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Original Article

Determination of the anatomic factors that affect the pain values in LDH diagnosed patients

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ABSTRACT

Introduction: Lumbar disc herniation (LDH) is one of the important diseases that cause lumbar pain. In this study to find the cause of the pain, the anatomical alterations of patients without spinal stenosis were examined through MRI retrospectively.
Methods: Seventy people with lumbar pain and seventy people who were diagnosed with L4-L5 lumbar disc hernia without spinal stenosis were selected respectively as the control group and the patient group. The maximum anterior-posterior hernia length and hernia width and spinal canal's sagittal-transverse diameters were measured on the T2-weighted axial and sagittal magnetic resonance images.
Results: The measured visual analog scale (VAS) values were compared between genders and the two groups and between herniation and spinal canal diameter. VAS values were found statistically significant between the groups ($p < 0.001$).
Discussion: LDH did not always coexist with spinal stenosis and by selecting only patient with L4-L5 LDH level we put forward that anatomic structures surrounding the disc heniation were not affected by the intervetebral disc (IVD) degeneration. Specially the herniation length is significant than the herniation width due to the risk of the dural sac remaining under central pressure depending on the length of increase of IVD. These findings also disclose the reason for the rise in the VAS value in LDH patients.

1. Introduction

Particularly acute and chronic neck and lumbar pains are among the most important health problems of our society and even the world.[1] It is known that this health problem takes place near the top and leads to serious curtailment of social activities and loss of man hours. Lumbar disc hernia (LDH) is one of the important diseases that cause lumbar pain.[2] Pain is seen particularly in the L4-L5 intervertebral disc (IVD) level of this disease.[3–5]

Lumbar pain reveals itself mostly as the first sign of the disease. It usually starts at once and gains continuity by being intensified from time to time. Sinuvertebral nerve endings lead to deep local pain in lumbar and to spasm in paravertebral muscles as a reflex when they are stimulated with the biochemical and mechanical effects of herniated nucleus pulposus and decline and tearing of posterior longitudinal ligament and annulus fibrosus. If the nerve endings are over-stimulated, the pain spreads to hips and sacroiliac joint region deeply and diffusely. This pain, which cannot be localized by patients well, is called discogenic, non-radicular or sclerotogenous pain.

Events increasing the intrathecal pressure, such as coughing and straining, on some positions and movements, sharpen the pain. Percussion of the processus spinosus at the distance where IVD hernia exists causes pain. Postural disorders in spine come up as a protection position according to the pressure implemented by the IVD hernia to nerve root. Scoliosis develops towards the other side in case of a lateral pressure and to the same side in case of a medial pressure on the nerve root and so the nerve root is to be relieved. The patient is in the position of leaning forward in cases of medial pressure. The lumbar lordosis frequently flattens out in such cases. Particularly the stoop and recurvation, both movements of lumbar, may be painful. Lumbar pain may disappear with the tearing of the annulus fibrosus and radicular symptoms may increase. Dermatogenic (radicular) pain may develop with the irritation of the nerve roots. This pain can be well localized and has a sharp and stinging characteristic which suits the relevant nerve

Abbreviations: LDH, Lumbar Disc Hernia; IVD, Intervertebral Disc; VAS, Visual Analog Scale; HI, Herniation Index.

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root dermatome. The pain spreads from the rear side of the femur to the leg dermatomally. While the rise in intrathecal pressure increases the pain, resting usually decreases it.[6]

Pain can be measured with the use of unidimensional or multidimensional measurement methods. The severity and decrease of pain are measured mostly through unidimensional methods. The main ones of these methods are as follows:

- Visual Analog Scale (VAS)
- Category Assessment Scale (Verbal Pain Rating Scale = VPRS)
- Numeric Pain Rating Scale (Numeric Pain Rating Scale)

The VAS is an extremely simple, efficient, repeatable scaling method that requires minimal tools. It is applied frequently in cases where scaling of the pain level is required rapidly under clinical conditions. Two definitive words of the subjective category exist in both ends of a line. Patients are told to mark the place on the line conforming to the severity of pain they feel.

The principal advantage of the use of VAS as a scale of pain rating level is its capability to rate pain differently from many other measurement methods. Thanks to this capability, it is possible to talk about the percental difference between the VAS measurements in different time intervals.

