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Original Research Article

Morphometric Study of Lumbar Intervertebral Spaces (discs) by Using MRI.

Dil Islam Mansur,[a,e] Pragya Shrestha,[b,e] Sunima Maskey,[c,e] Kalpana Sharma,[b,e] Subindra Karki,[a,f] Trishna Kisiju [d,e]

ABSTRACT

Introduction: The radiological space between two vertebrae is known as intervertebral space (height) which corresponds to the thickness of the intervertebral disc. Lumbar intervertebral disc is the most important structure which maintains the spinal function. An early diagnosis of pathological changes in disc has clinical significance. Hence the study aimed to determine normal height of the intervertebral disc space and effect of aging. **Methods:** It was a cross-sectional analytical study performed on 106 images of MRI scans of lumbar region. Dimensions of lumbar intervertebral spaces (discs) such as the anterior, middle, posterior intervertebral space height were measured in millimeter. **Results:** The mean anterior intervertebral space height was gradually increased from L1-L2 level (6.91 mm) to L5-S1 level (13.55 mm). The middle intervertebral space height increased from L1-L2 level (7.89 mm) to L4-L5 level (11.96 mm) whereas at L5-S1 level, there was a decrease (11.10 mm). Similarly, the posterior intervertebral space height showed an increment from L1-L2 level (5.52 mm) to L4-L5 level (8.09 mm) except at L5-S1 level, where it was decreased (6.94 mm). All mean values were found to be higher in males than in females except posterior intervertebral space height. The height of disc was increased up to third or fourth decade followed by a decrease. **Conclusion:** Knowing the normal lumbar intervertebral space height could be helpful for clinicians to diagnose and plan for proper treatment. It may also help to generate baseline data and to produce proper devices for Nepalese population.

Keywords: Intervertebral disc, Lumbar vertebrae, MRI scan

INTRODUCTION:

The intervertebral space (height) is the typically radiological space between adjacent vertebrae which corresponds to the thickness of the intervertebral disc. It is a vital and dynamic structure which lies between the vertebrae and consists of annulus fibrosus, nucleus pulposus and end plates.[1] It enables vertebral column to develop compound movement which has the structure that can most perfectly move and withstand the axial load.[2]

Lumbar region is the most vulnerable area for the common symptom of backache.[3] It is strongly associated with degeneration of the intervertebral disc.[4] The disc degeneration is a natural aging process characterized by cellular changes in the disc which leads to decrease in the disc height.[5] However, a study suggested that average height of the disc increases with advance ageing in some discs individually.[6]

Artificial disc replacement is recently being introduced to restore the intervertebral space that maintaining spinal alignment and facilitating range

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a- Associate Professor,
b- Assistant Professor,
c- Lecturer,
d- Research Assistant,
e- Department of Anatomy, Kathmandu University School of Medical Sciences, Dhulikhel, Nepal.
f- Department of Radio-diagnosis, Dhulikhel Hospital/Kathmandu University Hospital, Dhulikhel, Nepal.

Corresponding Author:
Dil Islam Mansur
e-mail: dilislam@kusms.edu.np
ORCID: https://orcid.org/0000-0001-5958-0423

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of movement.[7] Therefore, if the size of lumbar intervertebral disc for Nepalese population is known, it may help the clinicians for proper evaluation and treatment plan. Hence, the aim of this study was to evaluate normal height of the intervertebral disc and effect of aging on the height of the disc by using Magnetic Resonance Image (MRI) scan.

METHODS:

This was a descriptive cross-sectional study conducted in the Department of Anatomy and the images were collected from the Department of Radio-Diagnosis, Dhulikhel Hospital/Kathmandu University School of Medical Sciences (KUSMS), Dhulikhel, Nepal. Approval from institutional review committee (IRC-109/19) was taken prior to the beginning of study.

A total of 106 MRI scans (56 males and 50 females) of the lumbar region of vertebral column were included for this study. The participants had undergone MRI scan for abdominal and genitourinary complaints during the period of May to December, 2019. The participants between the ages of 20 to 69 years old as well as lumbar spine appearing normal on MRI images were included in this study. MRI image of individual with congenital vertebral abnormalities, lumbar spine pathology, previous spinal surgery, screw fixed lumbar vertebrae and unclear images were excluded from the study.

The MRI scanner used for the study was a 1.5 Tesla Ingenia MRI scanner. Measurements were done at the midsagittal T2-weighted images. The intervertebral space heights between L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 were measured in millimeter (mm) by using computerized digital caliper in both genders separately.

