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Original Article

Anatomy Section

Association of Mid-sagittal Anteroposterior Diameter of Lumbar Canal in Patients with Low Back Pain using MRI: A Cross-sectional Study from West Bengal, India

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ABSTRACT

Introduction: Lumbar spinal canal stenosis is the progressive narrowing of spinal canal that causes compression of nerve roots before their exit. The presenting symptoms of spinal canal stenosis includes bilateral lower extremity pain, altered sensation in both legs and poorly localised weakness and generally associated with low back pain. Determination of normal diameter and its variation with development of low back pain could prove useful in determining the aetiology and outcome of congenital or acquired causes of stenosis like spondylolisthesis, Paget's disease, fluorosis, etc.

Aim: To measure and compare the mid-sagittal anteroposterior diameter of lumbar canal in symptomatic cases with low back pain and asymptomatic subjects using Magnetic Resonance Imaging (MRI).

Materials and Methods: The present study was a hospital-based cross-sectional, observational study involving Outpatient Department (OPD) patients of Bangur Institute of Neurosciences, Kolkata, West Bengal, India, was undertaken from May 2012 to July 2012. The study participants were selected by systematic random sampling. Total number of 102 cases were investigated in the present study. Out of these, 52 cases were symptomatic patients of low back pain and rest 50 cases were asymptomatic. Magnetic Resonance Imaging (MRI) was done to estimate the mid-sagittal anteroposterior diameter at different levels of lumbar canal. Unpaired t-test was used as test of significance using Statistical Package for the Social Sciences (SPSS) version 19.0. A p-value <0.05 was considered as statistically significant.

Results: In the present study, in the asymptomatic group, the anteroposterior diameter at the intervertebral disc level-between L1-L2=18.364±1.4351 mm, L2-L3=17.470±1.3298 mm, L3-L4=16.670±1.6042 mm, L4-L5=15.200±1.8906 mm, L5-S1=14.196±2.1092 mm. Mean diameter of central lumbar vertebral canal was found to be lower in symptomatic cases with low back pain at different vertebral levels and the difference was found to be statistically significant between symptomatic and asymptomatic subjects. It was found that age of presentation did not show any statistical significance with the presence of low back pain.

Conclusion: The lumbar vertebral canal diameter was found to be significantly lower in subjects with low back pain than subjects having no complaints.

Keywords: Magnetic resonance imaging, Spinal canal, Spinal stenosis

INTRODUCTION

The spinal cord passes through the spinal canal, which is present as opening in each vertebra [1]. Adults can experience pain related to any of the conditions that also affect younger adults, individuals over age 60 years are more likely to suffer from pain related to degenerative diseases of the joints in the spine [1]. Two of the most common causes of lower back pain in older adults include osteoarthritis and spinal stenosis [1]. Lumbar spinal canal stenosis is a condition in which the spinal canal progressively narrows and therefore, compresses the spinal cord and nerves at the level of the lumbar vertebra [2]. Lumbar spinal stenosis is usually asymptomatic unless its contents, the spinal cord or the nerves are compressed [1]. When compressed, they result in low back pain. The syndrome of spinal canal stenosis includes bilateral lower extremity pain, altered sensation in both legs and poorly localised weakness and generally associated with low back pain [2]. Lumbar spinal stenosis does not cause symptoms unless the spinal cord or the spinal nerves are compressed [2]. It may be congenital, that is, from birth or acquired or it may result from a combination of congenital abnormalities with age related degenerative changes [2].

In a study done by Schroeder GD et al., it was found that, the prevalence of lumbar spinal stenosis was found to be approximately 9.3% of study population, highest incidence seen in the sixth or seventh decade of life [3]. The usual presentation is pain, cramping, and weakness in their legs that is worsened with standing and walking [3]. Different imaging modalities (X-ray, myelography, Computed Tomography (CT), CT myelography, and MRI) are used in the diagnosis and assessment of lumbar canal stenosis [4]. MRI is a non invasive imaging technique, which aids in diagnosis. The spinal fluid provides a myelographic effect on MRI. So, it may be considered as the diagnostic procedure of choice in the diagnosis of spinal stenosis because intervertebral discs, soft tissues, bones, and intrathecal contents are visualised [4-6].