It is known that radiological imaging methods matter in the definition of level and settlement of LDH, which causes pain as well as sensory and motor losses, implementation of the conservative treatment and when it is decided whether a surgical intervention is needed or not. The first study on this subject was performed by Jackson in 1989. CT, myelography and MRI findings were compared in this study and it was reported that the MRI had better values for making accurate diagnoses.[7] Advanced radiological methods were used in many scientific studies performed on LDH until today. MRI and CT are the primary techniques among these methods.[8–10] CT and MRI images were compared in many studies and it was reported that there was not a big difference between the two methods and they had the same structural properties except for the nerve root pressure.[11–13] It was reported that the MRI was more reliable compared to other imaging methods with regards to showing early period disc degeneration and providing direct imaging on the sagittal plane.[14]

2. Material and method

There were 140 patients who were admitted to the Brain and Nerve Surgery Polyclinic of the Research and Application Hospital with a complaint of lumbar pain included in the study, which was started with the preliminary approval received from Kocaeli University Human Research Ethical Committee. The MRI images of these patients were examined retrospectively and 70 cases with LDH diagnosis were accepted as the patient group and 70 cases that were not diagnosed with LDH were accepted as the control group. The patient group was only patients with LDH without any spinal pathology. The control group was only patients with low back pain without any LDH or other spinal pathology. The same patients were also examined for lumbar spinal stenosis coexisting frequently with lumbar disc hernia and in both groups, patients with spinal stenosis were not been included to study because spinal stenosis could increase the low back pain and increase the VAS value. When determining the patient group, only the cases with L4-L5 posterior disc hernia were selected. Cases with disc degeneration, disc hernia or spinal pathology other than L4-L5 levels, were not included in this study. The age range of the patient group, who were included in the study without making any discrimination in terms of gender, was 30–65 and it was 33–57 for the control group. T2 weighted axial and sagittal images of all MRI scans belonging to all of the cases were analyzed and their measurements were performed on a computer.

During the evaluations, information related to gender, age and the VAS received from the patient folders were used. The values described by patients for the pain levels between 1 and 10 were used as the VAS values.

The anterior-posterior herniation length (AB) and the herniation width (CD) as from the midpoint of the AB length were measured in the axial section of the MRI image of the patient group. These measurements were not performed in the control group due to the absence of herniation. Besides, sagittal (EF) and transverse (GH) diameters of the spinal canal were measured on the same sections in both groups.

An Index of Hernia (HI) was generated in order to define the ratio between spinal canal and herniated disc material. The more Index of hernia means, the more spinal canal spinal canal is being covered by disc material. As a result of measurements and in order to obtain an index of hernia, the formula given below was used.[15]

$$HI = [(AB \times CD)] / [(EF \times GH)] \times 1000$$

AB: Anterior-posterior herniation lengthCD: Herniation width as from the midpoint of the AB length EF: Sagittal (EF) diameter of the spinal canalGH: Transverse (GH) diameter of the spinal canal

Also to determine the relation between the degeneration of the surrounding anatomical structure and the herniated disc the L4-L5 vertebral body height, the width of spinal canal at L4-L5 IVD hernia level are measured. In order to compare, height of IVD one level up and down of level of hernia and width of spinal canal on that level were also measured. These measurements are width of spinal canal from back-middle point of L3- L4 IVD, height of L3-L4 IVD, width of spinal canal from back-middle point of L5-S1 IVD and height of L5-S1 IVD. Same measurements were also done for control group.

Statistical analyses were made in order to determine whether there is a significant difference between the measurements performed in the control and patient groups. Independent *t*-test was used in the comparison of the data. Chi-square test was used for the distribution of the two groups according to gender; and Spearman's correlation test was used for the VAS distribution between the two groups, between HI and VAS, between the herniation width and VAS, between the spinal canal diameters and VAS and in the distribution of spinal canal diameters according to gender. All data obtained was evaluated in SPSS 16 program ($p < 0,001$ was accepted significant).

3. Results

Included in our retrospective study, 70 of the 140 patients constituted the control group and 70 constituted the patient group; 86 (61.4%) were female and 54 (38.6%) were male. There were 47 of the 86 females in the control group and 39 in the patient group; 23 of the 54 males were in the control group and 31 were in the patient group (Table 1).

Independent sample *t*-test was made for the comparison between the measurements performed on the T2 sagittal and axial

Table 1
Numerical distributions of gender between groups.

