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ORIGINAL PAPER

CT Assessment of the *in vivo* Osseous Lumbar Intervertebral Foramen: a Radiologic Study with Clinical Applications

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ABSTRACT

Objectives: *The objective of this study was to investigate the dimensions of the osseous lumbar intervertebral foramen (IVF) regarding a sample without any clinical indication of spine pathology and, additionally, survey possible correlations of these measurements with clinical characteristics of the individuals.*

Materials and Methods: *CT images of spine-related asymptomatic individuals were examined on parasagittal and oblique projections for the evaluation of cranial foramen width (CrFW), caudal foramen width (CaFW), vertebral height (VH) and foraminal height (FH) in accordance with gender, age, height, weight, body mass index (BMI) and vertebral level.*

Results: *Overall, CT images of 73 individuals, 40 men and 33 women, with mean age 56.81 (± 14.79) years, mean height 1.69 (± 0.09) meters, mean weight 81.27 (± 18.14) kilograms and mean BMI 28.35 (± 5.62) were included. The maximum mean FW was the CaFWL1 and the minimum the CrFWL5, with values of 8.11 and 6.01 mm, respectively. Height and weight were presented as significantly bigger in men than women; however, women had bigger lumbar IVF values and no significant width measurement for IVF was*

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observed at any level for either sex. Age showed a negative impact on the elderly by reducing height and the majority of FW measurements. Statistically important differences in accordance with BMI were not seen.

Conclusions: *Data comparison with previous studies is ambiguous due to methodological differences and possible populational variations and they reveal just a glimpse of the* in vivo *lumbar IVF. Our data could have clinical application on lumbar spine interventions.*

Keywords: intervertebral foramen, lumbar, osseous, *in vivo*, radiologic, neurosurgery, spine surgery, foraminoplasty.

INTRODUCTION

It is known that the lumbar spine consists of five moveable vertebrae and it is characterized by a combination of these strong vertebrae linked by joint capsules, flexible ligaments, large muscles, and highly sensitive nerves. Lumbar spine is designed to be strong, to protect the spinal cord and the spinal nerve roots, and simultaneously flexible, providing mobility in many different planes of motion.

A significant entity of the lumbar spine is the lumbar intervertebral foramen (IVF). It is the pathway between the spinal canal and the periphery. This foramen is special due to its boundaries consisting of two movable joints: ventral intervertebral joint and dorsal zygapophysial joint. Generally, it is formed by the inferior part of the pedicle, the posteroinferior part of the vertebral body, the posterior articular lamina and the posterolateral aspect of the intervertebral disc (1).

Alterations of the dimensions of the lumbar IVF can hypothetically play a significant role in the pathophysiology of low back pain, a leading cause of disability in modern societies (2, 3). Additionally, the form of the lumbar IVF has been correlated with intervertebral disc pathology (4). Apart from disc pathology, the osseous borders of the foramen undergo ongoing remodeling and degenerative changes, which may lead to foraminal stenosis. The anatomy of the lumbar IVF has been well described, including recent reviews of the literature (5-8). Measurements of the osseous lumbar IVF are widely published and they mostly include cadaveric specimens (9). A few radiological studies referring to osteometric data of the osseous IVF have been conducted (10-15). However, so far, no radiologic study has fully investigated the static dimensions of the human osseous lumbar IVF of spine-related healthy population *in vivo*.

Thus, the main purpose of this study was to investigate the anatomic measurements of the osseous lumbar IVF referring to individuals without symptoms of spine-related disease and examine possible correlations of these measurements with clinical features including gender, age, height, weight, vertebral height and level, and body mass index (BMI). As an extension, the results of this study could be used for better application of the Efficacy of Transforaminal Endoscopic Spine System (TESSYS) Technique in treating lumbar disc herniation, especially during the foraminoplasty. ❑

MATERIALS AND METHOD

Seventy three individuals (40 men and 33 women) with mean age 56.81 (± 14.79) years, mean height 1.69 (± 0.09) meters, mean weight 81.27 (± 18.14) kilograms and mean BMI 28.35 (± 5.62) were included in our study (Tables 1 and 2).

