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RESEARCH ARTICLE

ANALYSIS OF THE EFFECTS OF ALTERATIONS OF ANTHROPOMETRIC CHARACTERISTICS OF THE SPINAL CANAL AND INTERVERTEBRAL DISC THAT AFFECT LUMBAR PAIN IN PATIENT WITH LDH

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ABSTRACT

Aim: We aim to identify the anatomical changes, of the anatomical relevant region on the spinal canal, lumbar vertebrae and intervertebral disc to determine the causes of pain in patient with lumbar disc herniation.

Methods: The heights of vertebral body and intervertebral disc, anterior-posterior transverse diameters of disc herniation and sagittal-transverse diameters of spinal canal were measured on the T2-weighted axial and sagittal MRI. Measured values, gender, age and visual analogue scale (VAS) value were statistically compared in two groups and in two genders.

Results: A significant difference was found between the sagittal diameters of spinal canals of the two groups ($p<0.001$), while a significant difference was not found between genders ($p=0.45$). As for the relationships between the disc herniation diameters and VAS, it was determined that anterior-posterior diameters were statistically more significant in the increase of pain ($p<0.001$).

Conclusion: 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 herniation were not affected by the intervertebral disc degeneration. Furthermore sagittal diameter of spinal canal and anterior-posterior length of herniation were significant in the increase of pain in cases with LDH due to the risk of the dural sac remaining under central pressure.

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INTRODUCTION

Vertebral column is the structure that protects the body posture and medulla spinalis inside the spinal canal (SC); and the intervertebral disc (IVD) taking part between vertebrae provides a definite springiness against the load over the spine. Under pressure the flexible annulus fibrosus remain intact but nucleus pulposus herniates and let into the SC and may apply pressure on the spinal nerves and even on the medulla spinalis. Degenerative alterations may develop in discs with advancing age. The disc herniation may come up at any region throughout the whole vertebral column (Yussen and Swartz, 1993; Takada and Takahashi, 2001; Borota *et al.,* 2008). The most common radiculopathies caused by lumbal disc herniation (LDH) are symptoms in the lower extremity (Kuslich *et al.,* 1991). In the wake of neuroanatomical studies, the presence of sinuvertebral nerves was identified inside the SC and these nerves end at the posterior longitudinal ligament and the exterior lamina of annulus fibrosus.

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Thus, the reason of the back pains in patients with LDH was found in terms of anatomic structures (Fishgrund *et al.,* 1993). Lumbar spinal stenosis (LSS) is the constriction of the lumbar part of the SC with various reasons (Fritz *et al.,* 1998). Congenital malformations, development defects, degenerative alterations, disc herniation or their combinations are among these reasons. The extension of the vertebra leads to constriction both in the central and lateral canals by triggering rearward protrusion of IVD and brimming of ligamentum flavum. The SC diameter decreases 9% with normal extension of spine, while it increases up to 67% in serious stenotic vertebra (Inufusa *et al.,* 1996). One of the dynamic factors that lead to the stenosis of SC is axial load and it was reported more comparing to the stenosis taking place in the extension (Schönström *et al.,* 1989). Particularly the decrease in disc height in old age leads to loosening of the ligaments that support the vertebral bodies, and so to increase of instability (Herno *et al.,* 1993). Lumbal disc herniation and lumbal spinal stenosis are the most common diseases that cause lumbar back pain. To know the anatomic structures that affect pain is important for doctors and surgeons to decide on the type of treatment. According this, in our study we expected to find the cause of the lumbar pain.

