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Original Research Article

THE MORPHOMETRIC STUDY OF INTERVERTEBRAL FORAMEN OF LUMBOSACRAL (L1-S1) REGION IN HUMAN CADAVERS

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ABSTRACT

Background and objective: The dimensions of intervertebral foramen can be altered by various factors. The objective of the present study was to measure the dimensions of L1-S1 intervertebral foramen and compare them on both sides and in both sexes.

Methodology: The present study was conducted on 10 human cadavers (100 intervertebral foramina), collected from the department of Anatomy, Mysore medical college and research institute, Mysore. Descriptive statistics, ANOVA (Analysis of Variance) and Independent t- test were used appropriately.

Results: It was observed that the foramen height was more than foramen length (antero-posterior length) at all levels. The foraminal height and length at the lower lumbar levels were significantly smaller than those at the upper levels. The difference observed in the morphometry of foramen on right and left side; and with respect to gender was statistically not significant.

Conclusions: The present study describes the normal parameters of intervertebral foramen.

KEY WORDS: Intervertebral foramen; lumbar spine.

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INTRODUCTION

The intervertebral foramen serves as a gate between the spinal canal and the periphery. It is located at all levels of the spine between the pedicles of the neighbouring vertebrae. Intervertebral foramen is the main route of entry and exit, to and from the vertebral canal. The boundaries of a generalised intervertebral foramen are anteriorly, from above downwards, the posterolateral aspect of the superior vertebral body, the posterolateral aspect of the intervertebral disc and a small(variable) posterolateral aspect of the body of inferior vertebra; superiorly, the deep arched inferior vertebral notch of the vertebra above; inferiorly, the shallow superior vertebral notch of the vertebral below; and posteriorly a part of the ventral aspect of the fibrous capsule of the facet synovial joint. This foramen is unique in its composition from other foramina of the body due to its boundaries consisting of two movable joints: ventral intervertebral joint and dorsal zygophyseal joint [1]. The proportion between

the size of foramen and the space occupied by the nerve root determines the chance of nerve root compression within the foramen.

The intervertebral foramina are highly significant in biomechanical, functional and clinical aspect, due their construction, content and susceptibility to multiple disorders. Three dimensional appreciations of the spinal root and its extension through intervertebral foramen are essential for efficient management of spinal injury, tumour and infection.

The purpose of this study was to define the anatomic borders and dimensions of intervertebral foramen.

MATERIALS AND METHODS

The present study was conducted by dissecting 100 foraminal levels in 10 human adult cadavers, of both gender (males-6 and females-4) and age ranging from 40-65 years, fixed with formalin which were collected from the department of Anatomy, Mysore medical college and research institute, Mysore, over a period of 18 months(December 2009 to March 2011). Human adult cadavers with no previous spinal surgery were included in the study. Those cadavers with gross evidence of congenital / acquired disorders of spine and foramen with distortion of normal anatomy were excluded.

Cadavers were placed in the prone position and a routine paraspinal approach was used to expose the posterior spinal elements from L1-S1. A meticulous dissection was performed, denuding all soft tissues from the spinous to transverse process laterally. The intertransversarious muscles were removed between each transverse process and anterior lumbar fascia connecting the superior and inferior borders of each transverse process was incised, preserving the anatomic relationship between bony and neural structures. An osteotomy of the iliac crest was performed to visualise the L1-S1 foramen. A segment of transverse processes were cut across proper visualisation of the foramina. The foraminal anatomy and exiting nerve roots were visualised between L1-L5. Then the morphometry of the intervertebral foramen was studied.

Parameters studied

i) Foramen height: Maximum distance between the inferior margin of pedicle of superior vertebrae and the superior margin of pedicle of inferior vertebrae.(Fig1)

ii) Foramen length (Antero posterior length): it is measured in horizontal plane.(Fig 2)

a. Superior foramen length: Maximum length in the superior part of the foramen.

b. nferior foramen length: Minimum length in the central part of the foramen.