The selected individuals were patients who underwent CT scanning of their chest and/or abdomen. All of them were of Caucasian origin. The chosen individuals had a CT scanning of their lumbar spine for reasons concerning pathological entities of the gastrointestinal and urinary tract, which did not affect in any morphological way the lumbar vertebrae. The exclusion criteria involved individuals with any indication of spine-related disease or spine-related pain, which was retrieved from their medical records. Furthermore, at the beginning of the study, two individuals were excluded due to gross morpho-

		Gender		Age		BMI	
		male	female	<60	≥60	<30	≥30
Count	N	40	33	41	32	48	25
	%	54.8	45.2	56.2	43.8	65.8	34.2

TABLE 1. Baseline data of the sample

	Minimum	Maximum	Mean	Std. Deviation
Age	16.00	86.00	56.8082	14.79176
Height	1.45	1.90	1.6905	.09043
Weight	43.00	131.00	81.2740	18.14545
BMI	17.93	46.97	28.3545	5.62019
CrFWL1	4.90	13.10	7.9583	1.43210
CrFWL2	4.70	13.40	7.4707	1.57628
CrFWL3	4.80	11.60	7.2338	1.43273
CrFWL4	4.10	11.20	7.1279	1.23466
CrFWL5	3.70	10.30	6.0965	1.39245
CaFWL1	3.20	14.20	8.1083	1.81742
CaFWL2	3.50	13.60	7.9824	2.06845
CaFWL3	3.50	12.70	7.7132	1.79775
CaFWL4	2.70	12.20	6.5508	1.85298
CaFWL5	3.80	11.90	6.6596	1.88119
VHL1	18.50	33.10	27.5403	2.73432
VHL2	23.70	34.70	29.1353	2.53805
VHL3	24.80	36.80	30.1221	2.49966
VHL4	25.20	38.60	31.0083	2.81505
VHL5	25.10	38.90	31.5246	2.83204
FHL1	12.80	30.20	20.2861	3.12195
FHL2	16.10	31.40	21.2235	2.96960
FHL3	14.60	28.30	21.4706	3.07494
FHL4	14.40	26.50	19.4050	2.76696
FHL5	10.70	26.70	19.0930	3.04143

TABLE 2. Descriptive statistics of the sample

FIGURE 1. Parasagittal oblique plane CT images of the lumbar spine

logical abnormalities which were visible on their CT images.

From the CT images of the chosen individuals, only the lumbar segments were used for data referring to the levels L1-L5. Four parameters were examined on the CT images, including cranial foramen width (CrFW), caudal foramen width (CaFW), vertebral height (VH) and foraminal height (FH) in accordance with gender, age, height, weight, BMI and vertebral level. The lumbar spine segments were imaged on parasagittal and oblique projections (Figure 1). CT scan was done in all the patients with 128 slice MDCT Siemens scanner. The routine protocol for scanning abdomen and/or pelvis was typically done with 120 kVp and an average of 250 mAs. The slice thickness for the all acquisitions was 6 mm with pitch equal to 0.6. After data acquisition, reconstruction series were typically being created with slice thickness of 1 mm and the B20f smooth kernel.

Concerning the data extraction, the measurements were electronically estimated using the radiologic software installed for processing and displaying medical images. The CrFW was defined as the shortest horizontal distance between superior posterior edges of vertebral body to corresponding superior articular process at level of cranial surface of vertebral body; the CaFW was defined as the shortest horizontal distance between inferior posterior edges of vertebral body to corresponding inferior articular process at level of caudal surface of vertebral body; the VH was defined as the height of each vertebra measured in the middle of the vertebral body on the parasagittal and oblique plane; the FH was defined as the distance between the superior and inferior vertebral notch of each IVF on the parasagittal and oblique plane (Figure 2). All measurements were made independently by two investigators; they were repeated twice, on both sides of the spine, and the average was used.

Regarding the data analysis, it was performed with the statistical package SPSS, version 23.00 (SPSS Inc, Chicago, IL). The p-value <0.05 was determined as statistically significant difference level. Continuous variables are expressed as mean ± standard deviation. We used Student's-t test for equality of means for quantitive-continuous variables of independent samples when comparing the subgroups and Wilcoxon signed-rank test for repeated measure-

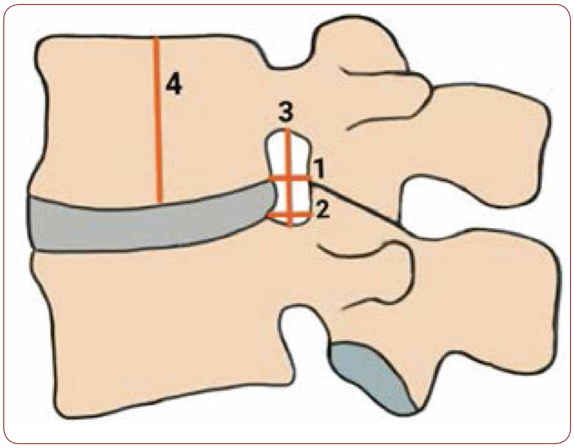

FIGURE 2. Illustration depicting the sagittal parameters of measurement. 1) caudal foraminal width, defined as the distance between inferior posterior edges of vertebral body of the superior vertebra to the corresponding inferior articular process; 2) cranial foraminal width defined as the distance between superior posterior edges of vertebral body of the inferior vertebra to the corresponding superior articular process; 3) foraminal height defined as the distance between the superior and inferior vertebral notch; 4) vertebral height defined as the height of each vertebra measured in the middle of the vertebral body.