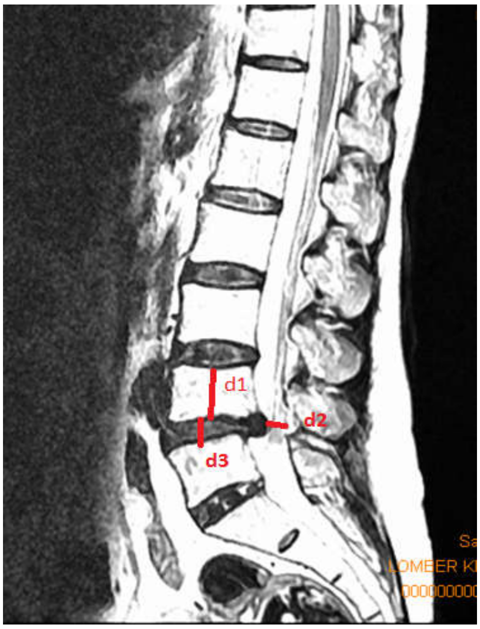
MATERIAL AND METHODS

140 patients who admitted to the Brain and Nerve Surgery Polyclinic of Research and Application Hospital with the complaint of lumbar pain were included in the study. 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 LDH were accepted as the control group. When determining the patient group, only the cases with L4-L5 posterior disc herniation were selected. Cases with vertebra degeneration or disc herniation except for L4-L5 levels were not included in this study. The same patient group was examined also due to spinal stenosis coexisting frequently with LDH. 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 in the control group. T2 weighted axial and sagittal images of all MRI images belonging to all of the cases were analyzed and their measurements were performed. Height of vertebral body (d1) was measured at L4 herniation level, SC width (d2) was measured at L4-L5 IVD herniation level and L4-L5 IVD height (d3) was measured in the T2 weighted sagittal image of the patient group. In addition, the heights of IVDs in the upper and lower levels of the herniation level and the width of the SC were measured in order to make a comparison.

In these measurements; the SC width as from the rear-midpoint of L3-L4 IVD was (d4), the height of L3-L4 IVD was (d5), the SC width as from the rear-midpoint of L5-S1 IVD was (d6) and the height of L5-S1 IVD was (d7). The same measurements were performed for the control group as well. Due to LDH was lacking in the control group, the measurement of the SC (d2) was performed as from the rear-midpoint of L4-L5 IVD (Figure 1). 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 lacking of herniation. Besides, sagittal (EF) and transvers (GH) diameters of SC (Figure 2) were measure on the same sections in both groups (Table 1).

RESULTS

Included in our retrospective study, 70 of the 140 patients constituted the control group and 70 constituted the patient group, and 86 (61.4%) were female and 54 (38.6%) were male. 47 of 86 females were in the control group and 39 were in the patient group; and 23 of 54 males were in the control group and 31 were in the patient group. Independent sample t test was made for the comparison between the measurements performed on the T2 sagittal and axial sections in the MRI images of the control and patient groups. Accordingly, statistically significant differences were found between the mean ages of the groups, SC widths at L4-L5 IVD herniation level, anterior-posterior herniation lengths of L4-L5 IVD and the sagittal diameters of SC at L4-L5 level. The diameters of SC of 140 cases were measured indiscriminately between the control and patient groups through the T2 axial images; the sagittal diameter was determined as 18.05 ± 2.0 mm in females and as 18.37 ± 2.9 mm in males; the transverse diameter was determined as 26.26 ± 2.9 mm in females and as 25.81 ± 4.0 mm in males on the average (Table 2). According to these values obtained, a statistically significant difference was not found between genders ($p>0.001$).



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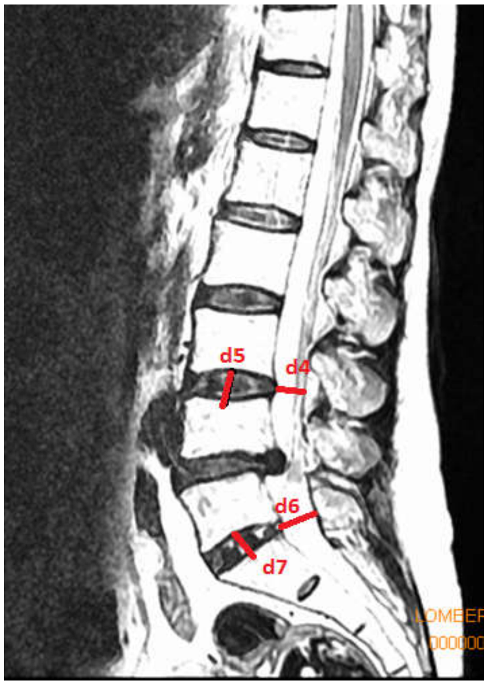

