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Cadaveric Study of Male Lumbar Intervertebral Foramina Morphometry in Ile-Ife

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Abstract:

Background: This study was designed to investigate the mean lumbar foramina height and length in male cadaveric specimens in Ile-Ife. *Aim and Objectives:* Two hundred and fifty intervertebral foramina derived from twenty-five male cadaveric specimens were analyzed, were studied. They were obtained from the Department of Anatomy, Obafemi Awolowo University, Ile-Ife, Osun State in Southwestern Nigeria. The cadavers were positioned prone and a routine paraspinal approach was employed to gain exposure to the posterior spinal element following meticulous soft tissue dissection. An osteotomy of the iliac crest was performed to adequately expose the fifth lumbar (L1-S1) foramina.Parameters assessed were; the foramen height and the foraminal length. The measurement was performed three times on each side using vernier calipers. The variations of the different measurements in the cephalo-caudal direction were analyzed for statistical differences using the "One way ANOVA" with post hoc test. *Results:* The result showed a gradual increase of the foramina height were observed on both right and left side from L1-L2 to L3-L4 and from then on decreased progressively towards the L5-S1 level. No statistical difference was noted in the measurements derived ($p<0.05$). *Conclusion:* A good understanding of the lumbar intervertebral foraminal are essential in surgical planning of suitably sized cannulas necessary for less invasive spine surgeries as well as help in diagnosis of pathologies surrounding this important region following adequate clinical evaluation and measurements using imaging.

Keywords: Cadaveric Specimens, Lumbar, Intervertebral Foramina, Morphometry, Anatomic Region

Introduction:

The intervertebral foramina are the anatomic region of the spine through which the spinal nerve roots exit the spinal cord to supply its distal anatomic structures. It is bounded anteriorly by the intervertebral disc and posteriorly by the zygapophyseal (facet) joint [1]. The nerve roots from the spinal cord traversing the intervertebral foramen are capable upon compression, of producing leg pain, while the dural tissue in the central canal is less sensitive [2].

A three-dimensional appreciation of the spinal nerve roots and extensions are essential for effective management of spinal injuries, tumors and infections [3, 4]. Anatomic narrowing of both the lumbar vertebral canal and intervertebral foramina has been reported by studies as the cause of compression of the cauda equina and emerging nerve roots [5]. Subtle changes in the spine such as a collapse of the intervertebral disc by only 4mm was sufficient to lead to a significant narrowing of the diameters of the intervertebral foramina at all levels of the lumbar spine which was further worsened by lumbar extension [6].

Several biomechanical studies using tomographic imaging have shown that even movements such as

flexion of the spine anteriorly and laterally resulted in an increased cross-sectional area of the foramina on the convex side and a decrease on the concave side. Whereas extension and with lateral flexion of the lumbar spine resulted in foramina narrowing at the convex side instead [7,8]. This study was aimed at offering a baseline assessment of this important anatomic region due to the paucity of local data regarding the lumbar intervertebral foramina morphometry in the Nigerian population and could be of immense benefit during minimally invasive surgical procedures and the objectives would be to determine the lumbar intervertebral foraminal heights and lengths (width) at all levels in male cadaveric specimens.

Material and Methods:

Two hundred and fifty intervertebral foramina derived from twenty-five male cadaveric specimens were analyzed. The cadavers were obtained from the Anatomy Department of the Obafemi Awolowo University, Ile-Ife, Osun state. Measurements made were adopted by the method described by Hrdlicka's Practical Anthropometry [9].The cadavers were positioned prone and a routine paraspinal approach was employed to gain exposure to the posterior spinal element following meticulous soft tissue dissection. An osteotomy of the iliac crest wasper formed to adequately expose the fifth lumbar (L1-S1) foramina.

Parameters assessed were; the foramen height (maximum distance between the inferior margin of the pedicle of the superior vertebra and the superior margin of the inferior vertebra) and the foraminal length (anteroposterior length of the intervertebral foramen). The measurement was performed three times on each side using vernier calipers to record the widest diameters of the aforementioned regions in millimeters (mm) and their mean values at each level and sides were extrapolated thereafter. The variations of the different measurements obtained in a cephalo-caudal fashion were analyzed for statistical significance using the 'One way ANOVA with post Hoc test (Scheffe).

Results:

Table 1: Male Foramina Height - Right Side

Foramen level	Range (mm)		Mean ± SD
	Minimum	Maximum	
L1-L2	13.02	16.55	14.67 ± 1.03
L2-L3	12.10	18.23	15.86 ± 1.80
L3-L4	15.60	20.60	18.13 ± 1.52
L4-L5	13.38	19.50	16.64 ± 1.55
L5-S1	12.12	18.02	14.85 ± 1.52

Table 2: Male Foramina Height – Left Side

Foramen level	Range (mm)		Mean ± SD
	Minimum	Maximum	
L1-L2	12.02	15.94	14.22 ± 1.09
L2-L3	14.15	18.39	16.08 ± 1.36
L3-L4	15.27	20.11	18.07 ± 1.73
L4-L5	14.07	20.05	16.30 ± 1.79
L5-S1	12.25	19.05	15.18 ± 1.69