ments within the whole sample. The correlation between the variables was studied with the Pearson correlation coefficient. ❑

RESULTS

Overall, 73 lumbar spine segments were analyzed using the CT images of the individuals. Referring to the whole sample, the following statistically significant correlations between the variables are observed (see Table 3 in the online version of this article). A positive correlation between height and weight and a negative correlation between height and age is seen. All CrFWs, all VHs and the CaFWL1, CaFWL2, CaFWL3, CaFWL4 present a negative correlation with age. The CrFWs and the CaFWs present a significant positive correlation between and amongst them, except for the correlation of CrFWL1 with CaFWL5, which is not significant. All VHs and FHL1, FHL2 present a positive correlation with height. All VHs, apart from VHL3, exhibit positive correlation with CrFWL4. VHL1, VHL2, VHL3, VHL4 seem to have positive correlation amongst them and with FHL1. The VHL5 presents positive correlation with the rest VHs but

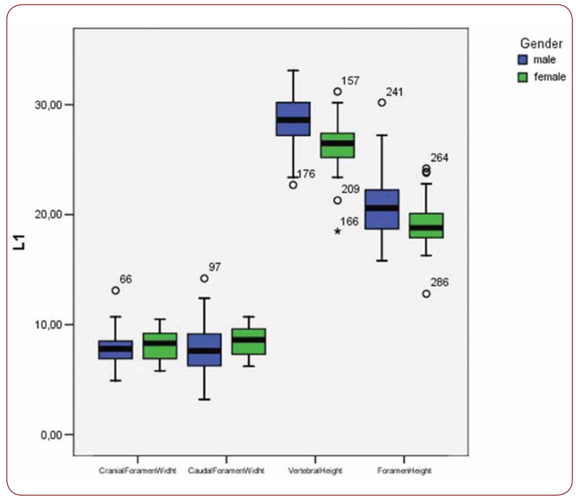

FIGURE 3. Box plot of CrFW, CaFW, VH and FW at L1 level based on gender

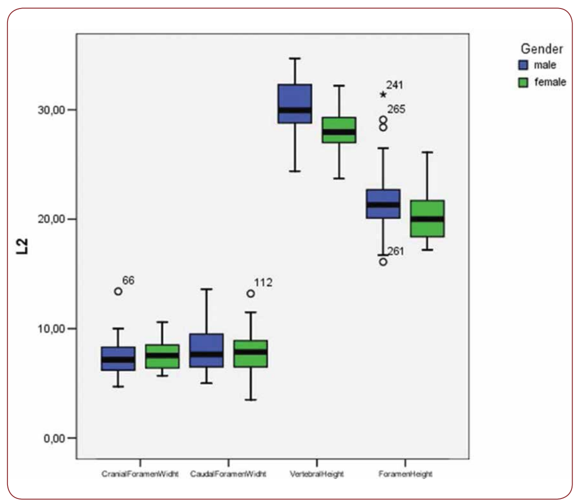

FIGURE 4. Box plot of CrFW, CaFW, VH and FW at L2 level based on gender

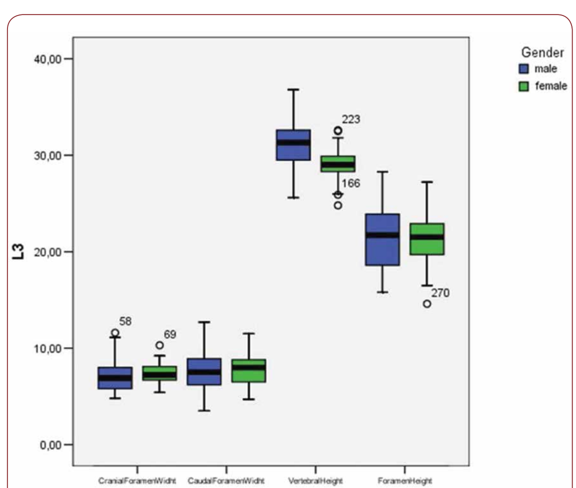

FIGURE 5. Box plot of CrFW, CaFW, VH and FW at L3 level based on gender

	Gender	Mean	Std. Deviation
Age	male	55.5750	15.94845
	female	58.3030	13.34514
Height	male	1.7473	.06243
	female	1.6218	.06899
Weight	male	86.0000	15.92611
	female	75.5455	19.23391
BMI	male	28.1102	4.56791
	female	28.6507	6.74348
CrFWL1	male	7.7949	1.49595
	female	8.1515	1.34980
CrFWL2	male	7.3529	1.75598
	female	7.6200	1.32857
CrFWL3	male	7.1342	1.60292
	female	7.3600	1.19787
CrFWL4	male	7.0364	1.45298
	female	7.2357	.92904
CrFWL5	male	6.1742	1.62869
	female	6.0038	1.06939
CaFWL1	male	7.8333	2.10367
	female	8.4333	1.36832
CaFWL2	male	8.0105	2.18592
	female	7.9467	1.94577
CaFWL3	male	7.6000	1.87530
	female	7.8567	1.71518
CaFWL4	male	6.3939	1.89950
	female	6.7357	1.81337
CaFWL5	male	6.5581	1.92558
	female	6.7808	1.85731
VHL1	male	28.6128	2.52474
	female	26.2727	2.44135
VHL2	male	30.0053	2.63633
	female	28.0333	1.94091
VHL3	male	30.9842	2.64458
	female	29.0300	1.81795
VHL4	male	32.0303	2.83918
	female	29.7593	2.26177
VHL5	male	32.5000	2.99600
	female	30.3615	2.14664
FHL1	male	21.1282	3.41128
	female	19.2909	2.43328
FHL2	male	21.8579	3.26783
	female	20.4200	2.35671
FHL3	male	21.4737	3.26080
	female	21.4667	2.87730
FHL4	male	19.5250	2.77500
	female	19.2679	2.80212
FHL5	male	19.8935	2.57733