Measurements were studied with the help of the divider. The ends of the divider were then kept on Vernier callipers (precision=0.1mm) and exact measurements were noted. Parameters observed were foramen height, foramen length (superior and middle). Descriptive statistics, ANOVA (Analysis of Variance) and Independent t- test were used appropriately.

Fig. 1: Intervertebral foramen height at L3-L4 level on left side).

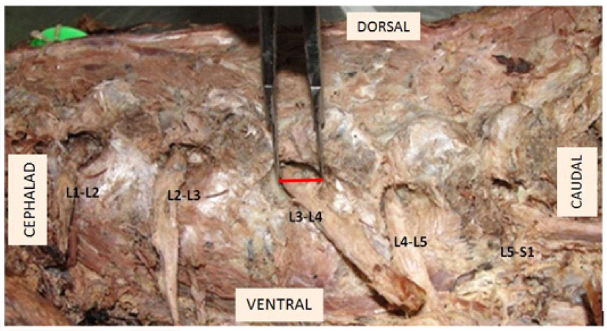
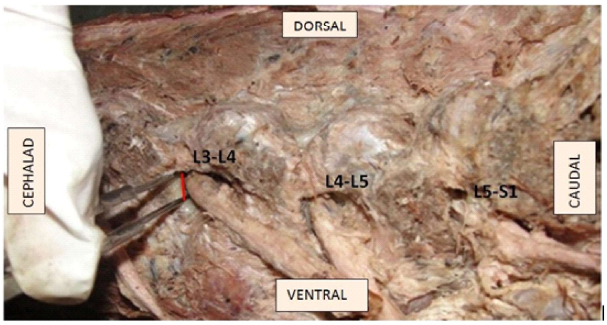


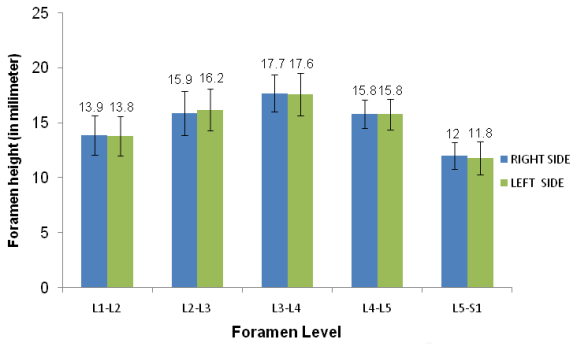
Fig. 2: Foramen length (superior) at L3-L4 level on left side).



RESULTS

There was a gradual increase in the foramen height on both right side and left side from L1-L2 to L3-L4 level and then decreases from L4-L5 to L5-S1 level and was statistically significant (p-value < 0.001). p-value (0.001) is significant for L5-S1 when compared with L2-L3, L3-L4 and L4-L5 level . The difference in the foramen height on right and left side was not statistically significant. (Graph1)

Graph 1: Foramen height on right and left side.



The foramen height on both right and left side were comparatively more in males than in females but was not statistically significant. (Table1)

Table 1: Showing gender wise changes in the foramen height on right and left side.

Foramen Level	Right Side		Left Side	
	Male	Female	Male	Female
	Mean(mm) ±SD	Mean(mm) ±SD	Mean(mm) ±SD	Mean(mm) ±SD
L1-L2	14.1 ± 2.3	13.8 ± 0.7	14.3 ± 2.3	13.1 ± 0.7
L2-L3	16.1 ± 2.2	15.7 ± 1.9	16.7 ± 2.1	15.4 ± 1.6
L3-L4	17.8 ± 2.1	17.5 ± 1.1	18.0 ± 2.2	17.1 ± 1.3
L4-L5	16.0 ± 1.4	15.5 ± 1.5	16.3 ± 1.4	15.2 ± 1.5
L5-S1	12.5 ± 1.2	11.2 ± 0.6	11.9 ± 1.9	11.6 ± 0.6

The foramen length (superior) on right side was more at L1-L2, L3-L4 and L5-S1 and less at L2-L3 and L4-L5 level. The change in the foramen length (superior) on left side was similar to that on right side. The increase length at L5-S1 level both on right and left side was statistically significant (p-value < 0.001).