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Figure 1 a-b. T2 weighted sagittal image of L4-L5 LDH. **(d1)** Height of vertebral body at L4 herniation level; **(d2)** spinal canal width at L4-L5 IVD herniation level; **(d3)** L4-L5 IVD height (a). **(d4)** spinal canal width as from the rear-midpoint of L3-L4 IVD; **(d5)** height of L3-L4 IVD; **(d6)** spinal canal width as from the rear-midpoint of L5-S1 IVD; **(d7)** height of L5-S1 IVD (b).

In the result of the evaluation of the transverse and sagittal diameters of the SC measured according to gender difference inside the same group, the mean value of the transverse diameter of SC was 26.51 ± 2.5 mm and the mean value of sagittal diameter was 17.53 ± 1.8 mm for females in the control group. The mean value of the transverse diameter of SC was 25.74 ± 3.7 mm and the mean value of sagittal diameter was 17.04 ± 2.7 mm for males in the control group (Table 3). A statistically significant difference was not found in the comparison related to the diameters of SC ($p>0.001$). The transverse diameter mean value was 25.95 ± 3.4 mm and the sagittal diameter mean value was 18.67 ± 2.0 mm for females in the patient group.

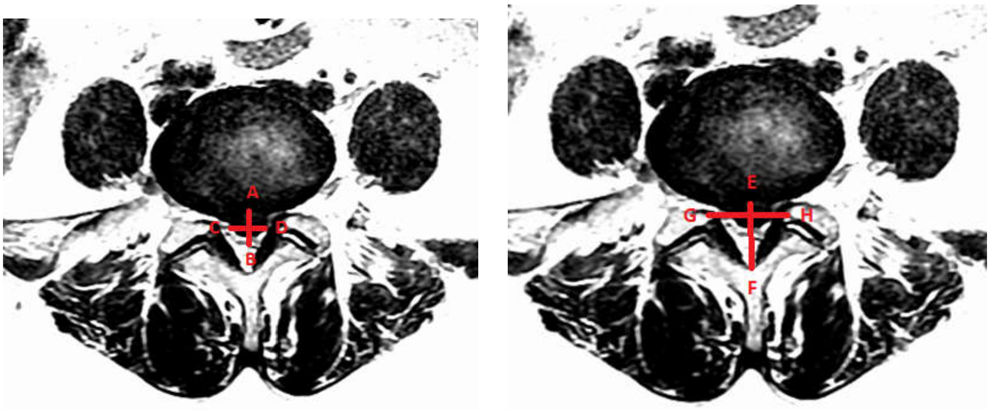

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Figure 2 a-b. T2 weighted axial image of herniated disc. (AB) Anterior-posterior herniation length; (CD) herniation width (a). (EF) spinal canal sagittal diameter; (GH) spinal canal transvers diameter (b)

Table 1. Spinal canal, lumbar vertebra and intervertebral discs mean values according to groups