	female	18.1385	3.31772

TABLE 4. Mean value and standard deviation of each variable according to gender

	Sig. (2-tailed)
Age	.437
Height	.000
Weight	.013
BMI	.686
CrFWL1	.296
CrFWL2	.492
CrFWL3	.523
CrFWL4	.534
CrFWL5	.650
CaFWL1	.164
CaFWL2	.901
CaFWL3	.563
CaFWL4	.477
CaFWL5	.660
VHL1	.000
VHL2	.001
VHL3	.001
VHL4	.001
VHL5	.004
FHL1	.012
FHL2	.047
FHL3	.993
FHL4	.723
FHL5	.029

TABLE 5. Significance of means based on gender

not with the FHL1. Additionally, the VHL5 presents positive correlation with the weight, CrFWL5, CaFWL3, CaFWL5. All VHs and FHL1, FHL2, FHL3 have a positive correlation with FHL5. All FHs present positive correlation amongst them. FHL5 presents positive correlation with CrFWL4. FHL4 with CrFWL3 positive correlation is observed. FHL4 presents positive correlation with CrFWL3. FHL3 presents positive correlation with CrFWL2, CrFWL3, CrFWL4. FHL2 shows positive correlation with CrFWL3. FHL1 presents positive correlation with CrFWL1, CrFWL2, CaFWL1. VHL1 presents a positive correlation with CaFWL5. A positive correlation between CrFWL4 and VHL1, VHL2, VHL4, VHL5 is seen.

With regard to the comparison between groups, using the t-test for equality of mean for independent samples, we observe that the height and weight is presented as significantly bigger in men than women. Furthermore, the VHL1, VHL2, VHL3, VHL4, VHL5, FHL1, FHL2, FHL5

	Age Group	Mean	Std. Deviation
Age	<60y	46.0976	9.72318
	>=60y	70.5313	6.32957
Height	<60y	1.7173	.08370
	>=60y	1.6563	.08827
Weight	<60y	82.6829	19.49287
	>=60y	79.4688	16.38446
BMI	<60y	27.9499	6.03095
	>=60y	28.8730	5.09276
CrFWL1	<60y	8.1425	1.58193
	>=60y	7.7281	1.20436
CrFWL2	<60y	7.7003	1.68949
	>=60y	7.1621	1.37825
CrFWL3	<60y	7.3718	1.45276
	>=60y	7.0483	1.40906
CrFWL4	<60y	7.2778	1.17281
	>=60y	6.9120	1.31254
CrFWL5	<60y	6.5088	1.32285
	>=60y	5.4870	1.28816
CaFWL1	<60y	8.2425	1.61640
	>=60y	7.9406	2.05565
CaFWL2	<60y	8.0949	1.92107
	>=60y	7.8310	2.27770
CaFWL3	<60y	8.0154	1.71810
	>=60y	7.3069	1.85182
CaFWL4	<60y	6.6389	1.82526
	>=60y	6.4240	1.92273
CaFWL5	<60y	6.6676	1.90004
	>=60y	6.6478	1.89542
VHL1	<60y	28.2550	2.66024
	>=60y	26.6469	2.59565
VHL2	<60y	29.6821	2.51353
	>=60y	28.4000	2.42148
VHL3	<60y	30.6744	2.50250
	>=60y	29.3793	2.33581
VHL4	<60y	31.4800	2.60133
	>=60y	30.3480	3.01926
VHL5	<60y	32.1500	2.44717
	>=60y	30.6000	3.15191
FHL1	<60y	19.8950	2.76804
	>=60y	20.7750	3.49848
FHL2	<60y	20.8333	2.51870
	>=60y	21.7483	3.46334
FHL3	<60y	21.4410	2.95481
	>=60y	21.5103	3.28224
FHL4	<60y	19.3914	2.97938
	>=60y	19.4240	2.49905
FHL5	<60y	18.8912	2.51340
	>=60y	19.3913	3.73021