Anterior intervertebral space height (AIVSH) was taken as the distance between the extreme anterior margins of the two adjacent vertebral endplates measured in mm as shown in fig. 1A. Middle intervertebral space height (MIVSH) was taken as the distance between the midpoints of the two adjacent vertebral endplates measured in mm as shown in fig. 1B. Posterior intervertebral space height (PIVSH) was measured as the distance between the extreme posterior margins of the two adjacent vertebral endplates measured in mm as shown in fig. 1C.

The obtained data were studied under different age groups of the participants. The age group was categorized in every 10 years.[8] The observed data were tabulated in Microsoft Office Excel 2007. The tabulated data were analyzed using Statistical Package for Social Sciences (SPSS™) software version 23.0) for descriptive statistical analysis. Independent sample Student's t test was done. P-value $p<0.05$ was considered statistically significant and the confidence interval was taken as 95%.

RESULTS:

A total of 106 MRI scans, 56 (52.8%) males and 50 (47.2%) females were included in the study. The mean age (±SD) of the studied population was 37.44±11.80 years. The mean age (±SD) of males was 37.5±11.69 years whereas 37.38±12.04 years was in females.

The mean AIVSH has cephalo-caudal gradient of increase from L1-L2 to L5-S1. There was increase in MIVSH and PIVSH from L1-L2 to L4-L5 but there was decrease in height at the level of L5-S1. [Table 1]

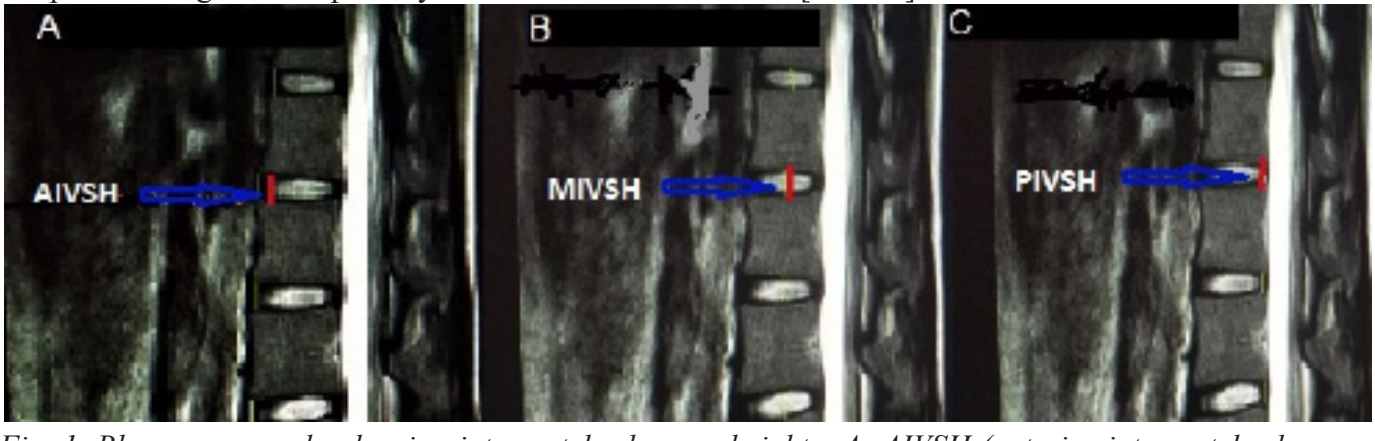

Fig. 1. Blue arrow marks showing intervertebral space heights- A; AIVSH (anterior intervertebral space height–red line), B; MIVSH (middle intervertebral space height–red line) and C; PIVSH (posterior intervertebral space height–red line).

Table 1. Intervertebral space height at various vertebral levels (Mean±SD) in mm.

	L1-L2	L2-L3	L3-L4	L4-L5	L5-S1
AIVSH	8.12± 1.28	9.53±1.42	11.15±1.60	12.92±2.03	13.55±2.47
MIVSH	8.87± 1.25	10.32±1.28	11.36±1.55	11.96±1.75	11.10±1.87
PIVSH	6.36±1.11	7.11±1.20	7.66±1.25	8.09±1.49	6.94+±1.35

Table 2. Gender-wise comparison of intervertebral space heights (mm) at various vertebral level.