There was a gradual decrease in the foramen length (middle) from L1-L2 to L4-L5 level and thereafter an increase at L5-S1 both on right and left side. The minimum value at L4-L5 level was statistically significant when compared with the values at the upper vertebral levels. The changes in the foramen length (superior) and foramen length (middle) on right and left side were not statistically significant. (Table 2)

Table 2: Showing changes in the foramen length on right and left side.

Foramen Level	Foramen Length (Superior)		Foramen Length (Middle)	
	Right Side	Left Side	Right Side	Left Side
	Mean(mm) ±SD	Mean(mm) ±SD	Mean(mm) ±SD	Mean(mm) ±SD
L1-L2	8.4 ± 1.0	8.3 ± 1.2	6.3 ± 0.9	6.4 ± 0.6
L2-L3	8.2 ± 1.0	7.6 ± 1.1	5.8 ± 0.7	5.8 ± 0.7
L3-L4	9.2 ± 1.4	9.1 ± 0.5	5.3 ± 0.7	5.2 ± 0.8
L4-L5	8.0 ± 1.3	8.0 ± 0.6	4.5 ± 1.0 *	4.6 ± 0.7*
L5-S1	9.9 ± 1.1*	10 ± 1.1*	5.9 ± 0.9	6.2 ± 1.0
* p-value < 0.001 compared to values at higher foraminal levels				

The foramen length (superior) on right side were comparatively more in males than in females but was not statistically significant. Increase in the foramen length (superior) on left side was observed in males than in females which were not statistically significant. (Table 3)

Table 3: Showing gender wise changes in the foramen length on right and left side.

Foramen Level	Foramen Length (Superior)				Foramen Length (Middle)			
	Right		Left		Right		Left	
	Male	Female	Male	Female	Male	Female	Male	Female
L1-L2	8.2±1.0	8.8 ±1.1	8.4±1.0	8.3 ±1.6	6.2 ± 1.0	6.3 ± 0.8	6.6 ± 0.6	6.1 ± 0.6
L2-L3	7.9±1.1	8.6 ±1.0	7.6±1.0	7.7±1.3	5.9 ± 0.9	5.7 ±0.5	6.0 ± 0.6	5.5 ± 0.8
L3-L4	9.7±1.6	9.7 ±1.6	9.3±0.5	9.0±0.4	5.2 ± 0.8	5.5 ±0.6	5.5 ± 0.6	4.7 ±0.9
L4-L5	7.7±1.4	8.3 ±1.2	7.9±0.7	8.1±0.6	4.5 ±1.1	4.4 ±0.9	4.9 ±0.8	4.3 ±0.5
L5-S1	9.7±1.4	10.2±0.7	9.7±1.5	10.4±0.3	5.7 ± 0.7	6.3 ±1.2	6.2 ± 1.0	6.2 ±1.2

DISCUSSION

The intervertebral foramen serves as the gate between the spinal canal and periphery. Different authors have chosen separate and distinct classification to describe the foramen. Crock [2] in 1981 has described the intervertebral foramen as a single sagittal slice through the narrowest portion of the nerve root canal. When looking through the intervertebral foramen the foramen takes the appearance of an oval, round or inverted tear drop shaped window. Schenck [3] described it as pear or light bulb shaped. The soft tissue structures such as intervertebral disc and ligaments were considered to be important in the pathology of diseases related to intervertebral foramen [4, 5].

Though foraminal morphology has been investigated in the literature [6-10], there is no agreement as to what constitutes a normal lumbar foramen, and how the foraminal dimensions vary with spinal level, gender or age [11].

