To Evaluate Significance of Anatomic and Morphometric Parameters of Intervertebral Disc Using Magnetic Resonance Imaging in Patients with Low Back Pain

Suvarn Gupta¹, Ankush Mohabey², Vasant Gawande³, Kunal Saoji⁴

¹Assistant Professor, Department of Orthopaedics, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences, Sawangi, Wardha, M.S., India; ²Assistant Professor, Department of Orthopaedics, Datta Meghe Medical College, Shalinitai Meghe Hospital and Research Centre, Nagpur, M.S. India; ³Associate Professor, Department of Orthopaedics, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences, Sawangi, India.; ⁴Assistant Professor, Department of Orthopaedics, Datta Meghe Medical College, Nagpur, India.

ABSTRACT

Aim: To evaluate significance of anatomic and morphometric parameters of the intervertebral disc using Magnetic resonance imaging in patients with low back pain.

Materials and Method: This prospective observational study was conducted from May 2017 to May 2109 (2 years). Minimum hundred patients of all gender of age group between 18 to 50 years with low backache were enrolled in the present study.

Observation and Results: On comparison of disc angle and skin angle between study and control population, we noted that disc angle and skin angle were comparable but statistical significance was not observed (p>0.05) except with regard to disc angle at L1-L2 (p=0.01), L2-L3 (p=0.05) and L3-L4 (p=0.001) and skin angle at L2-L3 (0.03) and L4-L5 (p value: 0.05) level where it was significant (p<0.05). On comparison of PDML and ADSL between study and control population, a significant difference was observed in Posterior Disc Material Length (PDML) between group A and group B except at L3-L4 and L5-S1, where it was non-significant (p>0.05).

Conclusion: To conclude, Low back pain is a common pathology in young and productive age groups. Disc morphometry and Dural Sac measurements are useful in diagnosing and understanding low backache pathology and these morphometric parameters have significant variations in symptomatic low back pain patients.

Key Words: Low back ache, Morphometric parameters, MRI, Dural Sac, LDH

INTRODUCTION

Low back pain (LBP) has multiple etiology including degenerative changes, spinal stenosis, neoplasm, infection, trauma, and inflammatory or arthritic processes. Acute low back pain generally gets resolved within 6 to 12 weeks, But, repeated recurrence of symptoms can result in chronic low back pain¹². Three main risk factors for recurrent and chronic LBP are evaluated from the previous literature: (1) history of LBP with associated limitations and treatments, (2) minimal work satisfaction, and (3) poor medical condition. Other risk factors such as socioeconomic and employment status, psychological status, and physically demanding work are also suggested.³

Various disc and muscle parameters and their correlation with lower back pain have been evaluated in the past.⁴,⁵,⁶,⁷,⁸,⁹,¹⁰ Size of Dural sac and height of intervertebral disc have a relation with Lumbar Disc Herniation (LDH) according to previous studies. Additionally, a positive correlation between spinal canal stenosis and LBP has been assessed in some cross-sectional studies.⁶ Literature suggests that disc height reduction is associated with LDHs and this factor was included in the current study.¹¹

The overall purpose of this research project was to investigate LBP and to find the correlation between lumbar disc parameters and low back pain.
MATERIAL AND METHODS

Aim: To evaluate significance anatomic and morphometric parameters of intervertebral disc using Magnetic resonance imaging in patients with low back pain.

This present study is a prospective observational study. It was conducted at the Department of Orthopaedics at Datta Meghe Medical College, Nagpur in collaboration with Departments of Radiodiagnosis and Orthopaedics, Jawaharlal Nehru Medical College, Sawangi from May 2017 to May 2109 (2 years). Minimum hundred patients of all gender of age group between 18 to 50 years with low backache were enrolled in the present study.

Inclusion criteria: Patients with low backache of minimum 3 consecutive months duration and those who were suffering from either

1. Lumbar disc herniation (LDH) and/or
2. Mechanical Back Pain and/or
3. Lumbar spondylosis (Lumbar canal stenosis, Degenerative disc disease)

Exclusion criteria: Patients with spinal deformities such as scoliosis, traumatic or pathologic fracture of spine, tumors, and infections of spine, patient with associated hip or pelvic pathologies, and bed-ridden patients.