Groups				P
Gender	Control	Patient	Total	
Women	47	39	86	0.166
Men	23	31	54	
Total	70	70	140	

Numerical distributions of the control group and patient group according to gender.

sections in the MRI images of the control and patient groups. The mean and standard deviation values obtained in the result of the *t*-test were calculated. Accordingly, a statistically significant difference was determined between the intergroup VAS mean values. *T*-test was implemented in order to determine the VAS mean values of the control and patient groups and a statistically significant difference was found ($p < 0{,}001$). The mean values obtained are 4.83 ± 0.7 for the control group and 7.23 ± 1.4 for the patient group. Spearman's correlation test was implemented for the intergroup VAS distribution (Table 2).

Therefore correlation graphics were performed to demonstrate relationship between several values and according to the correlation graphic between the VAS and the anterior-posterior disc herniation length (AB) (Fig. 1), a positive and strong relationship (r^2: 0,83) (CI: 0,77–0,87) was determined between the two values.

Correlation graphic was created between the measured herniation width (CD) and the VAS and it was determined that VAS values were in a positive relationship (r^2: 0,76) (CI: 0,68–0,72) with the herniation width (Fig. 2).

According to the herniation index and VAS correlation graphic obtained, it was determined that the VAS values were in a strong and positive relationship (r^2: 0,67) (CI: 0,57–0,75) with the herniation index (Fig. 3).

Furthermore the correlation graphic between the herniation index (HI) and the herniation width (CD) demonstrate a positive and strong relationship (r^2: 0,80) (CI: 0,73–0,85) between the two values (Fig. 4)

4. Discussion

The VAS is an extremely simple and efficient method to rate pain level and it is possible to talk about the percental difference between the VAS measurements in different time intervals. Therefore in this study we correlate the VAS value with IVD lenght and width to determine the increase of the pain in LDH patients. In this study we have define a VAS value for control group and patient group. The mean VAS value for control group was 4.83 ± 0.7 and 7.23 ± 1.4 for the patient group. In a other study VAS scores have been define before and after surgery and the mean VAS value for radicular pain was 8.02 in the preoperative period and respectively 4.07 and 2.3 and early postoperative periods and 3 months after surgery.[16]

The maximum anterior-posterior hernia length of L4-L5 IVD (AB) and hernia width (CD) were compared with the VAS in order to determine the anatomic factors that affect the VAS values (Figs. 1 and 2). Positive correlations were obtained in both comparisons statistically ($p < 0{,}001$). According to the herniation index and VAS correlation, it was determined that VAS values were in a positive and strong relationship with the herniation index (Fig. 3). When the correlations of AB and CD with VAS were compared with each other, it was determined that the AB value was more effective in the increase of VAS value. Hereunder, due to the risk of the dural sac remaining under central pressure depending on the length of increase of the maximum anterior- posterior hernia length of IVD, the VAS values defined by patients tend to increase as well. Similar to Yussen[17], we think that the data obtained about the correlation of VAS and herniation size would be helpful in determining the

Table 2
Distribution of VAS values ($p < 0{,}01$) between groups.

Groups		N	Average	Standard Deviation	P
VAS	Control	70	4.83	0.722	<0.001
	Patient	70	7.23	1.426	

The VAS mean values define a statistically significant difference between the control group and patient group ($p < 0{,}001$).

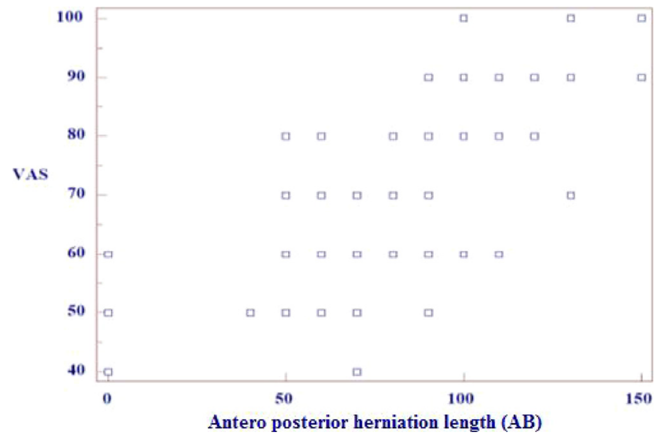

Fig. 1. The correlation graphic between the VAS and the anterior-posterior disc herniation length (AB) (r^2: 0,83) (CI:0,77–0,87).
According to the correlation graphic between the VAS and the anterior-posterior disc herniation length (AB), a positive and strong relationship was determined between the two values.