TABLE 6. Mean value and standard deviation of the each variable according to age

	Sig. (2-tailed)
Age	.000
Height	.004
Weight	.457
BMI	.490
CrFWL1	.225
CrFWL2	.165
CrFWL3	.361
CrFWL4	.259
CrFWL5	.005
CaFWL1	.488
CaFWL2	.607
CaFWL3	.109
CaFWL4	.660
CaFWL5	.969
VHL1	.012
VHL2	.038
VHL3	.034
VHL4	.126
VHL5	.042
FHL1	.237
FHL2	.211
FHL3	.928
FHL4	.965
FHL5	.547

TABLE 7. Significance of means based on age

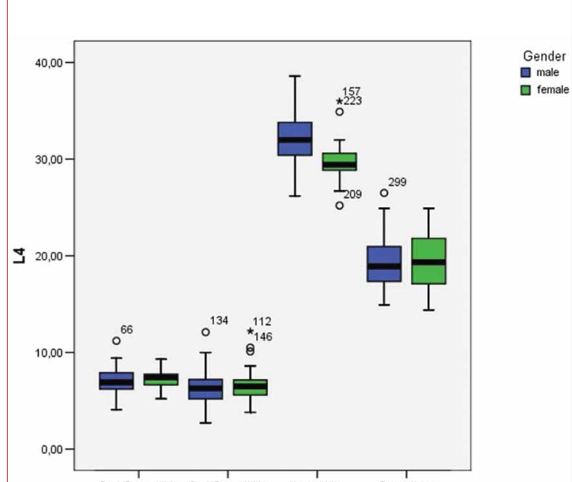

FIGURE 6. Box plot of CrFW, CaFW, VH and FW at L4 level based on gender

	BMI Grou	Mean	Std. Deviation
Age	<30	57.1250	16.08042
	>=30	56.2000	12.22361
Height	<30	1.6925	.08903
	>=30	1.6868	.09481
Weight	<30	72.5833	13.06422
	>=30	97.9600	14.57589
BMI	<30	25.2210	3.39386
	>=30	34.3709	3.85493
CrFWL1	<30	8.0000	1.13348
	>=30	7.8800	1.89605
CrFWL2	<30	7.3979	1.34644
	>=30	7.5960	1.93336
CrFWL3	<30	7.1814	1.49798
	>=30	7.3240	1.33800
CrFWL4	<30	7.2189	1.10046
	>=30	6.9875	1.43081
CrFWL5	<30	6.1639	1.46953
	>=30	5.9810	1.27578
CaFWL1	<30	8.2596	1.66846
	>=30	7.8240	2.07531
CaFWL2	<30	8.0140	2.19367
	>=30	7.9280	1.87562
CaFWL3	<30	7.8000	1.70559
	>=30	7.5640	1.97355
CaFWL4	<30	6.6595	1.92274
	>=30	6.3833	1.76701
CaFWL5	<30	6.7583	1.80339
	>=30	6.4905	2.04203
VHL1	<30	27.9766	2.47564
	>=30	26.7200	3.04918
VHL2	<30	29.4791	2.58425
	>=30	28.5440	2.39167
VHL3	<30	30.4140	2.66285
	>=30	29.6200	2.14922
VHL4	<30	31.4378	2.93403
	>=30	30.3174	2.52112
VHL5	<30	31.7694	2.97204
	>=30	31.1048	2.58969
FHL1	<30	20.5149	3.13833
	>=30	19.8560	3.10820
FHL2	<30	21.1721	2.96787
	>=30	21.3120	3.03168
FHL3	<30	21.2395	2.89377
	>=30	21.8680	3.38843
FHL4	<30	19.3833	2.90777
	>=30	19.4375	2.60214
FHL5	<30	19.4222	3.15550
	>=30	18.5286	2.81889

TABLE 8. Mean value and standard deviation of the each variable according to age

	Sig. (2-tailed)
Age	.802
Height	.800
Weight	.000
BMI	.000
CrFWL1	.738
CrFWL2	.621
CrFWL3	.695
CrFWL4	.479
CrFWL5	.637
CaFWL1	.336
CaFWL2	.870
CaFWL3	.605
CaFWL4	.574
CaFWL5	.609
VHL1	.063
VHL2	.144
VHL3	.209
VHL4	.135
VHL5	.398
FHL1	.398
FHL2	.853
FHL3	.421
FHL4	.942
FHL5	.289

