Original Article

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Study of Transverse Diameter of Lumbar Vertebral Body and Spinal Canal in Maharashtra Region

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Abstract

Introduction: Various aspects of lumbar vertebrae have been studied in the past and much of work has been done on morphometry of lumbar vertebrae and spinal canal. The size and shape of the spinal canal is important in relation to occurrence of symptoms of cord or root compression, especially when spondylatic changes supervene. Methods: For the present study forty complete known sets of lumbar vertebrae (25 sets of males and 15 sets of females) were collected from anatomy department of various medical colleges in Maharashtra region. Results: The parameters taken were transverse diameter of spinal canal and that of vertebral body. With the help of these parameters canal body ratio was calculated. The mean transverse diameter of spinal canal and vertebral body showed increase from L1 to L5 in both sexes. The canal body ratio ranged between 0.53 mm to 0.59 mm in females. The mean canal body ratio was about 0.6 mm at L1, L2 and L5 and about 0.5 mm at L3 and L4 in both sexes. The ratio between transverse diameter of spinal canal and vertebral body does not seem to be constant at all lumbar levels in both sexes. The parameters showed statistically significant difference in their mean values for males and females indicating sexual dimorphism. Conclusion: The present study showed regional variations in dimensions of lumbar vertebrae thus emphasizing the need to determine the normal ranges of values for different populations. These figures could help in forensic medicine because of observed racial and regional variations.

Keywords: Lumbar Vertebrae; Spinal Canal; Transverse Diameter; Canal Body Ratio.

Introduction

The vertebral column bears the weight of the trunk and upper limbs and transmits it to the lower limbs. This weight transmission subjects the vertebral column to vertical compressive forces, magnitude of which gradually increases from cervical to lumbar regions. The lumbar part of spinal canal houses the cauda equina. The narrowing of the canal may be developmental or it may be consequence of degenerative changes from aging, injury, disease or spinal operations which can lead to compression of the nerve roots and cause low back pain [1-5].

The pioneering work of Elsberg and Dyke and later reports by Verbiest , Hink, Clark and Hopkin have established the clinical value of measurements of interpedicular distance of lumbar vertebrae in the diagnosis of narrowing of spinal canal. Since then, the size of spinal canal has aroused interest for its clinical practice. Hence it is necessary to study the spinal canal [6].

Developmental spinal stenosis can occur at different segmental levels. Once standard tables and normal ranges are established, it becomes possible to diagnose segmental canal stenosis. These figures could help in forensic medicine because of observed racial and regional variations.

Hence present study is undertaken with the aim of examining the relationship of width of vertebral body (transverse diameter) with interpedicular distance of spinal canal by calculating canal body ratio and to find out if there are any regional and sex differences in the dimensions of lumbar vertebrae in Maharashtra region.

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Materials and Methods

For the present study forty complete known sets of lumbar vertebrae (25 sets of males and 15 sets of females) were collected from anatomy department of various medical colleges in Maharashtra region. The vertebrae with abnormal external features due to trauma, degenerative changes or congenital anomalies were excluded. Measurements were made by using Electronic Digital Vernier Caliper. Following measurements were taken and Canal –Body ratio (C / B) was calculated.

1. Transverse Diameter of the Lumbar Spinal Canal:

It was measured as the transverse distance between the medial surfaces of the roots of the vertebral arch of given vertebra (Photograph 1).

Fig. 1 Showing measurement of Transverse diameter of spinal canal

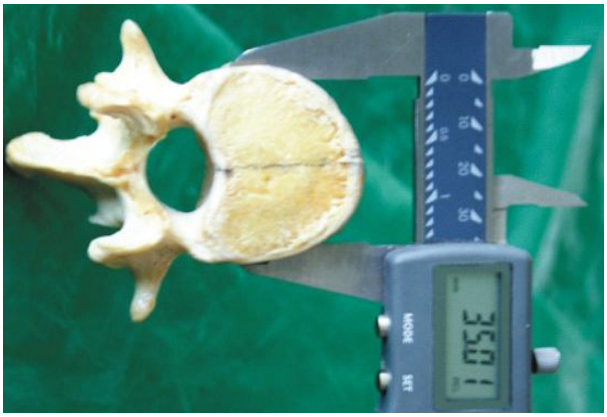

Fig. 2 Showing Measurement of Transverse Diameter of Vertebral Body

2. Transverse Diameter of the Vertebral Body

It was measured as the maximum transverse distance across the mid waist of the vertebral body (Photograph 2).

The Canal-Body Ratio (C/B) [7, 8]: It was calculated by using transverse diameter of spinal canal and corresponding vertebral body as follows.

C / B Ratio = Transverse Diameter of Spinal Canal / Transverse Diameters of Vertebral Body. Range, mean, calculated range and standard deviation for each of measurements of lumbar vertebrae were calculated. To know whether sex plays any statistically significant difference in parameters, paired *t* test is used and *p* values were calculated for each parameter in males as well as in females.