	Groups	N	Mean	Standard deviation	P value
Mean age	Control	70	42,57	5,709	
	patient	70	51,06	8,891	<0,001
Height of L4 vertebral body (d1)	Control	70	21,43	2,482	
	patient	70	21,16	1,91	0.37
Spinal canal width at L4-L5 Level (d2)	Control	70	10,96	1,245	
	patient	70	8,27	2,133	<0,001
L4-L5 IVD height (d3)	Control	70	11,16	1,681	
	patient	70	10,64	2,077	0,49
Spinal canal width of L3-L4 IVD (d4)	Control	70	11,49	1,401	0,68
	patient	70	11,69	2,551	
Height of L3-L4 IVD (d5)	Control	70	11,11	1,653	0,66
	patient	70	11,29	2,348	
Spinal canal width at L5-S1 Level (d6)	Control	70	12,06	1,887	0,12
	patient	70	12,64	2,735	
Height of L5-S1 IVD (d7)	Control	70	11,29	2,438	0,09
	patient	70	11,06	3,299	
L4-L5 anterior-posterior herniation length (AB)	Control	70	0,00	0,000	< 0,001
	patient	70	8,86	2,661	
Sagittal diameter of L4-L5 spinal canal (EF)	Control	70	18,97	2,201	< 0,001
	patient	70	17,37	2,408	
Transvers diameter of L4-L5 spinal canal (GH)	Control	70	26,26	2,996	0,63
	patient	70	25,99	3,840	
VAS	Control	70	4,83	0,722	< 0,001
	Patient	70	7,23	1,426	

Table 2. Spinal canal average length of sagittal and transverse diameter according to gender

Total patients	Spinal canal transvers diameter (mm)	Spinal canal sagittal diameter (mm)
Average of women	18.05	26.26
N	86	86
Standard deviation	2.011	2.995
Average of men	18.37	25.81
N	54	54
Standard deviation	2.999	4.057

Table 3. Spinal canal average length of sagittal and transverse diameter according to the control group gender

Gender of the control group	Spinal canal transfers Diameter (mm)	Spinal canal sagittal diameter (mm)
Average of women	26,51	17.53
N	47	47
Standard deviation	2,578	1.886
Average of men	25.74	17.04
N	23	23
Standard deviation	3.720	2.755

Table 4. Spinal canal average length of sagittal and transverse diameter according to the gender of patient group gender

Gender of the patient group	Spinal canal transfers Diameter (mm)	Spinal canal sagittal diameter (mm)
Averagen of women	25,95	18.67
N	39	39
Standard deviation	3.441	2.004
Average of men	25.87	19.35
N	31	31
Standard deviation	4.349	2.823

And these values were 25,87 ± 4.3 mm and 19.35 ± 2.8mm respectively for the transverse and sagittal mean diameters for males (Table 4). A statistically significant difference was not found in the comparison related to the diameters of SC (p>0.001). A value was obtained by subtracting the anterior-posterior disc herniation length (AB) from the sagittal diameter of SC (EF) in order to analyze whether there is a correlation between the SC and VAS at the level of IVD herniation. This value is the distance between the IVD herniation and the SC. The correlation between this value we obtained and VAS was evaluated. Accordingly, a negative correlation was determined between them. In other words, as the distance between the IVD herniation and the SC increases, VAS decreases. A significant difference was not found between the comparison made between females and males in terms of the EF value.

DISCUSSION

As is known, LDH develops in consequence of the tearing and deterioration of the structural integrity of the IVD. Due to deterioration of a healthy disc structure is extremely hard, it is reported that the vertebral body is damaged firstly when abnormal axial burdens fall on discs and that IVD fractures happen in cases of higher pressures (Boos *et al.,* 1997). For weak forces that are not enough to break up the corpus vertebrae to produce tears in discs, the histochemical structure of discs must be previously corrupted. And this may occur depending on age and genetic susceptibility (Holmes and Rothman, 1938; Morris, 1973; Humzah and Soames, 1988). All of our patients have normal anatomic structures, this makes us think that age and concomitant degenerative alterations were important factors in the development of herniation, considering the mean age of our patient group. We think that evaluating the damage in surrounding anatomic structures would play a significant role in the determination of the right treatment to be administered to patient. Various alterations occur in the shapes, structures and compositions of discs depending on age and these alterations change the mechanical properties of the vertebral column. The function disorder in the vertebral column and the frequency of the relevant pains vary by age. Due to these reasons, many researchers defined disc degeneration as the common reason for the lumbar pain in adults (Buckwalter, 1995).