TABLE 9. Significance of means based on body mass index

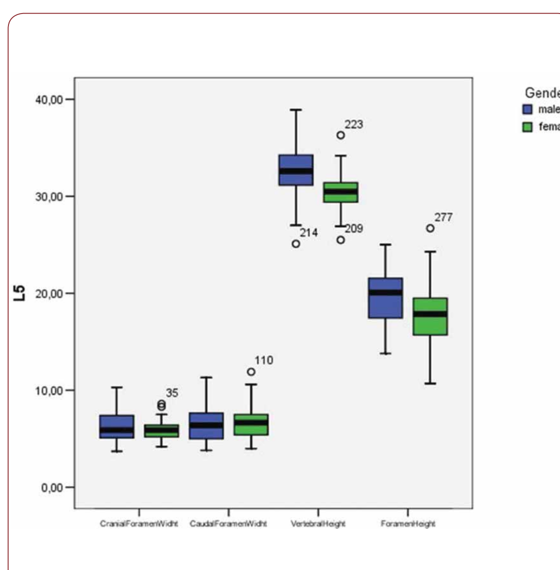

FIGURE 7. Box plot of CrFW, CaFW, VH and FW at L5 level based on gender

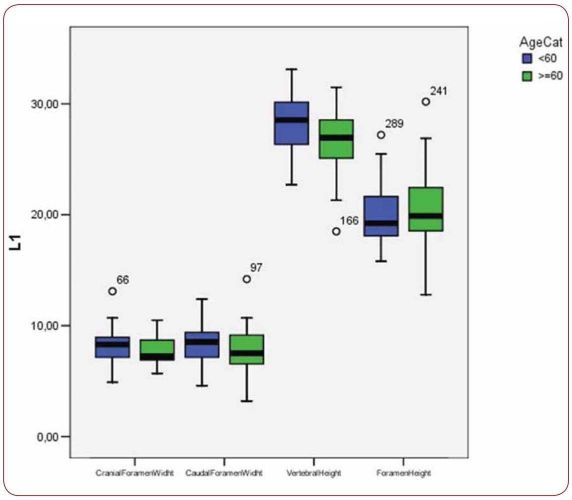

FIGURE 8. Box plot of CrFW, CaFW, VH and FW at L1 level based on age

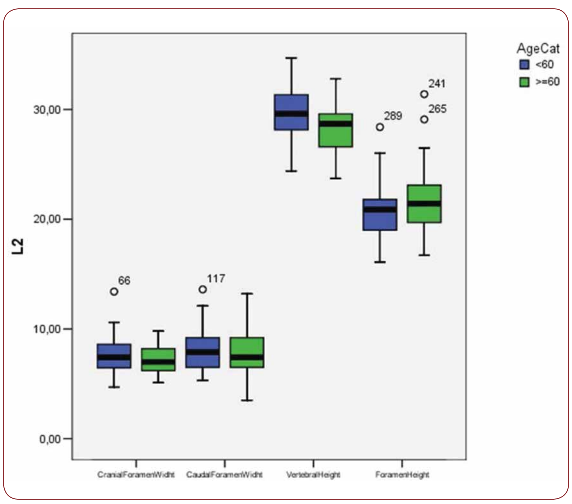

FIGURE 9. Box plot of CrFW, CaFW, VH and FW at L2 level based on age

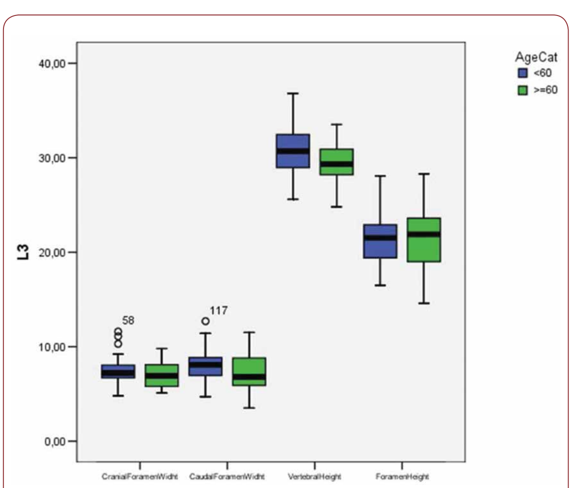

FIGURE 10. Box plot of CrFW, CaFW, VH and FW at L3 level based on age

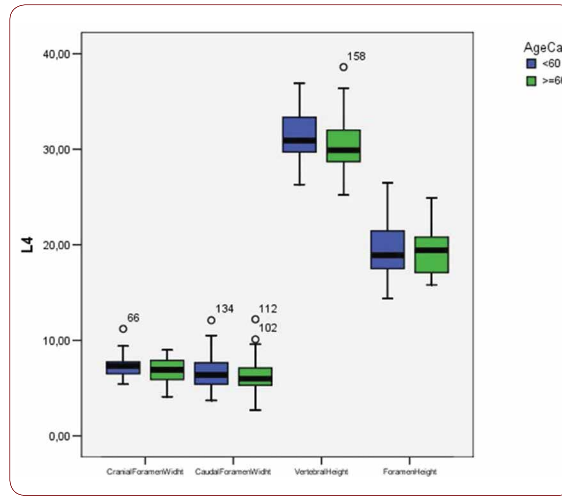

FIGURE 11. Box plot of CrFW, CaFW, VH and FW at L4 level based on age

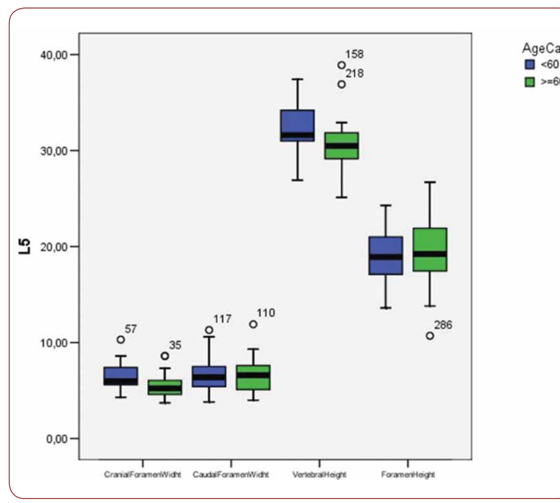

FIGURE 12. Box plot of CrFW, CaFW, VH and FW at L5 level based on age

are bigger in men as compared to women (Tables 4, 5 and Figures 3-7). Height seems to be bigger in subjects aged under 60. In this age group, CrFWL5 is wider and VHL1, VHL2, VHL3, VHL5 is also bigger (Tables 6, 7 and Figures 8-12). The BMI groups do not present major differences in the means (Tables 8 and 9). ❑

DISCUSSION

The borders of each lumbar IVF contain spinal nerve roots, sinuvertebral nerves, spinal arteries, internal and external venous plexuses, lymphatic vessels, and fatty areolar network which fills the foramen (26). In particular, these borders are formed, anteriorly: from a posterolateral part of the inferior vertebra, the posterolateral part of the intervertebral disc, and the posterolateral aspect of the superior vertebra; superiorly: from the inferior vertebral notch of the superior vertebra; posteriorly: from the superior articular process of the inferior vertebra, a part of the facet synovial joint, and the inferior articular process of the superior vertebra; inferiorly: from the superior vertebral notch of the inferior vertebra (6, 1).

In our study, generally, the examined variables seem to present a positive correlation between and amongst them, resulting in the harmonic architecture of the non-pathologic spine. Few correlations with minor clinical significance are observed. The data presented here suggest that age has a negative impact on the height of the elderly due to age-related degenerations and ongoing remodeling. This is also expressed by the majority of CrFWs, CaFWs and VHs of the lumbar vertebrae, which tend to present a smaller value in the individuals aged over sixty years old. CrFWL5 is smaller in those over 60 years old. Height and weight are presented as