The lumbar vertebral canal stenosis can lead to compression of cauda equina centrally from an anteroposterior direction at the intervertebral disc level. This compression may be caused either by a disc bulge or protrusion anteriorly or by hypertrophy and bulging of the ligamentum flavum associated with the zygapophyseal joint hypertrophy, which can intrude posteriorly [7].

The values of mid-sagittal anteroposterior diameter of lumbar vertebral canal at the level of intervertebral disc from Lumbar1-Lumbar2 (L1-L2) to Lumbar5-Sacral1 (L5-S1) level is different in individuals. According to Gray's Anatomy lumbar vertebrae are large in size and with wider body transversely [8]. Their superior articular process bears vertical concave articular facets facing posteromedially and the inferior articular process bear reciprocal vertical convex articular facets which face anterolaterally [8]. This synovial joint between superior and inferior articular process is known as zygapophyseal joint [8]. This reciprocal arrangement of articular facets allows flexion, extension, lateral bending and some degrees of rotation [8-9].

Measurement of lumbar vertebral canal deserves a special importance in determination of the cause of low back pain, especially in the viewpoint of stressful modern day lifestyle. In clinical practice, the accurate knowledge of the normal lumbar spinal canal measurements is very important. A variation of its size predisposes to back pain and may be due to spinal canal stenosis. This has been studied worldwide. These studies have given a clear indication of a large variability of threshold values for the maximum and minimum diameter of the spinal canal in different populations studied [4,9].

In this context, the present study was undertaken to measure and compare the mid-sagittal anteroposterior diameter of lumbar canal in symptomatic and asymptomatic patients with low back pain using MRI.

MATERIALS AND METHODS

A cross-sectional, observational, hospital-based study involving OPD patients was conducted for three months- May 2012 to July 2012 in the Department of Anatomy, Medical College, Kolkata in collaboration with Department of Radiology, Bangur Institute of Neurosciences, Kolkata, West Bengal, India. Ethical clearance was obtained from Institutional Ethics Committee (IEC) of Medical College, Kolkata on 08/01/2011. Before conducting the interview, informed consent was obtained from all subjects.

Sample size was decided by complete enumeration. Subjects were chosen by systematic random sampling. Every 5th patient who consented for examination in the study period was chosen as study subjects irrespective of chief complaints. Study subjects were chosen from both the genders irrespective of their socio-economic status and residence. A total 102 such patients maintaining inclusion criteria were found. Out of these, 52 cases are symptomatic patients of low back pain and rest 50 cases were asymptomatic in terms of low back pain.

Inclusion criteria: Study subjects were patients who attended OPD at Bangur Institute of Neurosciences. Aged 18 years or more and those who had consented for MRI scan at that Institute. The patients who attended OPD for the first time were only included in the study.

Exclusion criteria: Patients with already diagnosed congenital/developmental stenosis in lumbar region, tumours and cysts of lumbar vertebral canal or any bony congenital anomaly of lumbar region were excluded from the study. Patients with vascular claudication or with any acute condition who cannot co-operate during clinical and radiographic examination were excluded from the study.

The study variables of the selected subjects were noted in reference to name, age, sex, complaints, history of present illness in relation to low back pain, anteroposterior diameter of central lumbar vertebral canal, etc.

Study Tools and Techniques

Tools: The study was conducted using a MRI machine available in the Institute. The machine and magnet were manufactured by GE Model was Signa Horizon LX 1.5 T. Reflex Hammer was used for neurological examination.

Techniques

Interview of the patients and relatives was done at OPD. OPD ticket and previous prescriptions by private practitioner were studied.

Clinical examination: Examination of both the lower limbs was done meticulously with special references to power, tone, muscle bulk of the limb, deep reflexes, examination of sensory systems, leg raising and reverse leg raising test.