Data collection
Each patient was thoroughly examined clinically and was subjected to MRI. MRI was done on 1.5 T machine with the patient lying supine comfortably with knees and hips extended. Multislice sagittal and transverse sections were taken with the following MRI sequence. Locations of vertebral levels for MRI were determined on a parasagittal section. Measurement was done by using on-screen calipers using software OsiriX(version 5.1.2)\(^1\). Following parameters were measured:

Section at intervertebral Disc level

(i) Trunk dimensions
   (a) Width (Maximum width taken)
   (b) Depth (Anteroposterior diameter of the trunk at mid-sagittal section)
(ii) Disc angle - The angle between the vertical line and the midplane of each lumbar disc. (Figure 1)
(iii) Skin angle - The angle between the vertical line and the line tangent to the overlying skin.
(iv) Parameters (length, volume, CSA) of disc
   a) Anterior intervertebral height
   b) Posterior intervertebral height
   c) Anterior disc material
   d) Intervertebral disc
   e) Posterior disc material
(v) Dural sac

Figure 1: Showing measurement of disc angle.

Figure 2: Positioning of measured structures (a-i); (a-b) Anterior intervertebral height (AIVH); (c-d) Posterior intervertebral height (PIVH); (e-f) Anterior disc material (ADM); (f-g) Intervertebral disc (IVD); (g-h) Posterior disc material (PDM); (h-i) Dural sac (DS).

Fifty patients (Group A) of either sex between age range 18 to 50 years of age with low backache were assessed in the present study. Twenty-five asymptomatic volunteers (Group B) were selected as control group for MRI study.

STATISTICAL ANALYSIS

All the measurements and data were analyzed using standard statistical tools. For normally distributed data T-test was employed for analysis. Mann-Whitney and Chi-square test was employed for categorical and ordinal data. Correlation between variables was assessed by Pearson’s coefficient of correlation. Interobserver agreement of values between variables was assessed by kappa value (Cohen-Kappa). Statistical software SPSS version 25.0 was employed for analysis.
**OBSERVATION**

Fifty patients (Group A) of either sex within the age range 18 to 50 years with low backache were enrolled in the study. Twenty-five asymptomatic volunteers (Group B) were selected as a control for MRI study. The following were the observations of the present study.

**A. Demographic data**

In the present study, Group A patients were almost equally distributed in each decade of life. The mean age of all the patients was 36.24±9.07 Standard deviation (SD) years with an age range of 18-50 years. The mean age of the control population (Group B) was 35.57±8.87 SD years with a range of 18-50 years. There was almost equal distribution in each decade of life in control also. An equal number of males 25 (50%) and females 25 (50%) in group A and in (control) group B female participants were 15 (60%) and male participants were 10 (40%). In Group A, the mean height is 1.65±0.060 m, mean weight 68.04±10.93 Kg, and mean BMI is 24.94±3.2 Kg/m². Group B shows mean height 1.66±0.069 m, mean weight 70.48±9.39 Kg, and mean BMI was 24.60±2.26 Kg/m². In study, we found in Group A major participants are housewife 16 (32%) and Farmer 7 (14%). In the study of group B we found majorly are Doctors 5 (20%), Student 6 (24%).

**a) Symptomatology**

Paraspinal tenderness was present in 23 (46%) patients of group A and in control (group B), none were symptomatic. Paraspinal muscle spasm was present in 47 (94%) of Group A patients. This table also shows a straight leg raise test. In the present study (group A), almost equal patients had straight leg raise tests for left leg i.e. positive for 24 (48%) and negative for 26 (52%). The straight leg rise test for the right leg is positive for 20 (40%) and negative for 30 (60%). In the present study (Group A), mostly patients came to OPD with a history of pain for the last 3-12 months. Six patients (12%) had symptomatology for the last 13-24 months, three (6%) for last 25-36 months, and two (4%) for the last 49-60 months.

On comparison of trunk width and trunk depth, between study and control population of MRI measurements at all lumbar and lumbosacral levels. We noted that trunk width, trunk depth were found to be comparable but statistical significance was not seen in the comparison (p>0.05).