Table 3: Paired Comparison of Mean Intervertebral Foraminal Height in Male Cadavers

Side	Mean ± SD (mm)	t	p	Correlation
Left	16.17 ± 2.06	1.054	0.295	0.844
Right	16.03 ± 1.94			

A gradual increase of the foraminal height was observed on the right side from L1-L2 to L3-L4 and from then on decreased progressively towards the L5-S1 level. No statistical difference was noted in the measurements derived ($p<0.05$)

A gradual increase in the lumbar foraminal heights were observed on the left side from L1-L2 level up to L3-L4 and from then on decrease up to the L5-S1 level. The variations of the dimensions obtained were not statistically significant ($p <0.05$)

There was no statistical difference observed between the mean intervertebral foraminal heights observed between the right and left side ($p < 0.05$). The distal two levels were consistently larger than the proximal two levels on both sides studied. A positive correlation existed between lumbar intervertebral foraminal heights measured.

There was a gradual increase in the lumbar intervertebral foraminal lengths on the right side from L1-L2 to L3-L4 level and from then on a decrease distally to L5-S1 level which was statistically insignificant ($p < 0.05$)

There was increase in the lumbar intervertebral foraminal lengths on the left side from L1-L2 to L3-L4 level and from then on a decrease distally to L5-S1 level which was statistically insignificant ($p < 0.05$)

There was a significant difference observed from the length of the intervertebral foramen seen on both sides in the males ($p < 0.05$) ith the right larger than the left. A positive correlation existed between the intervertebral lengths measured on both sides.

Table 4: Male Foramina Length – Right Side

Foramen level	Range (mm)		Mean ± SD
	Minimum	Maximum	
L1-L2	7.60	16.20	12.10 ± 2.60
L2-L3	7.25	18.83	13.59 ± 3.60
L3-L4	9.02	20.71	15.40 ± 4.09
L4-L5	8.21	18.41	13.43 ± 3.96
L5-S1	7.35	16.53	11.80 ± 3.25

Table 5: Male Foramina Length – Left Side

Foramen level	Range (mm)		Mean ± SD
	Minimum	Maximum	
L1-L2	8.36	15.46	11.62 ± 2.31
L2-L3	8.40	17.29	13.16 ± 3.12
L3-L4	10.44	19.66	14.98 ± 3.54
L4-L5	6.67	18.21	12.98 ± 4.01
L5-S1	6.70	19.23	12.30 ± 3.94

Table 6: Paired Comparison of Mean Intervertebral Foraminal Lengths in Male Cadavers

Side	Mean ± SD (mm)	t	p	Correlation
Left	13.00 ± 3.53	-2.016	0.047	0.954
Right	13.26 ± 3.68			

Discussion:

In this study, the intervertebral foraminal heights and lengths showed similar patterns of decrease in dimensions cranially and caudally from the mid level (L3-L4) foramen which was the largest on both sides. No significant differences were seen in the foraminal height observed between the right or left side of the lumbosacrum. These findings were partly similar to the study by Kaneko *et al*. [4] where computed tomographic scanning used to measure the lumbosacral foramina dimensions of live subjects showed reduction in the mean foraminal height from the L3-L4 level to L5-S1 level however; the mean foramina width was maximal at the L5-S1 region followed by the L3-L4 level and then the L4-L5. The L1-L2 and L2-L3 level were not studied [4].

The foramina heights in this study were found to be larger at all levels than their corresponding lengths. This observation was slightly similar to those observed by Devi and Rajagopalan [3] who observed larger height dimensions than the length at all the lumbar levels except at the L5-S1 level in which it was the other way round. However, the largest dimensions were seen at the L2-L3 level and from then on reduced in size up to the L5-S1 level [3]. Another difference observed was in the foramina lengthwhich decreased from L1-L2 to L3-L4 level and from then on increased in dimensions distally to L5-S1 region. This was totally different to what was seen in this study which may be attributed to racial morphologic differences of the specimens studied.

The findings of this study were however in tandem with results observed among live male subjects in a study conducted in Jordan where magnetic resonance imaging was used in measuring the intervertebral foraminal height dimensions. It showed maximal diameters at the L3-L4 level with corresponding decrease both proximally and distally there on. The mean height measured were however larger than those observed in this study [10]. A limitation of this study was the assessment of only male cadaveric specimens. Inclusion of female cadaveric specimens would go a long way in defining gender differences in morphology which would be of immense benefit to the morphological database of this important region of the spine.

Conclusion:

A good understanding of the lumbar intervertebral foramina and its dimensions peculiar to our racial anatomic configuration is essential in surgical planning of suitably sized cannulas necessary for less invasive spine surgeries as well as help in diagnosis of pathologies surrounding this important region following adequate clinical evaluation and measurements using imaging. Further studies on live subjects and those with pathologies around this region will be necessary in gaining better understanding to the pathophysioanatomic processes resulting in lumbar foraminal stenosis.

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