Radiological examination: MRI of lumbar vertebra was done in patients in supine position. With the help of MRI mid-sagittal anteroposterior diameter in milimetre of central canal at the level of intervertebral disc from L1-L2 level to L5-S1 level was obtained. In order to reduce error due to human element, measurement at each level was made twice and average was obtained.

STATISTICAL ANALYSIS

Data were checked for completeness, consistency and normality using Kolmogorov-Smirnov test in SPSS; coded and entered into MS-Excel spreadsheet. Data was analysed using principles of descriptive and inferential statistics using SPSS version 19.0. Data were summarised and presented in suitable tables. Comparisons between groups were obtained by unpaired Student's t-test; a $p<0.05$ was considered to indicate significant differences.

RESULTS

Among 52 symptomatic cases, 30 (57.7%) were males and 22 (42.3%) were females. Out of total 50 asymptomatic cases, 32 (64%) males and 18 (36%) were females. The age of the study participants varied between 18-80 years. Out of total, 102 study subjects, 52 patients presented with low back pain, others presented with some other complaints.

Mean of mid-sagittal anteroposterior diameter of central lumbar vertebral canal at different vertebral level is presented in [Table/Fig-1]. Comparison of mid-sagittal anteroposterior diameter of central lumbar vertebral canal at different vertebral level between symptomatic and asymptomatic cases is represented in [Table/Fig-2].

Vertebral level	Mean diameter±standard deviation (in mm)
L1-L2	17.7±1.9
L2-L3	17.1±1.9
L3-L4	16.0±2.2
L4-L5	13.4±3.3
L5-SI	12.6±2.8

[Table/Fig-1]: Mean values of mid-sagittal anteroposterior diameter of central lumbar vertebral canal at different vertebral level (n=102). The standard convention followed for vertebral level is as Lumbar1-Lumbar2 is L1-L2 and so on.

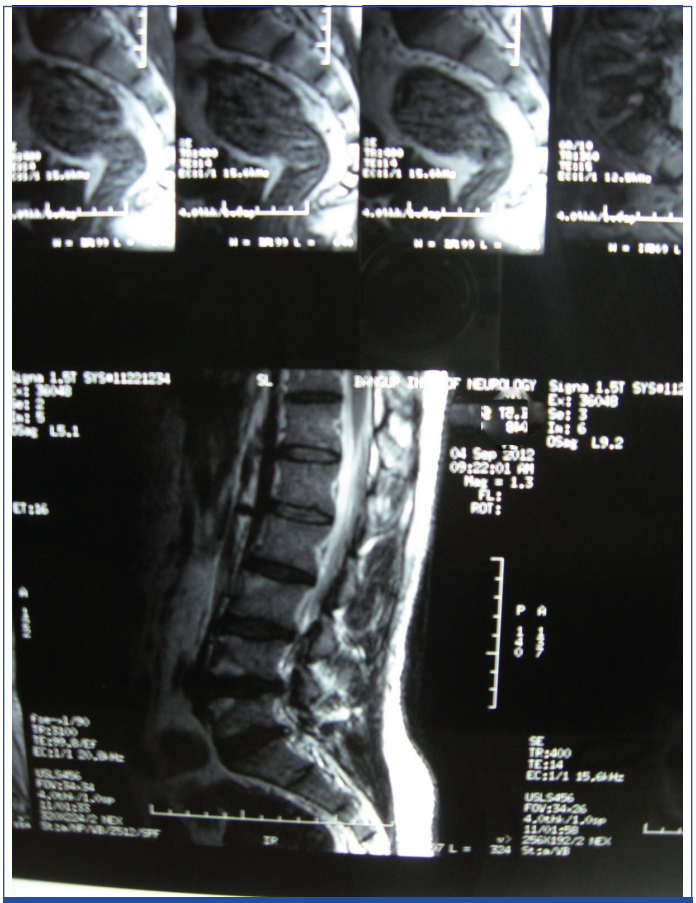
Vertebral level	Low back pain (symptomatic)	No. of cases	Mean diameter (mm)	Standard deviation	Standard error of mean	Unpaired 't' test (p-value)
L1-L2	Yes	52	17.225	2.2093	0.3064	0.003*
	No	50	18.364	1.4351	0.2030	
L2-L3	Yes	52	16.696	2.3457	0.3253	0.044*
	No	50	17.470	1.3298	0.1881	
L3-L4	Yes	52	15.348	2.5723	0.3567	0.003*
	No	50	16.670	1.6042	0.2269	
L4-L5	Yes	52	11.740	3.4945	0.4846	<0.001**
	No	50	15.200	1.8906	0.2674	
L5-S1	Yes	52	11.054	2.4393	0.3383	<0.001**
	No	50	14.196	2.1092	0.2983	