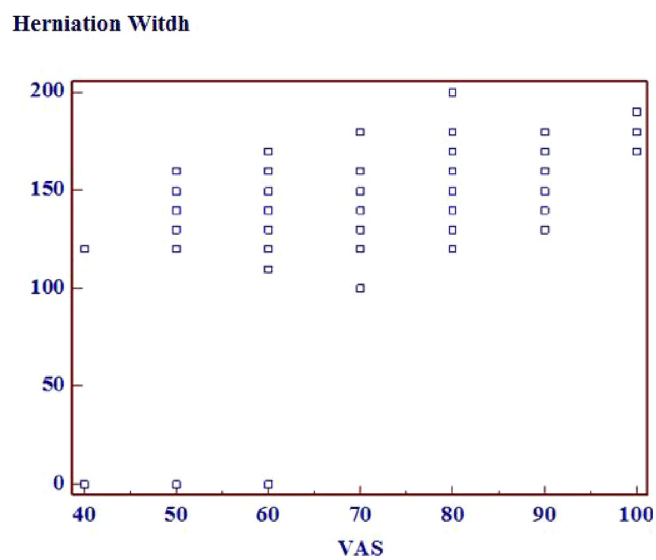

Fig. 2. The correlation graphic between the herniation width (CD) and the VAS (r^2: 0,76) (CI: 0,68–0,72).
Correlation graphic was created between the measured herniation width (CD) and the VAS and it was determined that VAS values were in a positive relationship with the herniation width.

extend of hernia. In a similar study, it was determined that the anterior-posterior hernia length was a decisive finding for the surgical intervention.[18,19] However, differently from the said study, no significant difference was found between females and males for the AB value in our study ($p > 0.001$). According to Tanq et al. the initial pain scores (JOA) that they determine on patients with single-level LDH showed significantly positive correlation with spinal canal midsagittal diameter and

available diameter, lateral recess width, and canal and dural sac area ($p < 0.01$); also presented positive correlation with the ratio of available diameter to midsagittal diameter and the ratio of lateral recess width to midsagittal diameter ($p < 0.05$); but there was a significantly negative correlation between initial JOA scores and the area ratio of dural sac to spinal canal.[20]

According to literature not enough study have compared the hernia measurements with the VAS but a new study give a good perspective to this subject; Cuchanski et al.[22] have measured percent occlusion of the spinal canal and intervertebral foramen by

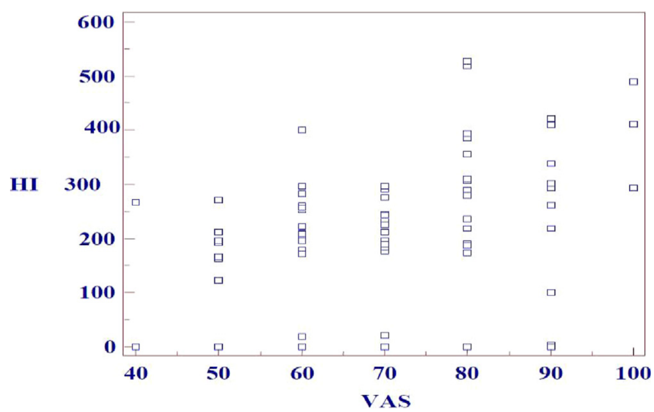

Fig. 3. The correlation graphic between herniation index (HI) and VAS (r^2 :0,67) (CI: 0,57–0,75).
According to the herniation index and VAS correlation graphic obtained, it was determined that the VAS values were in a strong and positive relationship with the herniation index.