On comparison of disc angle (showed in fig no 1) and skin angle between study and control population. We noted that disc angle and skin angle were comparable but statistical significance was not observed (p>0.05) except with regard to disc angle at L1-L2 (p=0.01), L2-L3 (p=0.05) and L3-L4 (p=0.001) and skin angle at L2-L3 (0.03) and L4-L5 (p value: 0.05) level where it was significant (p<0.05).

It was noted that comparison of disc parameters like Anterior intervertebral Disc Height (AIVH), Posterior intervertebral Disc Height (PIVH) was not statistically significant except with regard to AIVH at L2-L3 (p=0.05) and L5-S1 (p=0.05) level, PIVH at L1-L2 (p=0.03) and L5-S1 (p=0.002) level where it was statistically significant.

On the correlation of parameters like Intervertebral Disc Length (IVDL), Anterior Disc Material Length (ADML), it was seen that above parameter comparison was not statistically significant except a significant difference with regard to IVDL at L4-L5 level (p=0.03), ADML at L3-L4 (p=0.002) and L5-S1 level (p=0.001).

On comparison of PDML and ADSL (showed in fig no 2) between study and control population, a significant difference was observed in Posterior Disc Material Length (PDML) between group A and group B except at L3-L4 and L5-S1, where it was non-significant (p>0.05).

Anterior Dural sac Length (ADSL) was significantly different between two groups at lower lumbar levels i.e. L3-L4 (p=0.01), L4-L5 (p=0.001) and L5-S1 level (p=0.001) (Table no 2).

| Parameters comparison between group A and group B | Intervertebral Disc levels | Significant P values |
|-----------------------------------------------|---------------------------|----------------------|
| Disc Angle                                    | L1-L2, L2-L3, L3-L4       | 0.01,0.05,0.001      |
| Skin Angle                                    | L2-L3, L4-L5              | 0.03,0.005           |
| AIVH                                          | L2-L3, L5-S1              | 0.05,0.05            |
| PIVH                                          | L1-L2, L5-S1              | 0.03,0.002           |
| IVDL                                          | L4-L5                     | 0.03                 |
| ADML                                          | L3-L4, L5-S1              | 0.002, 0.001         |
| PDML                                          | L1-L2, L2-L3, L4-L5       | 0.001                |
| ADSL                                          | L3-L4, L4-L5, L5-S1       | 0.01,0.001,0.001     |

**d) MRI measurements of cross sectional area of disc :**
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MRI measurements at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 disc level between Group A and Group B

| Cross section area (CSA) (mm²) | Mean±SD | (Range) | 95% CI |
|-------------------------------|---------|---------|-------|
|                               | GROUP A (n=50) | GROUP B (n=25) | p VALUE | LOWER | UPPER |
| CAIH                          |          |         |       |
| L1-L2                         | 296.55±66.35 (189.00-458.70) | 263.18±51.64 (207.15-384.31) | 0.031 | 3.148 | 63.581 |
| L2-L3                         | 356.98±79.27 (218.65-532.00) | 302.14±61.74 (221.16-428.56) | 0.003 | 18.730 | 90.945 |
| L3-L4                         | 426.76±85.67 (279.40-583.00) | 377.38±150.58 (239.94-966.94) | 0.074 | -4.937 | 103.707 |
| L4-L5                         | 483.91±111.16 (302.39-782.50) | 410.73±116.27 (40.86-602.84) | 0.010 | 18.078 | 128.278 |
| L5-S1                         | 486.39±108.30 (244.33-733.56) | 404.16±145.36 (73.73-599.94) | 0.007 | 22.804 | 141.663 |
| CPIH                          |          |         |       |
| L1-L2                         | 243.60±67.14 (120.05-459.92) | 206.20±39.42 (162.32-269.56) | 0.012 | 8.368 | 66.432 |
| L2-L3                         | 268.85±59.73 (131.64-404.27) | 223.23±39.89 (174.23-291.36) | 0.001 | 19.253 | 71.989 |
| L3-L4                         | 295.71±65.82 (164.23-464.50) | 237.78±57.13 (169.62-363.23) | 0.001 | 27.128 | 88.734 |
| L4-L5                         | 313.14±69.56 (166.01-506.22) | 254.56±54.12 (189.87-376.92) | 0.001 | 26.907 | 90.264 |
| L5-S1                         | 279.29±48.80 (185.63-409.42) | 219.80±59.04 (150.90-353.63) | 0.001 | 33.913 | 85.066 |