Vertebral level		Males (n=56)	Females (n=50)	Statistics
L1-L2	AIVSH	8.60±1. 17	7.58±1.19	t(104,106)=4.283, p<0.05
	MIVSH	9.03±1.15	8.69±1.34	t(104,106)=0.304, p>0.05
	PIVSH	6.25±1.10	6.49±1.11	t(104,106)=-0.936, p>0.05
L2-L3	AIVSH	10.00±1.33	9.00±1.34	t(104,106)=3.866, p<0.05
	MIVSH	10.63±1.34	9.97±1.13	t(104,106)=2.577, p>0.05
	PIVSH	7.23±1.21	6.97±1.19	t(104,106)=1.553, p>0.05
L3-L4	AIVSH	11.46±1.41	10.81±1.75	t(104,106)=2.103, p<0.05
	MIVSH	11.58±1.71	11.12±1.33	t(104,106)=1.567, p>0.05
	PIVSH	7.81±1.23	7.49±1.27	t(104,106)=1.715, p>0.05
L4-L5	AIVSH	13.25±1.61	12.54±2.38	t(104,106)=1.602, p>0.05
	MIVSH	11.90±1.66	12.03±1.86	t(104,106)=-0.538, p>0.05
	PIVSH	8.30±1.38	7.85+±1.58	t(104,106)=1.537, p>0.05
L5-S1	AIVSH	13.86±2.20	13.20±2.73	t(104,106)=1.473, p>0.05
	MIVSH	11.18±1.66	11.01±2.10	t(104,106)=0.561, p>0.05
	PIVSH	7.04±1.20	6.83±1.51	t(104,106)=0.960, p>0.05

Table 3. Comparison of the mean values of the intervertebral space height among different age groups.

Vertebral level	Parameters	Age groups (years)				
		20-29	30-39	40-49	50-59	60-69
L1-L2	AIVSH	8.64±1.84	8.13±1.33	8.44±1.16	7.72±0.73	7.35±1.07
	MIVSH	8.71±1.01	8.69±1.22	9.02±1.29	9.62±1.29	8.37±0.61
	PIVSH	7.02±1.29	6.281.09	6.39±0.95	6.72±1.17	6. 42±1.82
L2-L3	AIVSH	9.44±1.97	9.63±1.47	9.85±1.01	8.93±1.21	9.08±1.26
	MIVSH	9.40±1.33	10.24±1.36	10.55±1.30	10.62±1.12	10.41±0.18
	PIVSH	7.22±1.68	7.10±1.26	7.06±1.08	7.23±1.86	6.79±1.38
L3-L4	AIVSH	10.29±2.011	11.44±1.59	11.00±1.28	10.65±1.84	10.91±1.21
	MIVSH	10.86±2.10	11.30±1.16	11.46±1.45	11.65±1.08	11.82±1.15
	PIVSH	7.40±1.76	7.85±1.06	7.63±1.49	7.17±1.00	7.55±1.15
L4-L5	AIVSH	11.77±2.65	13.18±1.99	13.07±2.10	12.53±1.46	11.59±2.35
	MIVSH	11.27±2.40	11.93±1.66	11.97±1.800	12.80±1.22	10.72±2.62
	PIVSH	8.11±1.97	8.30±1.41	7.86±1.96	7.87±1.05	7.36±1.61
L5-S1	AIVSH	13.16±2.84	13.24±2.61	13.75±1.67	14.20±2.19	14.04±2.41
	MIVSH	10.55±2.03	10.80±1.59	11.25±2.14	11.57±2.21	13.40±1.81
	PIVSH	7.29±1.33	6.89±1.33	6.93±1.87	6.74±1.46	8.38±0.79

AIVSH increased from the level of L1-L2 to L5-S1 for both sexes whereas MIVSH and PIVSH increased from the level of L1-L2 to L4-L5 and decreased at the level of L5-S1 for both sexes. There was statistically significant difference in AIVSH of male and female in the region of L1-L2, L2-L3 and L3-L4 ($p<0.05$). However, there was no statistically significant difference in MIVSH and PIVSH of male and female ($p>0.05$) [Table 2].

This study presented that there was steady increase in AIVSH up to 49 years followed by decrease after 50 years. PIVSH at the level of L1-L2, L2-L3 and L4-L5 increased up to 59 years followed by decrease after 60 years. PIVSH at the level of L3-L4 showed increase up to 49 years followed by decrease at 50 years. At the level of L5-S1 there was as continuous increase in AIVSH and PIVSH with the age [Table 3].

DISCUSSION:

The intervertebral disc connects the vertebral bodies to each other and enables them to produce compound movement. It has the structures that transmit the axial load.[2] Accurate anatomical knowledge of the disc is essential for the clinicians for diagnostic interpretation. It is not only important for the understanding of biomechanics of lumbar spine but also for various interventions such as stabilization and correction of deformities.[9]

A study observed that the mean values for anterior intervertebral space height gradually increased from L1-L2 to L5-S1 levels whereas there was increment in middle intervertebral space height and posterior intervertebral space height from L1-L2 to L4-L5 but decrease in height at the level of L5-S1 disc among the Egyptian[8] and the Iranian[10] populations which is similar to the findings of the present study. Another study done in Korea claimed a typical cephalo-caudal gradient of increment in anterior, middle and posterior heights of disc from the level of L1-L2 to L4-L5 followed by a decline at the level of L5-S1.[9]

