Afr. J. Med. Med. Sci. (2021) **50**, 69-76

Lumbar spinal canal dimensions in Nigerians using computed tomography scan

OJ Alonge[1], AA Adeolu[2], AB Omololu[3] and OM Atalabi[4]
Department of Orthopedics[1], University College Hospital, Ibadan
Department of Neurological Surgery[2], Surgery[3] and Radiology[4],
College of Medicine, University of Ibadan, Ibadan

Abstract

Introduction: The Lumbar Spinal Canal (LSC) dimension is known to vary among races, and is marginally smaller in blacks than in whites. The average diameters of 16mm for anteroposterior (AP) and 20mm for transverse diameters were derived in the past from studies on bone specimens and radiographs, and more recently from Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). These investigation modalities which are most accurate for LSC dimensions were largely on Caucasian populations. As a result, there is a lack of consensus among spine surgeons as to what constitutes radiological narrowing of the lumbar spine in people of black heritage.

Objectives: To describe the normal spinal canal dimension using CT scan images of people of a black population in Nigeria.

Research Design: This was a retrospective study that measured lumbar spinal canal parameters from abdominal CT scan images.

Methodology: It evaluated 120 abdominal CT scan images done between July 1st, 2017 and June 30th, 2019 at Lagoon Hospitals, Lagos. Data collection was on a structured proforma and subjected to statistical analysis.

Results: The mean anteroposterior diameter, APD was 15.8 (SD ±2.0)mm. The mean transverse diameter, TD was 25.82 (SD ± 2.4)mm. The mean Vertebral Torg ratio was 0.62. The narrowest APD of the lumbar canal was at L3 for both sexes while the widest point of the canal in males was at L1, and at L5 in females. The narrowest TD was at L1 while the widest point was at L5. The prevalence of developmental lumbar canal stenosis was 2.67%.

Conclusion: The average APD of the lumbar canal in Nigerians is 15.8 (SD ± 2)mm. The narrowest point of the lumbar canal is at L3.

Keywords*: Lumbar Spinal canal, Nigerians, CT scan, stenosis*

Résumé

Contexte: La dimension du canal rachidien lombaire (LSC) est connue pour varier selon les races, et est légèrement plus petite chez les noirs que chez les blancs. Les diamètres moyens de 16 mm pour les diamètres antéro-postérieur (AP) et 20 mm pour les diamètres transversaux ont été dérivés dans le passé d'études sur des échantillons osseux et des radiographies, et plus récemment de la tomographie par ordinateur (CT) et de l'imagerie par résonance magnétique (IRM). Ces modalités d'enquête qui sont les plus précises pour les dimensions LSC étaient en grande partie sur les populations de race Blanche. En conséquence, il y a un manque de consensus parmi les chirurgiens de la colonne vertébrale sur ce qui constitue un rétrécissement radiologique de la colonne lombaire chez les personnes d'origine noire.

Objectifs: Décrire la dimension normale du canal rachidien à l'aide d'images tomodensitométriques de personnes d'une population noire au Nigéria.

Conception de la recherche: Il s'agissait d'une étude rétrospective qui mesurait les paramètres du canal rachidien lombaire à partir d'images tomodensitométriques abdominales.

Méthodologie: Il a évalué 120 images de tomodensitométrie abdominale réalisées entre le 1er juillet 2017 et le 30 juin 2019 dans les hôpitaux Lagoon de Lagos. La collecte des données a été effectuée sur un formulaire structuré et soumise à une analyse statistique.

Résultats: Le diamètre antéropostérieur moyen, APD était de 15,8 (ET ± 2,0) mm. Le diamètre transversal moyen, TD était de 25,82 (ET ± 2,4) mm. Le ratio moyen de Torg vertébral était de 0,62. La DPA la plus étroite du canal lombaire était à L3 pour les deux sexes tandis que le point le plus large du canal chez les mâles était à L1 et à L5 chez les femelles. Le TD le plus étroit était à L1 tandis que le point le plus large était à L5. La prévalence de la sténose développementale du canal lombaire était de 2,67%.

Conclusion: L'APD moyenne du canal lombaire chez les Nigérians est de 15,8 (SD ± 2) mm. Le point le plus étroit du canal lombaire est en L3.

Mots clés: *canal rachidien lombaire, Nigérians, tomodensitométrie, sténose*

Correspondence: Dr. O. J. Alonge, Department of Orthopedics, University College Hospital, Ibadan. Nigeria. E-mail: kunle.alonge@yahoo.co.uk

Introduction

The lumbar spinal canal contains the terminal end of the spinal cord and other neural elements such as the cauda equina. It is oval in cross section across most of its span, but in lower segments in some series, it has been noted to be trefoil shaped [1]. This consists of a central canal and the lateral recesses. The central canal appears to be more involved in stenosis than the lateral canal [2]. A narrow lateral recess of the trefoil shape is implicated in lumbar spinal stenosis (LSS) [1].