Table 1 Shows Mean transverse diameter of spinal canal (mm)

Level	Sex	Mean	Standard Deviation	Calculated Range ±3S.D	t	P Value	Significance
	M	20.63	1.198	17-24			Highly
L_1	F	19.38	1.399	15-23	2.880	0.008	Significant
	M	21.10	1.075	18-24			Highly
L_2	F	19.65	1.226	16-23	3.779	0.001	Significant
	M	21.27	2.083	15-27			Significant
L_3	F	19.85	1.816	14-25	2.263	0.030	
	M	22.23	1.645	17-27			Highly
L_4	F	20.95	1.284	17-24	2.728	0.010	Significant
	M	24.87	2.463	17-32			Not
L_5	F	24.02	2.419	16-31	1.063	0.296	Significant

(If P<0.001 -Highly Significant, P<0.05- Significant, P>0.05 - Not Significant)

Table 2: Shows the values (mm) suggestive of spinal canal stenosis and intraspinal space occupying lesion

Transverse Diameter of Spinal Canal(mm)			
Level	Sex	Suggestive of spinal canal stenosis	Suggestive of intraspinal space occupying lesion
L_1	Male	< 17.03	>24.22
	Female	< 15.18	>23.57
L_2	Male	< 17.86	>24.32
	Female	< 15.97	>23.32
L_3	Male	< 15.02	>27.52
	Female	< 14.40	>25.30
L_4	Male	< 17.29	>27.16
	Female	<17.10	>24.80
L_5	Male	< 17.48	>32.25
	Female	< 16.76	>31.28

Results

Parameters were studied and analysis was done. Analyzed data was tabulated in tables.

The mean values of transverse diameter of spinal canal gradually increased from L_1 to L_5 in both sexes. The values were more in males than females. The difference was statistically significant for males and females at L_1 to L_4 vertebra.

Considering the calculated range of transverse diameter of spinal canal, values less than lower limits of calculated range are suggestive of spinal canal stenosis, similarly the values more than the upper limits of calculated range are of suggestive of intraspinal space occupying lesions. [9].

The transverse diameter of vertebral body gradually increased from L_1 to L_5 in both sexes. The values were more in males than females. The differences between the means of the two were statistically significant at L_1 and L_3 levels.

Table 3 Shows Mean transverse diameter of vertebral body (mm)

Level	Sex	Mean	Standard Deviation	Calculated Range ± 3S.D	t	P Value	Significance
L_1	Male	35.53	3.684	24-46	2.165	0.038	Significant
	Female	32.98	3.566	22-43			
L_2	Male	36.89	3.282	27-46	1.839	0.076	Not Significant
	Female	34.84	3.488	24-45			
L_3	Male	39.67	4.653	26-54	2.331	0.025	Significant
	Female	36.78	3.179	27-46			
L_4	Male	41.64	3.930	30-53	1.793	0.081	Not Significant
	Female	39.67	2.993	30-48			
L_5	Male	44.51	3.774	33-55	1.676	0.105	Not Significant
	Female	42.30	4.217	30-55			

(If P<0.001 -Highly Significant, P<0.05- Significant, P>0.05 - Not Significant)

Table 4 Shows Canal body ratio of present Study

Level	Sex	Mean Transverse Diameter of Spinal Canal	Mean Transverse Diameter of Vertebral Body	Canal-Body Ratio
L_1	Male	20.63	35.53	0.58
	Female	19.38	32.98	0.59
L_2	Male	21.10	36.89	0.57
	Female	19.65	34.84	0.56
L_3	Male	21.27	39.67	0.54
	Female	19.85	36.78	0.54
L_4	Male	22.23	41.64	0.53
	Female	20.95	39.67	0.53
L_5	Male	24.87	44.51	0.56
	Female	24.02	42.30	0.57

The mean canal body ratio was about 0.6 mm at L_1, L_2 and L_5 and about 0.5 mm at L_3 and L_4 in both sexes.

Discussion

The shape of lumbar vertebral canal varies from oval to triangular. The lumbar spinal canal contains conus medullaris and cauda equina within dural sac as well as epidural vessels with variable amount of fat outside the dura. The bony wall of canal is unyielding and there is normally certain minimal free space between the canal and contents. This space allows for the free movement of contents of canal without tension or pressure during these movements. Therefore, the normal size of canal is important.

Table 5 Shows Comparison of mean of transverse diameter of spinal canal in both Sexes of present study with previous data (mm)

Authors	Sex	N	Level				
			L_1	L_2	L_3	L_4	L_5
Eisenstein 1977[3] South African Caucasoid	M	78	23	24	23	24	26
	F	35	22	22	23	23	25
Eisenstein 1977 [3] Zulus	M	108	21	22	22	23	26
	F	54	20	21	21	22	24
Eisenstein 1977 [3] Sotho Negroid	M	106	21	21	22	23	25
	F	62	20	20	21	22	24
Jadhav 2013[9] Western Maharashtra	M	44	22.16	22.66	23.66	24.78	27.03
	F	40	19.84	20.16	21.59	23.09	25.47
Present Study	M	25	20.63	21.10	21.27	22.23	24.87
	F	15	19.38	19.65	19.85	20.96	24.02

An abnormal reduction in the size of the canal could predispose the individual to lower back pain.