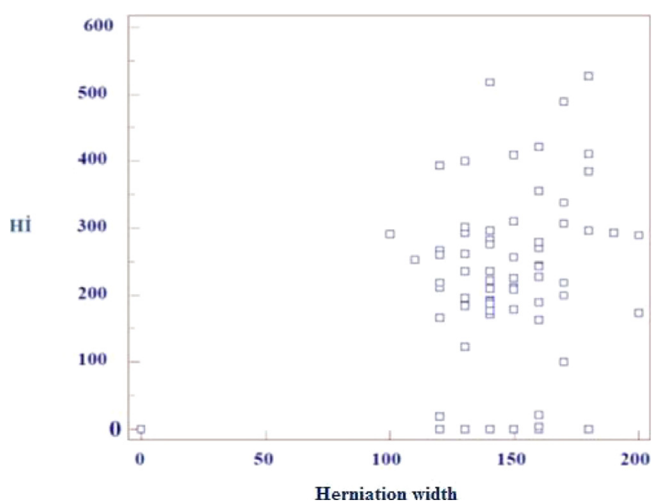

Fig. 4. The correlation graphic between the herniation index (HI) and the herniation width (CD) r^2 :0,80 (CI: 0,73–0,85).
A positive and strong relationship was determined between the two values in the correlation between the herniation width and the herniation index, r^2: 0,80 (CI: 0,73–0,85).

disc bulge under different loading conditions by using CT images. They used human lumbar spine cadaveric specimens and obtain two measurements (spinal canal depth and IVD width). They define a mean spinal canal depth and a mean foraminal (IVD) width as 19 ± 4 mm and 5 ± 2 mm, respectively. Their objective was to quantitatively assess the percent occlusion of the spinal canal and intervertebral foramen by disc bulge under different loading conditions. They define that the disc bulge at the posterior and posterolateral sites of the intervertebral disc under 3 different load protocols (axial compression, flexion/extension, and lateral bend) and maximal and overall occlusion percentages were greatest at the intervertebral foramen. Furthermore, the results of this study support the proposal that exiting neural elements at the location of the intervertebral foramen are the most vulnerable to impingement and generation of pain. In the context of this study, pain generation is defined as stimulation of pain nerve fibers by mechanical compression. stimulation of pain nerve fibers potentially could generate a subjective feeling of pain.[21]

In this study, first, a value was obtained by subtracting the maximum anterior-posterior disc length (AB) from the maximum anterior-posterior canal width (EF) in order to determine whether there is a correlation between the diameter of spinal canal and the VAS. This value is the distance of the remaining spinal canal as from the rear midpoint of hernia. The correlation between the value we obtained and the VAS was evaluated. A statistically negative correlation was determined between them. In a word, as the difference between the anterior- posterior diameter of hernia and the sagittal diameter of the spinal canal decreases, the VAS increases. And this supports our idea that hernia exerted pressure on the dural sac. Concordantly, the VAS value is shown as 6 and above in patients with a disc hernia. In another study where the mean pain value was 7.9, the need for discectomy was emphasized. The positive relationship between the herniation index and VAS correlation also supports our idea. In a study performed on LDH, an index was obtained with the dividing of hernia material's diameter to the maximum anterior-posterior spinal canal diameter and it was shown that as this rate decreased, the pain decreased as well.[8] Furthermore in a complex study researchers made several measurement related to spinal canal and dural sac. They compared width and height of the spinal canal on preoperative and postoperative MRIs in the supine position (The mean width increased from 9 ± 1.6 mm to 12.8 ± 2.3 mm. The mean height increased from 11.4 ± 2.3 mm to 16.1 ± 2.3 mm with) and also they have performed an intraoperative measurement of the spinal canal using a caliper in prone position. They define VAS scores improved significantly from 44.3 to 16.1 mm (leg pain) and from 52.7 to 26.8 mm (back pain) on a 100-mm scale. According to this study authors determine that changes in lumbar spinal canal morphology due to different postures between the intraoperative situation (prone) and the radiological situation (supine) can not be used as an argument to explain the differences seen in intraoperative dimensions by the surgeon and postoperative dimensions on MRI. They define that the height of the dural sac was significantly smaller on prone MR images, suggesting that position does play a role in spinal canal morphology. This could be explained by increased lordosis and therefore increased compression of the dural sac when patients are lying in the prone position.[22]

5. Conclusion

As a result of our study, we determined that LDH did not always coexist with spinal stenosis because patients with only LDH have mentioned a high value of VAS. Furthermore, by selecting only patient with L4-L5 LDH level we put forward that anatomic structures surrounding the disc heniation were not affected by the IVD degeneration. We suggest that many study will support our finding in this regard.

As the herniation index increases, the need for a surgical intervention increases; this is because as the disc area with herniation increases, the spinal canal areas decrease. Specially the herniation length (AB) is significant than the herniation width (CD) due to the risk of the dural sac remaining under central pressure depending on the length of increase of IVD. These findings also disclose the reason for the rise in the VAS value in LDH patients.

Conflicts of interest

All the authors have none to declare.

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