*p value calculated from independent t-test

Table shows comparison of Cross sectional areas of AIVH (CAIH), Cross sectional areas of PIVH (CPIH) between study and control population. We noted that disc parameters like CAIH and CPIH were mostly statistically significant (p<0.05) at almost all lumbar disc level except CAIH at L3-L4 level (p=0.07).
Above Table shows a comparison of Cross-sectional areas of intervertebral disc (CIVD), Cross-sectional areas of anterior disc material (CADM) between study and control population. We noted that disc parameters like CIVD and CADM were mostly statistically significant (p<0.05) at almost all lumbar disc levels except CIVD at L1-L2 (p=0.48) and L2-L3 (p=0.27) level, CADM at L1-L2 (p=0.32), and L4-L5 (p=0.29) level which were compared and found to be statistically non-significant.

Table 8(C) shows a comparison of Cross-sectional areas of posterior disc material (CPDM), Cross-sectional areas of dural sac (CDS) between study and control population. We noted that disc parameters like CPDM and CDS were mostly statistically significant (p<0.05) at almost all lumbar disc levels except CPDM at L1-L2 (p=0.86) and L2-L3 (p=0.18) level and CDS at L3-L4 (p=0.78) level which were comparable and found to be statistically non-significant.

On comparison of Volume of anterior disc material (VADM) and volume of posterior disc material (VPDM) between study and control population, we noted that Volume of anterior disc material (VADM) and volume of posterior disc material (VPDM) at all lumbar disc levels were statistically significant (p<0.005).

In the comparison of cross-sectional area of discs between study and control population, it was noted that Cross-sectional area of lumbar disc at L1-L2, L2-L3 were comparable at L3-L4 (p=0.02), L4-L5 (p=0.01), and L5-S1 (p=0.02) level where statistically significant difference was there in cross-sectional area.

**DISCUSSION**

The present study was conducted in the Department of Orthopaedics in a study population of 75 patients. In the present study, participants were divided into study group, Group A [chronic low backache, n=50] and Group B [control group, n=25; asymptomatic healthy volunteers].

**Age and Sex distribution**

In Group A, 50 patients (25 males, 25 females) with LBP were included and the mean age of patients was 36.24±9.07 SD years. The most symptomatic age group was 18-40 years forming 68% of the total study group. This indicated that most of the patients were of a productive age group with significant socioeconomic impact were involved. In the control group (Group B), the mean age of 25 participants (10 males, 15 females) was 35.57±8.87 SD years. Lee et al. studied a group of 38 low back pain patients (22 males, 16 females) with mean age 29.1±4.6 years.[15] Mengiardi et al. studied 25 patients (13 women, 12 men; mean age 40.5 years) with chronic Low Back Pain (LBP).[16]

**BMI**

In the present study mean height of the patients (Group A), Mean BMI of the patients was 24.94±3.27 kg/m² and in Group B mean BMI of 24.60±2.26 kg/m². The results were comparable with study done by Lee et al. mean BMI of chronic back pain (CBP) group and improved back pain (IBP) group was 22.46±2.10SD kg/m² and 22.08±2.60SD kg/m² respectively.[15]

**Occupation**

Most patients were housewives (32%) suffering from chronic back pain followed by farmers/laborers in the symptomatic group. Xu et al. also reported an increase in low back pain among Chinese coal mine labourers.[17]

**Symptomatology**

In the present study, paraspinal tenderness was present in almost half of the patients (46%) but paraspinal muscle spasm was present in 94% of the patients. In nearly half of the patients (48%), straight leg raise test was positive for left side and 52% patients had positive straight leg raise test for the right side. In patients with chronic low backache, mostly patients were not having sensory deficits and only (4%) had motor deficit. The mean duration of symptoms was 11.93±12.62 months in the present study (Table 5). Ploumis et al. studied patients of unilateral back pain with symptom with a mean duration of 15.5±14.1 months[18]

**MRI measurements at L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 disc levels and comparison between group A and group B population**

MRI appears to be the imaging of choice to evaluate disc morphology and it has been used in numerous studies including this study.[16,18] In the present study, various parameters including cross-sectional areas (CSA) discs were measured on axial and mid-sagittal T2 weighted MR images at L1-L2, L2-L3, L3-L4, L4-L5, and L5-S1 disc levels of 50 chronic LBA patients (Group A) and 25 matched control group participants (Group B) and comparison was done between study and control subjects.