Various causes have been attributed to low backache, but lumbar spinal canal stenosis as a causative factor in lumbar stenosis especially in the extent to which the cauda equina may be compressed within the lumbar spinal canal by constriction or narrowing of the bony ring of the canal, in contract to impingement by soft tissue [10].

Clinical value of spinal canal measurements is twofold. First, expanding intraspinal masses which enlarge the spinal canal can be detected. Second, bony encroachment upon the spinal canal can be diagnosed. The first recognizable example of lumbar spinal stenosis is provided by the Greek God Hephaestus who was having Achondroplasia limped as a result of trauma to an already narrowed spinal canal [9, 11 and 12].

Transverse diameter of spinal canal

The transverse diameter of spinal canal increased from L_1 to L_5 levels. Similar findings were observed in previous studies also. In the present study, the mean values of transverse diameter of spinal canal in females were comparable with other studies in western Maharashtra population and Sotho Negroid females [3,9] ,but the values in males differed slightly.

Transverse diameter of vertebral body

In the present study we found steady increase in transverse diameter of vertebral body. Widest transverse diameter was at L_5 and narrowest at L_1 in both sexes. The findings were similar to previous studies; however, the values of this parameter were less than the previous studies.

It was also seen that dimensions of vertebral body were larger in males than in females. The transverse growth of vertebral body is dependent on masculinity to some extent. This fact contributes to larger transverse diameters of vertebral bodies in males, who are more muscular than females [9].

Canal body ratio

The size of vertebral body is proportionate with build of individual. To find out the relationship between canal and body size of vertebra, the canal body ratio was calculated.

Table 6 Shows Comparison of mean transverse diameter of vertebral body in males and females of present study with previous data (mm)

Authors	Sex	N	Level				
			L_1	L_2	L_3	L_4	L_5
Eisenstein 1977 SouthAfrican Caucasoid[3]	M	78	39	40	43	44	46
	F	35	34	35	37	39	42
Eisenstein 1977 Zulus[3]	M	108	39	40	42	44	45
	F	54	35	37	38	41	43
Eisenstein 1977 Sotho Negroid [3]	M	106	38	39	41	43	44
	F	62	34	36	38	40	42
Jadhav2013 Western Maharashtra [9]	M	44	36.19	38.09	40.19	42.44	45.44
	F	40	33.34	35.22	37.16	39.69	41.84
Present Study	M	25	35.53	36.89	39.67	41.64	44.52
	F	15	32.98	34.84	36.78	39.67	42.30

Correlation between the width of lumbar vertebral canal and that of vertebral bodies showed a positive relation, here interpedicular diameter proportionally increased with transverse diameter of the body. This relation is so steady that the ratio between the two was found to be constant about 0.6 at L_1, L_2 and L_5. At L_3 and L_4 the ratios are different and both are equal, being about 0.5 in both sexes and this signifies that at these two levels (L_3 and L_4) the vertebral bodies are larger than the canal and are thus susceptible to stenosis [13].

The ratios of the present study were comparable with that of Jadhav [9] at L_1, L_2 and L_5 in both sexes where as for L_3 and L_4 they were lower [9]. When compared with the study by Devi [4], the present study showed higher values. The reasons for these differences are not clear, but interplay of racial, ethnic and environmental factors cannot be ruled out. Calculation of canal body ratio for different segments can also help in specifying whether individual measurements of spinal canal are within the normal limit for respective body size or not, thus helping to identify stenosis or dilatation of spinal canal[1,14-16].

Table 7 Shows Comparison of canal body ratio of present study with previous study

Level	Authors				
	Devi 2003 South Indian [4]	Jadhav2013 Western Maharashtra [9]		Present Study	
		Male	Female	Male	Female
L1	0.52	0.61	0.59	0.58	0.59
L2	0.49	0.60	0.57	0.57	0.56
L3	0.48	0.59	0.58	0.54	0.54
L4	0.49	0.59	0.58	0.53	0.53
L5	0.53	0.60	0.61	0.56	0.57

There are considerable variations in transverse diameter of vertebral body and spinal canal between different races. Variations can occur in relation to general somatic size within a population. But transverse diameter of the spinal canal at any segmental level is proportional to the width of the vertebral body at that level [1, 14]. The obvious differences in canal size of various studied groups emphasize the need to compile tables applicable to a particular group.

Conclusion

In the present study transverse diameter of spinal canal and vertebral body and canal body ratio were studied. Transverse diameter of spinal canal and vertebral body showed statistically significant difference in their mean values for males and females indicating sexual dimorphism. The canal body ratio was not constant for L_1 to L_5 vertebral levels in both sexes. The present study also showed regional variations in dimensions of lumbar vertebrae thus emphasizing the need to determine the normal ranges of values for different populations. These figures could help in forensic medicine because of observed racial and regional variations.

Furthermore study of these parameters can be useful in detection of clinical conditions like spinal canal stenosis and some cases of intraspinal tumors etc.

Abbreviations used

1. S.D.-Standard Deviation
2. P-Probability or level of significance for difference between two means.
3. M -Male
4. F- Female
5. N-Total number of sample size

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