Particularly the decrease in disc height in old age leads to loosening of the ligaments that support the vertebral bodies, and so to increase of instability. In addition, all these alterations may cause to spinal stenosis. In a study performed, the anterior and posterior heights of all IVDs in the lumbar region were measured in healthy females and males between the ages of 40-50 and it was shown that these heights increased in the descending order (Kapakin and Aksit, 2009). In the same study, the mean anterior disc heights at the level of L4-L5 were determined as 12.6 ± 2.4 mm in males and as 12.9 ± 2.3 mm in females; and the mean posterior disc heights were determined as 7.9 ± 2.2 mm in males and as 7.5 ± 1.7 mm in females. In our study, we determined the IVD height through a single measurement from the midpoint on the sagittal images. According to these measurements, a slight increase in the IVD heights of this region was observed downwards in the control group, as the L4-L5 height decreased comparing to the other levels. The studies performed support that there is a relation between the decrease of disc height, degeneration and aging (Nachemson *et al.,* 1979). In the light of this information, the mean age of the patient group in our study to be 51.06 shows parallelism with the literature information that reports age-related disc degeneration. Besides, having a great number of women with high mean age, our study is supported by the studies which report that the hormonal alterations in the menopause and postmenopausal period broke the disc structures (Fahrni and Trueman, 1965). Furthermore in this study, firstly we obtained a value by subtracting the maximum anterior-posterior disc length (AB) from the maximum anterior-posterior canal width (EF) in order to analyze whether there is a correlation between the diameter of the SC and VAS. This value is the distance of remaining SC as from the rear midpoint of herniation. The correlation between the value we obtained and VAS was evaluated. A statistically negative correlation was determined between them. In a word, as the difference between the anteriorposterior diameter of herniation and the sagittal diameter of SC decreases, VAS increases. And when we compared the relationships between VAS and SC diameters and disc herniation widths, it was came out that sagittal diameter and anterior-posterior length of herniation were significant in the increase of pain in cases with LDH.

If one or both of the sagittal and transverse diameters of the SC contract, neurological symptoms lead to clinical picture called spinal stenosis (Ng *et al.,* 2002; Zileli *et al.,* 2002). In the result of many studies performed up until today, the mean lower limit of sagittal diameter of the canal was reported as 15 mm and its transverse diameter as 20 mm (Eisenstein, 1977). In our study, we determined a minimal sagittal diameter as 14 for both gender and a minimal transverse diameter as 19 mm for females and 20 mm for males. In line with these values we obtained, we have seen that a serious spinal stenosis did not coexist with LDH in our cases. The pathological alterations in the sagittal and transverse diameters of the SC lead to aches in the lumbar region and lower extremity. Therefore, it is important to know the sizes of SC. First of all, the diameters of SC of 140 cases we included in our study were measured indiscriminately between the control and patient groups through the T2 axial images (Table 2). According to these values obtained, a statistically significant difference was not found between genders (p>0.001). However, in the comparison made between the groups, the mean sagittal diameter in the control group (Table 1), a difference was not found in the comparison of transverse diameter comparison. According to these results, we think that sagittal diameter is the significant diameter in the stenosis of SC. In a similar study, in the result of the measurements performed on BT, the sagittal diameter was found as 17.08 ± 2.50 mm in females and as 17.52 ± 2.86 mm in males; and the transverse diameter was found as 25.53 ± 3.42 mm in females and as 25.81 ±3.15 mm in males on the average (Basaloglu *et al.,* 2002).