[Table/Fig-2]: Comparison of mid-sagittal anteroposterior diameter of central lumbar vertebral canal at different vertebral level between symptomatic and asymptomatic subjects. The standard convention followed for vertebral level is as Lumbar1-Lumbar2 is L1-L2 and so on.
p-value <0.05* was considered as statistically significant. p-value <0.001** is considered highly significant

Mid-sagittal anteroposterior diameter of central lumbar vertebral canal decreased from above downwards (L1-S1). Mean diameter of central lumbar vertebral canal was found to be statistically significant with low back pain at L1-L2, L2-L3 and L3-L4. It was highly significant at the level of L4-L5 and L5-S1. Age and low back pain showed statistically insignificant result. Age was not statistically associated with the incidence of low back pain [Table/Fig-3]. MRI of lumbo-sacral spine showing decrease in mid-sagittal diameter in L4-L5 and L5-S1 levels in spinal canal is shown in [Table/Fig-4].

Parameters	Low back pain (symptomatic)	No. of cases	Mean age	Standard deviation	Standard error of mean	Unpaired 't' test (p-value)
Age	Yes	52	44.90	13.439	1.864	0.129
	No	50	40.38	16.306	2.306	

[Table/Fig-3]: Comparison of mean age of subjects between symptomatic and asymptomatic cases for low back pain.



[Table/Fig-4]: MRI of lumbo-sacral spine showing decrease in mid-sagittal diameter.

DISCUSSION

In the present study, mid-sagittal anteroposterior diameter of central lumbar vertebral canal at different vertebral level was measured by MRI. Out of 102 study subjects, 52 were symptomatic for low back pain, rest were asymptomatic. Not only the diameter of the central canal was measured, its relationship with low back pain was ascertained by principles of inferential statistics.

Malghem J et al., established MRI to be a better diagnostic modality than CT for evaluating lumbar spine [9]. In a study at Srinagar, Jahangir M et al., measured the mid-sagittal anteroposterior diameter lumbar spinal canal in Kashmiri adults by MRI [10]. This study showed the normal values in asymptomatic individuals. The values were as follows: L1-L2=17.7±1.9 mm, L2-L3=17.1±1.9 mm, L3-L4=16.0±2.2 mm, L4-L5=13.4±3.3 mm, L5-S1=12.6±2.8 mm. In present study, in the asymptomatic group, the anteroposterior diameter at the intervertebral disc at different levels of lumbar vertebra varied between 18.364-14.196 mm. So, the study was more or less similar to the above-mentioned study by Jahangir M et al., [10].

Verbiest H performed decompressive laminectomy in middle-aged men who had radicular symptoms in the lower extremities that were aggravated by walking or standing. In all of these patients, the anteroposterior diameter of the lumbar spinal canal was 12 mm or less, much smaller than the 15 mm to 23 mm diameter in normal cadaver skeletons [11]. Present study on asymptomatic group showed that the measurements (18.364 mm-14.196 mm) were almost within this range of diameter.

