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Clinical Anatomy

MORPHOMETRIC STUDY OF INTERVERTEBRAL DISC USING MRI IN LOW BACK PAIN SUBJECTS

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ABSTRACT **Introduction:** Low back pain is one of most prevalent musculoskeletal disorders worldwide and is frequently associated with degenerative changes of lumbar intervertebral discs. The intervertebral disc plays crucial role in maintaining spinal stability, flexibility, and effective load transmission across vertebral column. Degeneration of disc results in reduction of disc height, altered spinal biomechanics, and may ultimately lead to neural compression and chronic pain. Magnetic resonance imaging (MRI) provides reliable, non-invasive modality for evaluating intervertebral disc morphology and early degenerative changes. **Objective:** To evaluate intervertebral disc parameters such as disc height and antero-posterior diameter in low back pain subjects and asymptomatic controls using MRI. **Material and Methods:** This case-control study was conducted on lumbar MRI scans of 200 individuals aged 21–80 years, including 100 subjects with clinically diagnosed low back pain and 100 asymptomatic controls. Intervertebral disc height and antero-posterior disc diameter were measured from L1–L2 to L5–S1 levels. **Results:** In cases, height and AP diameter of intervertebral disc went on increasing from L1-L2 to L4 L5 level then decreased at L5-S1 level. While in control subjects, height of intervertebral disc went on increasing from L1-L2 to L5-S1 levels and antero-posterior diameter of intervertebral disc went on increasing from L1-L2 to L4-L5 level and then decreased at L5-S1 level. **Conclusion:** MRI-based morphometric evaluation of intervertebral discs provides objective insight into disc degeneration and its association with low back pain and can aid in early diagnosis and clinical management.

KEYWORDS : Low Back Pain, Intervertebral Disc, MRI, Lumbar Spine

INTRODUCTION

Low back pain is among leading causes of disability worldwide, affecting nearly 70–85% of individuals. (1,2) It represents major public health problem and contributes substantially to work absenteeism and socioeconomic burden (3).

The intervertebral disc is fibrocartilaginous structure composed of nucleus pulposus, annulus fibrosus, and cartilaginous endplates, and plays critical role in spinal stability and mobility (4). Degenerative changes of disc occur as part of aging process and are influenced by mechanical loading, resulting in dehydration of nucleus pulposus, annular fissuring, and reduction in disc height (5,6).

Lower lumbar discs, particularly at L4–L5 and L5–S1 levels, are exposed to greater axial loading and mobility, making them susceptible to degeneration and mechanical failure (7). Magnetic resonance imaging is imaging modality of choice for evaluating intervertebral disc morphology due to its excellent soft-tissue contrast and ability to detect early degenerative changes (8,9). MRI-based morphometric studies provide valuable quantitative data regarding disc degeneration. However, such studies remain limited in Indian population, emphasizing need for population-specific morphometric analysis (10,11).

AIM AND OBJECTIVES

1. To measure intervertebral disc height and antero-posterior disc diameter using MRI in cases and controls.
2. To assess age- and gender-related variations in intervertebral disc morphology.

MATERIAL AND METHODS

This case-control study was conducted after obtaining approval from Institutional Ethics Committee. Lumbar MRI scans of 200 individuals aged 21–80 years were analysed.

Inclusion Criteria

- Individuals aged 21–80 years undergoing lumbar MRI.
- Subjects with clinically diagnosed low back pain.
- Asymptomatic individuals undergoing MRI for non-spinal indications.

Exclusion Criteria

- History of spinal trauma, infection, malignancy, or previous spinal surgery
- Presence of metallic implants and congenital spinal anomalies

Method

MRI was performed using 1.5 Tesla scanner. Sagittal and axial T1- and T2-weighted images were obtained with slice thickness of 4 mm. Measurements were performed on mid-sagittal images.

Measurement Technique

Intervertebral disc height was calculated as mean of anterior, middle, and posterior disc heights at each lumbar level from L1–L2 to L5–S1 levels. Antero-posterior disc diameter was measured from anterior to posterior margin at midpoint of each disc.

Statistical Analysis

Mean and standard deviation were calculated. Student's t-test and one-way ANOVA were applied as appropriate, p-value <0.05 was considered statistically significant.

RESULTS

Height (mm) of intervertebral disc was found to be having mean of 7.87, 8.98, 9.87, 10.06 and 9.93 with SD of 1.89, 1.89, 2.10, 2.44 and 2.44 at L1 L2, L2-L3, L3-L4, L4-L5 and L5-S1 levels, respectively. Furthermore, it was found that height of intervertebral disc went on increasing from L1-L2 to L4-L5 level then it decreased at L5-S1 level.

