supine position, and a patient was fixed by belts in order to keep both knees and both ankles from being spreading. To measure lumbar lordosis, we drew an extended line backward from the top surface of the pyramid of the lumbar spine 1 from the lateral lumbar spine. Then, we drew an extended line of the basal area of the sacral vertebra backward. Draw two vertical lines were drawn, one on each of the 2 lines, and name the angle of the crossing angle of the 2 vertical lines, A, and was measured it for comparison[9]. To measure L4-5 disc angles, we drew a extended line backward on the top surface of the pyramid of the lumbar spine 6 from the lateral lumbar spine. Then, we drew a extended line on the bottom surface of the lumbar spine 4 backward and name the angle of the crossing angle of the 2 lines, B, and measure it for comparison[8]. To measure L4-5 disc heights, the disc heights of the front part, the middle part, and the rear part were measured on the lateral lumbar spine and the heights were averaged and divided by 3: The formula for disc height measurements is (a+b+c)/3(mm)[10]. To measure lumbosacral angles, we drew a extended line on the basal area of the sacral vertebra backward from the lateral lumbar spine. At the point where this line meets with the pelvis, we drew a line parallel to the outline of the film and name angle of the crossing angle of the 2 lines, which is the lumbosacral angle, C, and was measured (Fig. 1)[9,11].

The measured data were analyzed using the SPSS 12.0 KO (SPSS, Chicago, IL, USA) statistics program. The differences between the 2 groups were tested using independent t-tests; Pearson correlation coefficient analyses were conducted to monitor the correlations between L4-5 HNP, lumbar lordosis, L4-5 disc angles, L4-5 disc heights, and lumbosacral angles. The statistical significance level α was set to 0.05 in all the cases.

Table 1. Comparison of lumbar lordosis, L_{4-5} disc angles, disc heights L_{4-5}, and lumbosacral angle between L4-5 HNP patients and the Control group (unit: degree)

Category	L_{4-5} HNP	Control
Lumbar lordosis*	34.04 ± 4.76	46.17 ± 3.49
L_{4-5} disc angle*	7.69 ± 1.24	12.78 ± 0.43
L_{4-5} disc height*	9.27 ± 1.23	13.46 ± 0.75
Lumbosacral angle*	33.05 ± 5.01	39.60 ± 2.74

* $p<0.05$.

RESULTS

We compared of the lumbar lordosis, L4-5 disc angles, L4-5 disc heights, and lumbosacral angles of the 2 groups with each other, and the MRIs of the HNP group and the control group were analyzed with a full PACS system. The results show the degrees of lumbar lordosis, L4-5 disc angle, L4-5 disc height, and lumbosacral angle of the HNP group were significantly smaller than those of the control group statistically ($p<0.05$)(Table 1). The correlations between the lumbar lordosis, L4-5 disc angle, L4-5 disc height, and lumbosacral angle of the HNP group in the HNP group, the lumbar lordosis, L4-5 disc angle, L4-5 disc height, and lumbosacral angle showed positive correlations, indicating that as the lumbar lordosis decreases; the L4-5 disc angle, L4-5 disc height, and lumbosacral angle will also decrease. In particular, the lumbar lordosis and the L4-5 disc angle and L4-5 disc height showed strong positive correlations (Table 2).

DISCUSSION

Changes in postures are important risk factors for back pain. Abnormal postures produce strain on ligaments and muscles and affect lumbar lordosis[4]. An abnormal results in the development and progression of lumbar lordosis make spinal osteoarthritis. Degenerative changes in the spine make the loads imposed on the spine distribute abnormally, which will result in the breakdown of the spinal form[12]. This study was intended to examined the relationship between L4-5 HNP and abnormal sagittal spinal alignments; by analysis of the MRIs of an L4-5 HNP patients group and normal adults were analyzed. Based on the results, HNP patients showed a significantly smaller degree of lumbar lordosis, L4-5 disc angle, L4-5 disc height, and lumbosacral angle than the control group. In the study of Kornovessis, the lumbar lordosis of normal adults was 45°. This study also showed a similar result, 46.17 ± 3.49°. The lumbar lordosis of L4-5 HNP patients was a ($p<0.05$), which revealed a smaller angle than the normal lumbar lordosis.[13]

Kimura et al. study imposed a load of 50% of body weight on each of 8 young subjects from the shoulder toward the feet and measured the lumbar spine angles and disc heights before loading and under load using MRI[8]. Based on the results, they reported that whereas the lumbar spine angles between L4-5 did not change, the disc heights between L4-5 significantly decreased, indicating that pressures in the vertical directions would results in decreased disc heights. Von Lacum et al. study suggested that, because an increased degree

Table 2. Correlation of the lumbar lordosis, L_{4-5} disc angle, disc height L_{4-5} and lumbosacral angle in L4-5 HNP patients (unit: degree)

Category	Lumbar lordosis	L_{4-5} disc angle	disc height L_{4-5}	Lumbosacral angle
Lumbar lordosis	1.00			
L_{4-5} disc angle	0.81**	1.00		
L_{4-5} disc height	0.77**	0.90**	1.00	
Lumbosacral angle	0.62**	0.63**	0.67**	1.00

**$p<0.01$.

of lumbar lordosis would increase the shear force on the lumbosacral junction, back pain patients would bend the lumbar spine to minimize the shear force on the lumbosacral junction, a strategy which would eventually decrease the degree of lumbar lordosis[14]. Taking these results are put together, back pain is considered a functional problem; and thus, differences in the degrees of lumbar lordosis are not remarkable among patients. In contrast HNP resulted in unbalanced alignments and the consequent structural problems such as shear force thereby brought about decreased degrees of lumbar lordosis, disc angles, disc height, and lumbosacral angles. Therefore, additional studies comparing the imbalance in the spines and muscles of simple back pain patients with those of HNP patients will be necessary. In this study, it was seen that, as the degree of lumbar lordosis decreased, L4-5 disc angle, L4-5 disc height, and the lumbosacral angle also decreased and, in particular, very high correlations were shown between lumbar lordosis, L4-5 disc angle, and L4-5 disc height. Evcik and Yücel's study took lateral view radiographs of 50 chronic back pain patients and 50 acute back pain patients in standing postures to analyze the correlations between the angles of the lower lumbar spine and spinal mobility[4]. Based on the results, they reported that when the mobility of lumbar spinal extension was large, the sacral inclination angle was also large ($p<0.005$, $r=0.32$), and that chronic back pain affected the angles of the lower lumbar spine and spinal mobility. This result can be considered the same as the result of this present study Which indicates the lumbosacral angles of L4-5 disc patients would be smaller compared with normal persons.

Based on the study results mentioned here, it can be inferred that the lumbar lordosis, L4-5 disc angles, L4-5 disc heights, and lumbosacral angles of L4-5 HNP patients will be less than those of normal persons. In addition, as the degree of lumbar lordosis would decreases, L4-5 disc angle, L4-5 disc height, and the lumbosacral angle will also decrease. Therefore, We conclude that L4-5 HNP patients have abnormal sagittal spinal alignments.

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