Eisenstein S reported the variations of the spinal canal in the Caucasian, African Zulu Negroid and South Negroid and concluded that, the lumbar spinal canal was marginally less capacious in the Negroid than in the Caucasian [12]. Postachini F in a morphometric study on 121 skeletons (63 Italians and 58 Indians) found that the mean anteroposterior diameter was to be significantly greater in Italian skeletons by using radiographs and axial tomography [13]. The lowest normal limits of the anteroposterior dimension of the lumbar canal in Korean were 11 mm [14]. In a study, it has been shown that maximum and minimum mean value for spinal canal diameter were seen at L1 level in asymptomatic controls (16.93 mm) and L4 level in symptomatic cases (13.93 mm) respectively [15]. This was partly matched with the results of the studies done by Pawar et al., and Chatha DS and Schweitzer ME, who also found the spinal canal to be widest at L1. However, they had found minimum diameter at L5 level of the canal [16,17].

In present study, the mean mid-sagittal anteroposterior diameter of central lumbar vertebral canal at different vertebral level was around 16 mm. It was also found that the mean diameter was also statistically significant in patients with low back pain. So, it may be concluded from this study that, diameter of the central lumbar canal also varies from one part of the world to other as mentioned in other studies.

Verbiest H had tried to measure the sagittal diameter during operation at the cephalad and cauded borders of the neural canal and while doing so, he formulated a ratio which was less than one in normal subjects and was equal or greater than one in subjects with narrow canal [18]. It can be seen from the various studies conducted by Verbiest H that a sagittal diameter of 12 mm was considered as narrow (relative stenosis), while a sagittal diameter of 10 mm or less was considered a severely narrowed (absolute stenosis) [18,19]. The diagnostic techniques, MRI and CT scan have a definite advantage of direct visualisation of both the central canal and the lateral canal of spinal cord. MRI has an additional advantage, that it can clearly visualise the soft tissues as well [4-6].

According to one study by Koc Z et al., that mid-sagittal anteroposterior diameter of central spinal canal in the lumbar region <12 mm is indicative of symptomatic central canal stenosis [20]. Though Yong PY et al., studied that lumbar canal stenosis should be considered when anteroposterior mid-sagittal diameter is less than 15 mm [21]. As per study of Lee CK et al., [22] an anteroposterior diameter of <15 mm in the lumbar region suggests narrowing while the same below 10 mm is usually diagnostic in symptomatic patients. Hennemann S and de Abreu MR concluded that lumbar spinal stenosis can be diagnosed based on the anteroposterior diameter of the spinal canal bony canal anteroposterior diameter <12 mm at the lumbar spine [23].

Present study showed similar findings as earlier studies among symptomatic patients, particularly in the lower part of the lumbar vertebral canal. As the lumbar vertebral canal gradually decreases in size from L1 to L5 vertebra in study subjects, narrower diameter of lumbar vertebral canal was observed in the lower part of the canal. This may in turn caused compression of the neural elements, more commonly seen in the lower lumbar vertebral level which may have cause symptoms among study subjects.

It is generally believed that low back pain is more common among elderly individuals. But in this study [Table/Fig-3] it was found that the age of presentation did not showed any statistically significant

inference with low back pain. Porter RW and Bewley B reported a 10-year risk of small canal size (mean diameter, 14.5 mm) at L5 for low back pain among young subjects. They concluded that small canal dimensions are not predictors of low back pain but are a risk factor for severe back pain in early working life [24]. Present study also showed that low back pain can affect individuals at any age.

Limitation(s)

The study would have been much more robust with inclusion of larger sample of study subjects and participation of hospitals in different parts of the country. The generalisability of the inferences may increase. The lumbar spine is subjected to dynamic changes. Imaging remains primarily an evaluation of static non load bearing morphology. The dynamic dimension of spine biomechanics remains largely outside the ability to image on a routine basis.

CONCLUSION(S)

It may be concluded that low back pain is prevalent more among those who have narrowed lumbar spinal canal. So, measurement of lumbar vertebral canal mid-sagittal anteroposterior deserves importance in the management of low back pain. But age is not co related with occurrence of low back pain.

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