**a) Disc parameters:**

Lumbar intervertebral disc degeneration is one of the commonest factor which causes low back pain.[19] In the present study, we evaluated disc parameters to find their correlation with low back pain. A significant correlation was found with regard to L1-L2 disc angle (p=0.01), L2-L3 disc angle (p=0.05), L3-L4 disc angle (p=0.001). A significant difference was also found with regard to skin angle at the L2-L3 level (p=0.03) and L4-L5 level (p=0.05). We also found a significant difference regarding CSAs of the disc at L3-L4 (p=0.02), L4-L5 (p=0.01), and L5-S1 (p=0.02) lumbar disc levels. The findings reported by Tracy et al. regarding...
discs and skin angles match with the present study group population.[13] Singh et al. in their study also found a significant difference with regard to regard to L3-L4 disc angle \((p=0.005)\) and L4-L5 disc angle \((p=0.02)\).

Tunset et al. (2013) in his study measured parameters of disc length, area and volume at L3-L4, L4-L5 and L5-S1 disc level whereas in the present study, we measured the parameters like disc length, and volume at all the lumbar disc levels and measured mean at each level independently. However, the mean values of parameters were lower in the present study as compared to the study done by Tunset et al.

We found that AIVH was higher in patients with Low Back Ache (LBA) compared to controls at all levels but at L2-L3 and L5-S1, it was significant\((p=0.05)\), PIVH was also higher in chronic LBA cases at all levels but it was significant at L1-L2 \((p=0.03)\) and L5-S1 \((p=0.002)\) level, IVDL was also higher in chronic LBA cases at all levels but it was significant at L4-L5 \((p=0.03)\) level, ADML was also higher in chronic LBA cases at all levels but it was significant at L3-L4 \((p=0.002)\) and L5-S1 \((p=0.001)\) level, PDML was higher in patients with LBA compared to controls at all levels but significant at L1-L2 \((p=0.004)\) level, L2-L3 \((p=0.008)\) level and L4-L5 \((p=0.001)\) level, ADSL was lower in patients with chronic LBA compared to controls at all levels but significant at L3-L4 \((p=0.01)\) level, L4-L5 \((p=0.001)\) level, L5-S1 \((p=0.001)\). This result matches with the previous literature. [4,5,6,21] Pneumaticos also reported in his study that patients with low back pain have smaller dural sac lengths as compared to the control population.

In the present study, we found that parameters like CAIH, CPIH, CIVD, CADM and CPDM were larger in group A (study) population than group B (control) population. CDS was smaller in group A than group B population. Kjaer et al. studied that the mean value of cross-sectional areas of LDH, dural sac area and disc height measured at L3-L4, L4-L5, and L5-S1 level were smaller than what we found in the present study. Pneumaticos also reported in his study that patients with CLBP have smaller CDS as compared to the control population.

We also found a statistically significant difference \((p<0.005)\) between study and control population regarding parameters like Volume of anterior disc material (VADM) and volume of posterior disc material (VPDM) at all lumbar disc levels i.e. L1-L2, L2-L3, L3-L4, L4-L5, and L5-S1 level. We noted that VADM and VPDM were larger in group A (study) population than group B (control) population. However, there is no literature to compare the parameters. However, Holodny et al. reported the volume of herniated material for all lumbar and lumbosacral levels with a mean of 503±301mm³.

A significant difference was found in CSAs of the disc at L3-L4, L4-L5, and L5-S1 level in group A cases as compared to control (group B) population. CSAs of the disc in group A cases were larger as compared to control population.

CONCLUSION

To conclude, Low back pain is the common pathology in young and productive age groups. Disc morphometry and Dural Sac measurements are useful in diagnosing and understanding low backache pathology and these morphometric parameters have significant variations in symptomatic low back pain patients. However, Sequential MRI studies are needed to evaluate changes in intervertebral disc parameters in different pathologies like lumbar disc prolapse, lumbar canal stenosis, etc.

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