Furthermore in our study, in the result of the evaluation of the transverse and sagittal diameters of the SC measured according to gender difference inside the same group (Table 3; Table 4) a statistically significant difference was not found in the comparison related to the diameters of SC in 3 analyses performed between the genders of the same group and between intergroup females and intergroup males (P>0.001). Besides, according to the statistics in patient groups, a statistically significant difference was not found when the heights of IVDs in the upper and lower levels of the herniation level and the widths of SC were compared (p>0.001). In various studies performed, it was reported that the SC diameters varied by genders and races. A statistically significant difference was determined in a study on the sagittal diameter measurements performed comparatively between the Italians and Indians ignoring the gender (Postacchini *et al.,* 1983), while the sagittal diameters were found in the range of 14-20 mm in Caucasian males, 12-20 mm in Caucasian females; and 13-21 mm in black males and 13-19 mm in black females (Ng *et al.,* 2002). In another study performed by Marchesi et al., the mean sagittal diameter was found as 16.9 mm and the mean transverse diameter as 24.3 mm in the measurements made directly on bone; and the mean sagittal diameter was found as 17.2 mm and the mean transverse diameter as 25.1 mm in the radiological measurements (Marchesi *et al.,* 1988).

According to literature there is not enough study demonstrating the correlation the hernia measurements and VAS. However Cuchanski et al give a good perspective to this subject. These researchers have measured percent occlusion of the spinal canal and intervertebral foramen by disc bulge under different loading conditions by using CT images. They measured the spinal canal depth and the IVD width. "They define a mean spinal canal depth and a mean foraminal (IVD) width as 19 ± 4 mm and 5 ± 2 mm, respectively. They demonstrated 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 (Cuchanski *et al.,* 2011)". This study supports the proposal that exiting neural elements at the location of the intervertebral foramen are the most vulnerable to impingement and generation of pain. Therefore we consider that mechanical compression on nerve fibers stimulate the pain. Furthermore in a complex study researchers made several measurements 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 and also they have performed an intraoperative measurement of the spinal canal using a caliper in prone position. The 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. So according to Schenck et al different postures situation changes (like prone position in intraoperative case and supine position in radiological case) in lumbar spinal canal morphology cannot 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 (Schenck *et al.,* 2016).

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 herniation were not affected by the IVD degeneration. The decrease of the intervertebral disc height is associated with age and degeneration. And when we compared the relationships between VAS and spinal canal diameters and disc herniation widths, we think that sagittal diameter of SC and anterior-posterior length of herniation were significant in the increase of pain in cases with LDH due to the risk of the dural sac remaining under central pressure.

Suggestion

While a difference was not found in the comparison of the transverse diameter of the SC we think that sagittal diameter is the significant diameter in the stenosis of SC. Therefore we consider that mechanical compression on nerve fibers stimulate the pain. To enlighten our study and reveal new ideas about this subject we think that new studies with more patients need to be performed.

Conflict of Interest: No conflict of interest was declared by the authors.

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Limitation of the study: Cases with vertebra degeneration or disc herniation except for L4-L5 levels were not included in this study.

REFERENCES

Basaloglu H, Turgut M, Basaloglu HK. 2002. Lumbal canalis vertebralis'in sagittal ve transvers caplarinin incelenmesi morfometrik ve radyolojik bir calisma. *Ege tip Dergisi.,* 41(2): 63-66.

Boos N, Dreier D, Hilfiker E. 1997. Tissue characterization of symptomatic and asymptomatic disc herniations by quantitative magnetic resonance imaging. *J Orthop Res.,* 15 (1): 141-9.

Borota L, Jonasson P, Agolli A. 2008. Spontaneous resorption of intradural lumbar disc fragments. *The spine Journal.,* 397-403

Buckwalter JA. 1995. Ageing and degeneration of the human intervertebral disc. Spine, 20: 1307-1314.

Cuchanski M, Cook D, Whiting DM, Cheng. 2011. Measurement of occlusion of the spinal canal and intervertebral foramen by intervertebral disc bulge. *SAS J.,* 1;5(1):9-15.