significantly bigger in men than women. Also, the majority of VHs and FHs are bigger in men. The BMI subgroups do not show major differences in the means because the lumbar spine is a dynamic structure composed of bones, muscles and ligaments, which retains the normal anatomy even in increased axial load. CrFWL1 with CaFWL5 do not appear to have a significant correlation between them due to the fact that they are at the extremities of the lumbar spine and differentiate enough in terms of analogy and allometry. Similarly, the VHL5 presents positive correlation with the rest VHs but not with the FHL1.

Although few radiologic reports on the dimensions of the IVF exist, they do not estimate the *in vivo* size of the foramen. The majority of the studies examining the IVF dimensions are cadaveric studies. Contrary to Ruhli et al., in a similar study which used cadaveric sample, our data seems to present a correlation between age and height and osseous lumbar IVF size (8). We confirmed similarly that the CrFW was the largest at the L1 level for both sexes, and the CaFW at the L1 level only for women. Also, in the majority of measurements, women showed larger lumbar IVF values than men and no significant width measurement for IVF was observed at any level for either sex. This finding is in accordance with earlier reports on the sex-dependent size of spinal dimensions (17, 18). Humphreys et al. found that cervical IFWs in particular are larger in healthy individuals than in symptomatic persons (19). Furthermore, the size of the lumbar IVF was described by Stephens et al. to be biggest at L5/S1 (4). In the present study, the values of the osseous IFW at level L5 were smaller than at L1. In another recent cadaveric study, no statistically important differences referring to the descriptive data of both sexes were found (6). Nevertheless, statistically, important positive correlation between the vertebral height and the foraminal width was observed, especially for men. Additionally, Hong et al. mentioned a significant correlation between disc degeneration, nerve root compression, disc height and foraminal width (14). Cinotti et al. reported that narrowing of the disc space significantly reduces the vertical diameter of the foramen but has no significant effects on its sagittal dimensions. In contrast, the sagittal dimensions of the foramen are strictly related to the sagittal diameter of the spinal canal and the pedicle length (20).