Our results agree with these earlier descriptions of the foraminal dimensions (Table 4,5,6) [9,11,12], with respect to the finding that the upper lumbar levels have larger foraminal height and smaller foraminal length than the lower levels though there was differences with respect to analysis methods and sample sizes. Twomey and Taylor [13] observed the foramen height changes with ageing in both males and females. They also observed a steady increase in the foramen length from L1-L2 to L5-S1and increases with ageing at all levels in males. The decrease in the foramen height with age in females could be related to reduced length of vertebral column, may be because of osteoporosis or

changes in the posture of lumbosacral spine with ageing.

At the lower lumbar levels, the deep gutter on the posterior aspect of vertebral body causes a further widening of the intervertebral foramen on the anterior aspect. The posterior positioning of inferior articular process and the sloping of lamina further posteriorly widens the transverse diameter. The antero-posterior dimension of the pedicle as well as the gradually increasing medio-lateral dimension is important in determining the antero posterior length of the intervertebral foramen in the superior as well as inferior aspects [12]. Quite contrary to the present study, that done by Senoo et al [11] and on Nigerians by Amonoo-Kuofi [14] showed a, but steady decrease in the foramen length in both sexes.

Table 4: Comparison of foramen height and length with other studies.

Foramen level	Rema devi et al [12]		Hasegawa et al[9]			Senoo et al[11]		Present study		
Study design	Cadaveric		Cadaveric			in vivo 3D CT		Cadaveric		
Sample size	21		18(5M,13F) n=100 foramina			59(31M,28F) n=590 foramina		10(6M,4F) n=100 foramina		
Age range(yrs)	25-60		35-86			22-58		40-65		
	FH	FL	FH	FLS	FLM	FH	FL	FH	FLS	FLM
L1-L2	14.8	9.9	20	7.8	5.7	17.9	7.2	13.9	8.4	6.4
L2-L3	15.5	9.9	21.2	8.8	5.1	18	6.8	16.1	7.9	5.8
L3-L4	15.3	9.8	21.4	9.1	5.1	17.2	6.5	17.7	9.2	5.3
L4-L5	15.1	11.3	20.1	9.1	4.1	16.1	5.5	15.8	8	4.6
L5-S1	12.5	13.3	19.9	9.6	5.4	15.9	5	11.9	10	6.1

Table 5: Comparison of foramen height with other studies with respect gender.

Foramen level	Twomey and Taylor[13]		Present study (40-65yrs)	
	Male	Female	Male	Female
L1-L2	14.8	14.2	14.2	13.1
L2-L3	16	15.4	16.7	15.4
L3-L4	16.3	16.2	18	17.1
L4-L5	15.4	15.9	16.3	15.2
L5-S1	12.8	12.5	11.9	11.6

Table 6: Comparision of foramen length with other studies with respect gender.

Foramen level	Twomey and Taylor [13]		Amonoo-Kuofi [14] 23-60yrs		Present study (40-65yrs)			
					Male		Female	
	Male	Female	Male	Female	Sup	Mid	Sup	Mid
L1-L2	8.4	9	8.8	8.1	8.3	6.4	8.5	6.2
L2-L3	8.6	8.9	8.4	7.8	7.7	5.9	8.1	5.6
L3-L4	8.9	8.6	7.6	7.5	9.5	5.3	9.3	5.1
L4-L5	9.2	8.8	7.5	7.4	7.8	4.7	8.2	4.3
L5-S1	12.2	10.9	7	7.3	9.7	5.9	10.3	6.2

Knowledge of foraminal anatomy helps the surgeons to correlate and to treat the patient appropriately and effectively. The increasing application of minimally invasive procedures like percutaneous disectomy lends a new importance to study of this region.

CONCLUSION

The intervertebral foramen continues to be poorly defined region of the spinal cord. However, its general anatomic boundaries aid us in describing the structures that exist within the foramen. This study describes the normal parameters of foramen height & foramen length.

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Conflicts of Interests: None

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