Eisenstein S. 1977. The Morphometric and Pathological anatomy of the lumbar spine in South African negroes and caucasoids with specific reference to spinal stenosis. *J Bone Joint Surg Br.,* 59 (2): 173-80.

Fahrni WH, Trueman GE. 1965. Comparative radiological studies of the spines of a primitive population with north American and north Europeans. *J Bone Joint Surg.,* 47: 552-555.

Fishgrund JS, Montgomery DM. 1993. Diagnosis and Treatment of Discogenic low back pain. *Orthopedic Rev.,* 22: 311-318.

Fritz JM, Delitto A, Welch WC, Erhard RE. 1998. Lomber Spinal Stenosis: A review of current concepts in evaluation, management and outcome measurements. *Arc Phys Med Rehabil.,* 79: 700-8.

Herno A, Airaksinem O, Sari T. 1993. Long-term result of surgical treatment of lumbar spinal stenosis. *Spine*, 18 (11): 1471-1474

Holmes HE, Rothman RH. 1938. Lumbar disc disease: Clinical and computed tomographic evaluation Computed Tomography of the Spine. New York.

Humzah MD, Soames RW. 1988. Human intervertebral disc: Sturcture and Function. *Anat Rec.,* 220: 337-356,

Inufusa A, An HS, Lim TM, Hasegawa T. 1996. Anatomic changes of the spinal canal and intervertebral foramen associated with flexion-extension movement. *Spine*, 21: 2412-20.

Kapakin S, Aksit D. 2009. Manyetitk rezonans goruntuleme yontemi ile lumbal intervetebral disklerin morfometrik degerlendilmesi. *Ataturk Universitesi vet Bil*., 4: (2): 77-85.

Kuslich SD, Ulstrom C, Michael CJ. 1991. The tissue origin of low back pain and sciatica: a report of pain response to tissue stimulation during operations on the lumbar spine using local anesthesia. *Othop Clin North Am.,* 22: 181-187.

Marchesi D, Schneider E, Glauser P. 1988. Morphometric analysis of the thoracolumbar and lumbar pedicles, anatomo-radiologic study. *Surg Radiol Anat.,* (10): s 317-322.

Morris JM. 1973. Biomechanics of the Spine. *Arch Surg.,* 107: 418-423.

Nachemson AL, Shultz AB, Berkson MH. 1979. Mechanical properties of human lumbar spinal segments. *Spine*, 4: 1-8.

Ng Yt, Mancias P, Butler LT. 2002. Lumbar spinal stenosis casuing congenital clubfoot. *J Child Neurol.,*17: 72-74.

Postacchini F, Ripani M, Carpano S. 1983. Morphometry of lumbar vertebra. An anatomic study in two caucasoid ethnic groups. *Clin Orthop.,* 172: 296-303.

Schenck C, van Susante J, van Gorp M, Belder R, Vleggeert-Lankamp C. 2016. Lumbar spinal canal dimensions measured intraoperatively after decompression are not properly rendered on early postoperative MRI. Acta Neurochir (Wien) 158(5):981-8.

Schönström N, Lindahl S, Willen J, Hansson T. 1989. Dinamic Changes in the Dimensions of the Lomber Spinal Canal: An Experimental study in vitro. *J Orthop Res.,* 7: 115-21.

Takada E, Takahashi M. 2001. Natural history of lumbar disc hernia with radiculart leg painSpontaneus MR Changes of the herniated mass and correlation with clinical outcome. *Jounal Orthopedic Surg.,* 9: 1-7.

Yussen P, Swartz JD. 1993. The acute lumbar disc herniation. Imaging diagnosis. Semin Ultrasound CT MR. 14(6): 389-398.

Zileli B, Ertekin C, Zileli M. 2002. Diagnostic value of electrical stimulation of lumbosacral roots in lumbar spinal stenosis. *Acta Neurol Scand.,*105: 221-227.

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