On gender wise evaluation, it was found that height (mm) of intervertebral disc in males was having mean of 9.92, 10.57, 9.96, 9.20 and 7.94 with SD of 1.59, 1.94, 2.64, 2.64 and 2.83 at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 levels, respectively. While in females it was found to be having mean of 7.81, 8.77, 9.78, 9.58 and 9.95 with SD of 2.15, 1.83, 1.41, 2.14 and 2.02 at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 levels, respectively. However, no statistically significant difference was observed between males and females.

Age wise analysis showed mean values of height (mm) of intervertebral disc for group 1 (Age 21-40 years) at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 level to be 7.29, 8.09, 9.00, 8.67 and 9.36, for group 2 (Age 41-60 years) 7.64, 8.90, 9.67, 10.61 and 10.42, and for group 3 (Age 61-80 years) 8.93, 10.00, 11.10, 10.10 and 9.37, respectively. Statistically significant difference was observed between all age groups at all levels of intervertebral disc except at L5-S1 level.

In controls height (mm) of intervertebral disc was found to be having mean of 7.06, 8.20, 9.30, 9.93 and 9.95 with SD of 1.43, 1.47, 1.39, 1.58 and 2.10 at L1 L2, L2-L3, L3-L4, L4-L5 and L5-S1 levels,

respectively. Furthermore, it was found height of intervertebral disc went on increasing from L1-L2 to L5-S1 levels. In controls, in gender wise evaluation, However, no statistically significant difference was observed between males and females at any of vertebral levels studied. Also, age wise no statistical difference was observed.

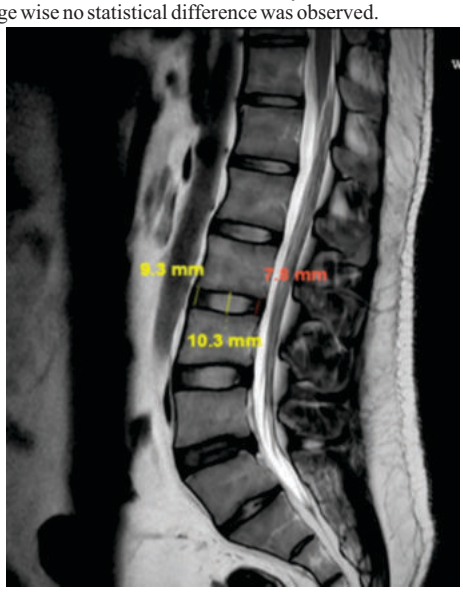

Figure 1: Showing Height of Inter Vertebral Disc in Mid Sagittal Plane

Table 1: Mean, Range and Standard Deviation of Intervertebral Disc Height (mm) in Cases and Controls

Levels	Cases Mean (mm)	Range (mm)	SD	Controls Mean (mm)	Range (mm)	SD	P value
L1 – L2	7.87	3.40 – 17.10	1.89	7.06	4.90 – 10.80	1.43	0.001
L2 – L3	8.98	3.00 – 13.30	1.89	8.2	5.50 – 11.90	1.47	0.001
L3 – L4	9.87	2.10 – 15.30	2.1	9.32	6.40 – 12.90	1.39	0.032
L4 – L5	10.06	3.80 – 16.70	2.44	9.93	6.90 – 13.90	1.58	0.635
L5 – S1	9.93	4.60 – 19.90	2.44	9.95	4.60 – 15.70	2.1	0.953

For AP diameter (mm) of Intervertebral disk, in cases, was found to be having mean of 29.37, 31.25, 32.42, 33.41 and 31.83 with SD of 3.59, 3.92, 3.52, 3.46 and 3.92 at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 intervertebral disc levels, respectively. Furthermore, it was found AP diameters of intervertebral disc went on increasing from L1 L2 to L4-L5 level and then decreased at L5-S1 level. Thus L4-L5 disc had greatest antero-posterior diameter amongst discs.

On gender wise evaluation, it was found AP diameter (mm) of intervertebral disc in males was having mean of 30.96, 32.92, 33.71, 34.33 and 32.99 with SD of 3.56, 3.67, 3.31, 2.77 and 4.11 at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 levels, respectively. While in females it was found to be having mean of 27.85, 29.64, 31.19, 32.52 and 30.71 with SD of 2.92, 3.48, 3.28, 3.83 and 3.40 at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 86 levels, respectively. Furthermore, it was found that antero-posterior diameter of intervertebral disc went on increasing from L1-L2 to L4-L5 disc level and then decreased at L5-S1 disc level, in both males and females. It was also seen that, antero-posterior diameter of intervertebral discs was larger in males than in females with statistically significant difference.

Age wise analysis showed that, mean AP diameter (mm) of intervertebral disc for group 1 (Age 21-40 years) at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 levels to be 28.90, 29.74, 31.56, 32.00 and 31.61, for group 2 (Age 41-60 years) 29.24, 31.26, 32.14, 32.88 and 31.51 and for group 3 (Age 61-80 years) 30.11, 32.59, 33.84, 35.89 and 32.75 respectively. Furthermore, it was found that AP diameter of intervertebral disc went on increasing from L1-L2 to L4-L5 disc level and then decreased at L5-S1 disc level in all age groups. Thus L4-L5 disc had greatest antero-posterior diameter amongst various intervertebral discs studied. However, no statistically significant difference was observed between all age groups at all levels of intervertebral disc except at L2-L3 and L4-L5 levels.