In the present study, it was also reported that the mean values for disc heights were higher among males than females which is also supported by an another study.[2] As there is difference in stature of males and females, the difference in disc height is also anticipated.[5] However, a study claimed that there was no sexual dimorphism in anterior disc height[11] which is in contrast to this study. Moreover, the mean disc height was larger in males than female subjects at all level except at L5-S1 disc at which, the disc height was slightly larger in females.[12]

Similarly, a study reported that the L4-L5 disc was found to be the thickest which may be due to greater mobility at that level of spine.[13] A recent study also revealed that disc was found greater among the long-distance runners at the lower lumbar vertebral levels L3-L4 to L5-S1. This may be due the strongest anabolic stimulus and hypertrophic response for adaptation in the human intervertebral disc with exercise.[14] On the other hand, a study quoted that the disc height was progressively increased from L1-L2 to L5-S1 disc in both genders[11] which are in accordance with the present study except anterior disc height. However, a study also claimed that the height of L5-S1 disc was to some extent changeable: in some individuals it was small and in others it was the largest one.[12]

A study quoted that there is a continuous development and remodeling of vertebrae which may be due to the changing demands of the body.[13] In fact, in the intervertebral disc receiving continuous stress for a long period, a process of the decomposition and regenesis should be available to sustain its function.[6] It is know that there is a tendency for the general population to become taller, due to factors still under study. Anthropometric analysis shows that Humans get taller as they reach adult years and consequently the intervertebral discs height are also raised.[5]

As there is alteration in thickness of intervertebral disc with ages, it is essential for the age particular computation of the disc.[11] There was an increment in disc height up to the third or fourth decade followed by a decrease in height. But at the level of L5-S1 there was steady increase in height of the disc with the increasing age in the present study. However, a study reported that a cephalo-caudal gradient of increase was observed in the lumbar disc heights and diameters from the level of L1-L2 to L4-L5 discs followed by a decline at lumbo-sacral disc (L5-S1) especially in 5th and 6th decades. In a study, the disc heights appeared to have gained an increase in 6th decade when compared to 3rd decade with significant differences in both males and females at different segmental levels.[8]

Lumbar region is the most common site for causing low back pain due to heavy mechanical pressure on this region as compared to any other part of spine, it is more prone to be affected by degenerative changes.[15] A study claimed that lumbar degenerative disc which is age related disease is one of the causes of low back pain[16] whereas a study reported that disc herniation and nerve root compression were common in patients who presented with back pain.[15] They also reported that the most common cause of back pain is degenerative disc disease and the most common age group is in the fourth decade of life. In their findings, the degenerative discs of the lumbar spine occur most commonly at L4-5 and L5-S1. It may be happening due to the highest mechanical stress at these levels.[17,18] An another study quoted that that the most affected by degenerative diseases are the discs L5-S1, L4-L5, followed by the L3-L4.[5]

It was also important to distinguish the space height between males and females and to understand changes in height as age increases. If the height of disc is too high, then it may induce facet joint pain and if it is low, it induces early degeneration change of the facet joint.[2] The restoration of the appropriate intervertebral disc space is an important factor[2] for some therapeutic procedures like spine fusion or artificial disc replacement.[10]

The mean values of the present study were higher than that of the Korean population [2] and lower than that of the Iranian population.[10] Hence, it was indicated that variations in the measurements were found in different populations and ethnic groups. Therefore, it is important to pay attention during spine procedures, taking into account that there may be a inconsistency in size (height) between device, level, gender and the population being treated.[5]

Total disc replacement is a pioneering procedure that has gained traction in spine surgery. The objective behind it is that the removing the pain causing disc and restoring painless movement of the spinal column.[7] If there is mismatched between the device height and the disc space height that may produce neurological complications and failure of disc replacement in some sequences. Few of the complications will be permanent and require reoperations at the operated level and also in adjacent vertebrae [19,20]. Hence, knowing the disc height is mandatory for proper selection of intervertebral devices.[5]

CONCLUSION:

The present study showed that the anterior space height gradually increased cephalo-caudally whereas middle and posterior space heights increased cephalo-caudally upto L4-L5 level followed by decreased at L5-S1 level. All measurements were found to be smaller in females than males. The L3-L4 and L4-L5 discs present greater anterior height than posterior and this difference tends to decrease with aging. A good knowledge on lumbar vertebral space heights is essential for radiologists and clinicians during their routine practices, and to select the appropriate size of the artificial disc inserted in the intervertebral space. This study was only conducted in the middle region of Nepal, therefore, the results might not be generalized.

Conflict of interest: Authors declare that no competing interest exists.

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