Comparative studies using cadaveric specimens have shown the 3DCT to be an unreliable tool to quantify the dimensions of the lumbar foramen (21). Direct osteometric measurements and fresh cadaver studies are still considered the best method to determine spinal dimensions (22, 23). However, due to the dissimilar methods, it is difficult to compare directly the IFW values of the present study with the values published earlier. Furthermore, it is important to mention that the size of the IVF varies between populations and depending on axial loading, time of day and dynamic changes of the spine (24, 15). The measurement of two different dimensions of IFW in the same vertebra is reliable for assessing the overall dimension, and therefore, indirectly the functional capacity, of that particular IVF (20). We used both cranial and caudal foraminal width and also instead of the intervertebral disc height, as it has been measured in various studies, we estimated the foraminal height which including the previous. The intraobserver error of the measurement of IFW has been determined in a previous cadaveric study for the lumbar region as being up to 0.3–0.4 mm (24). The present study could be a case control study using CT or MRI, with an additional group of spine-related symptomatic individuals. However, we wanted to emphasize on the normal osseous dimensions and as a result we estimated CT images of asymptomatic sample. Furthermore, the sample may seem to have heterogenicity as regards to gender, age and BMI, however we wanted to include a broad spectrum of values in our sample while maintaining a minimum statistically sufficient number of individuals per subgroup. The increasing availability of three-dimensional digitizers and morphometry analysis tools will also enable more universal and eligible assessments of the IVF.

One of the major symptoms referred to the lumbar spine and the lumbar IVF is low back pain. The pathophysiology of low back pain is influenced by a wide range of etiologies (3). It has been linked with lumbar disc herniation and spinal stenosis. The narrowing of the maximum FW seems to be the only cause of radiculopathy or spinal stenosis and in a similar way the decrease of the FH is considered insignificant (25). The endoscopic lumbar discectomy is growing in popularity for treating lumbar disc herniation. Among minimally invasive techniques, the transforaminal endoscopic spine system (TESSYS) has become a prevalent therapy for lumbar disc herniation, presenting less trauma and quicker postoperative recovery in comparison with fenestration discectomy (26). With this technique it is possible to use foraminoplasty to operate inside the spinal canal and widen the foramen with different size reamers. Most recent percutaneous endoscopic discectomy techniques are based on the Kambin's transforaminal approach and especially on the trapezoidal perspective of the working zone. A needle is initially placed through the Kambin's triangle under fluoroscopic technique and after verification of the level, administration of mild sedation and analgesia, the passage of dilators and the cannula with the endoscope is the following step. Subsequently, the discectomy is performed with graspers. Crucial step of the surgery is the sequential passage of three different size reamers 5.5, 6.5, and 7.5 mm (joimax) (27). Data suggest that radiological measurements including the spinal root and foraminal areas should be obtained before endoscopic discectomy surgery for a safer procedure (28). In the study of Tamrong *et al.*, the average dimension of the calculated largest ellipsoidal cannula that could be placed was 5.83×11.02 mm at L1–2, 6.97×10.78 mm at L2–3, 9.30×10.67 mm at L3–4, 8.84×13.15 mm at L4–5, and 6.61×14.07 mm at L5–S1 (29). Additionally, anatomic considerations for percutaneous lumbar interbody fusion were made by Wimmer et al. and they reported that the maximum safe cannula diameter was 8 mm from L1–L4 and 7 mm from L4–S1 (30). Therefore, the dimensions of the lumbar IVF should be taken into serious consideration when using the TESSYS technique in order to prevent possible tissue damages during foraminoplasty. ❑

CONCLUSIONS

Morphometric data of the spine can have clinical significance and application considering spine surgery, physical anthropology and even forensics. Spine surgeons and interventional radiologists have to estimate and understand the anatomy of the osseous lumbar IVF and its dimensions. When using the TESSYS technique for the treatment of lumbar disc herniation, it is crucial to know the anatomy of the foramen and especially during foraminoplasty. Cadaveric measurements seem to be abundant in the relative literature. Radiologic studies provide an estimation of the *in vivo* size, which depends on soft tissue and dynamic components and tends to depict the age related alterations. An improved knowledge of human spinal dimensions could further enlighten our knowledge of the continuous evolution of the spine. ❑

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