In controls, it was found, antero-posterior diameter of intervertebral disc went on increasing from L1-L2 to L4-L5 level and then decreased at L5-S1 level. Thus L4-L5 disc had greatest antero-posterior diameter amongst discs studied.

In gender wise evaluation of controls, it was found antero-posterior diameter of intervertebral disc went on increasing from L1-L2 to L4-L5 disc level and then decreased at L5-S1 disc level, in both males and females. L4-L5 level disc had greatest antero-posterior diameter amongst various intervertebral discs studied. It was also seen that antero-posterior diameter of intervertebral disc was larger in males then in females. Statistically significant difference was observed between males and females at all levels of intervertebral disc.

Age wise, it was found antero-posterior diameter of intervertebral disc went on increasing from L1-L2 to L4-L5 disc level and then decreased at L5-S1 disc level in all age groups. Thus L4-L5 level disc had greatest antero-posterior diameter amongst various intervertebral discs levels studied. Statistically significant difference was observed between all age groups at all levels of intervertebral disc except at L5-S1 disc level.

Figure 2: Showing Measurement of Antero-posterior Diameter of Intervertebral Disc in Mid Sagittal Plane

Table 2: Mean, Range and Standard Deviation of Intervertebral Disc AP Diameter (mm) in Cases and Controls

Levels	Cases Mean (mm)	Range (mm)	SD	Controls Mean (mm)	Range (mm)	SD	P value
L1 – L2	29.37	22.10 – 36.90	3.59	26.04	22.40 – 34.60	2.61	<0.001
L2 – L3	31.25	22.70 – 41.10	3.92	27.25	22.90 – 33.30	2.27	<0.001
L3 – L4	32.42	24.70 – 39.70	3.52	28.01	24.60 – 33.20	2.11	<0.001
L4 – L5	33.41	22.30 – 41.20	3.46	29.12	25.60 – 36.20	2.42	<0.001
L5 – S1	31.83	24.30 – 40.90	3.92	28.24	21.30 – 33.10	2.71	<0.001

DISCUSSION

Case control study was performed in tertiary care hospital to assess height and AP diameter of lumbar intervertebral discs, using MRI. In our study, differences in height of intervertebral disc were found to be statistically significant with a p-value of 0.001, 0.001 and 0.032 at L1-L2, L2-L3 and L3-L4 level between cases and controls (Table 1). Chang Hwa Hong et al in their study on MRI scans of 178 cases, found mean values of height (mm) of intervertebral discs to be 7.97, 8.57, 9.64, 10.05 and 9.58 at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 levels, respectively.[8] Nuket Gocmen-Mas et al in their study on MRI scans of 25 healthy subjects comprising of 13 males and 12 females measured height of lumbar intervertebral discs at different levels.[10] They found mean values of height (mm) of intervertebral discs to be 8.8, 9.5, 11.0 and 11.6 in males and 8.8, 9.8, 10.8 and 12.0 in females at L1-L2, L2-L3, L3-L4 and L4-L5 levels, respectively. However, no statistically significant difference was observed between values of males and females at different levels of discs. Iris Busscher et al in their study on CT scans of 6 fresh frozen human male cadaveric spines, found mean values of height (mm) of intervertebral discs to be 10.3, 11.5, 11.8, 12.7

and 8.8 at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 levels respectively.[12] Similarly, S. H. Zhou et al in their study on CT scans of 126 patients found mean values of height (mm) of intervertebral discs to be 11.6, 11.3 and 10.7 at L3-L4, L4-L5 and L5-S1 levels, respectively.[11]

In our study, AP diameter of inter-vertebral disk in cases and controls is as shown in table 2. In study conducted by, Chang Hwa Hong et al on MRI scans of 178 cases, found mean values of antero-posterior diameter (mm) of intervertebral discs to be 30.31, 31.84, 33.38, 33.96 and 33.48 at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 disc levels, respectively. Findings of study conducted by Chang Hwa Hong correlated with findings of present study.[8]

Limitations

The study was case control study and did not evaluate longitudinal progression of disc degeneration. Factors such as body mass index, occupational stress, and physical activity were not assessed. Future longitudinal studies incorporating advanced MRI techniques are recommended.

CONCLUSION

Reduction in intervertebral disc height is significantly associated with low back pain, particularly at lower lumbar levels. AP diameter goes on increasing from L1-L2 caudally to L5-S1 level in cases of disc degeneration. Disc degeneration increases with advancing age, while gender differences are minimal. MRI-based morphometric evaluation of intervertebral discs is reliable, non-invasive tool for early detection and clinical assessment of lumbar disc degeneration.

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