There are documented racial variations in the size of the lumbar spinal canal [3-5]. The anteroposterior (AP) diameter measured in the midline is the most important and most commonly implicated in spinal canal stenosis [6]. The importance of the lumbar canal dimension is linked to LSS. LSS could be developmental (also called congenital) when it is due to a developmental narrowing of the canal or degenerative when it is due to degenerative lumbar spine disease. The former presents in young adults while the latter presents in older individuals.

The syndrome of LSS consists of low back ache, bilateral lower limb pain, numbness, weakness and neurogenic claudication. This syndrome occurs as a result of compression of neural elements in the central canal, lateral recess and intervertebral foramina and carries significant morbidity [7]. The commonest site of spinal stenosis is L4/L5 [8].

LSS may be congenital or acquired. The less common congenital type usually presents in young age with symptoms similar to that in the acquired type. The anteroposterior diameter, cross sectional area and transverse diameters have all been shown to be smaller in these patients, so also are the corresponding vertebral body width and pedicle length at all lumbar levels [9]. Also, these individuals have an increased incidence of degenerative spine disease [10]. The acquired type usually due to degenerative disease, presents in middle and old age with low back pain associated with neurogenic claudication, a symptom fairly specific for lumbar canal stenosis.

Diagnosis of LSS is based on clinical and radiological features of narrowing. There are however, no universally agreed radiological features of congenital stenosis. A large systematic review on radiological criteria for diagnosis of LSS revealed up to 10 different criteria for diagnosis [11]. This may be because of the variations in canal dimensions across populations [9].

Currently, the reference values for the lumbar spinal canal dimensions are derived from Caucasian studies [12]. Subsequent studies [3,13] on LSS have then used this criteria by Verbiest: range of 15-27mm for anteroposterior diameter (APD), a value of less than 12mm as evidence of stenosis and less than 10mm indicating definite stenosis [14]. Most studies on African populations are either old or based on radiographs [15] and anatomical specimen [3,16]. Others were done on symptomatic individuals [17]. Two recent studies, using most accurate modalities of computed tomography (CT) [18] and magnetic resonance imaging (MRI) [19] on asymptomatic Africans were found and their findings need to be corroborated among Nigerians. CT scans and MRI scans are the most accurate modalities in measuring these parameters and are an important part of the evaluation of patients with degenerative spine disease.

The aim of this study therefore, was to determine the normal lumbar spinal canal diameter in the Nigerian population using CT scan.

Materials and methods

This was a retrospective study that evaluated the lumbar canal in abdominal CT scan images. Abdominal CT images were chosen because the lumbar vertebrae are captured automatically during image acquisition. Individuals with these abdominal CT images are not known to have symptoms referable to the lumbar spine and, therefore, representative of the normal population. This approach also excluded additional cost and extra radiation exposure to the study subjects as would be the case if lumbar CT scan was used on asymptomatic individuals.

The data was obtained from the Radiology (CT scan) database of Lagoon Hospitals, Lagos. This data includes abdominal CT scan images taken from 1st July, 2017 to 30th June, 2019.

Inclusion criteria

The study included all the abdominal CT scan images of patients of Nigerian heritage as indicated by one native Nigerian name.

Exclusion criteria

Images of patients below 18 years or above 65 years of age were excluded from the study. Also excluded were images with degenerative changes at the bony landmarks, images with spondylolisthesis, images suggestive of spondylodiscitis or other infective pathology of the spine and images that did not clearly show all the lumbar vertebrae. Eighteen years was used as the lower cut off because skeletal maturity is expected to have occurred by this age in both sexes, while 65 years was used as the upper cut off because degenerative changes are florid beyond this age.

Study protocol

The images were opened on the hospital CT workstation. Each image that met the inclusion criteria was then reviewed for any of the exclusion criteria. Following this, basic demographic data was obtained which include patient initials, sex, age, tribe and hospital number.

The sagittal and axial cuts were placed side by side with reference lines linked to both images. Bone window view was selected and magnification of the images done to 4.00x. The parameters were measured in millimeters. The antero-posterior diameter (APD) of the canal was measured on the mid-sagittal cut with care taken to ensure the cursor and reference lines were always at the midline on the axial view at each vertebral level. The vertebral antero-posterior diameter (VAPD) was measured at the same level with the APD (Figure 3). For the APD, the measurement cursor was drawn perpendicularly from the posterior border of each vertebra to the lamina. (Figure 1) The transverse diameter (TD) was measured on the axial cut at the point of maximum pedicle width (Figure 2). The shape of the vertebral canal was noted at each vertebral level.

Data collection and analysis

The data obtained was entered into Epi Info Version 7.2.2.6. Descriptive data was presented in tables and pie charts. The means of the various parameters were computed. The means were also cross-tabulated by sex to identify sex differences.

Ethical considerations

As this study used secondary data, there were no individual informed consent forms. However, permission for use of the information from the institutional database was sought and obtained.The data obtained was de-identified. There was absolute confidentiality of the data, as only the researcher had access to the data collected.

Results

Demographics: This study evaluated 120 CT scan images. There was a slight preponderance of females (55%) than males (45%). Majority of the participants were of Yoruba ethnic group (51%) whereas 21% were of Igbo tribe and the remaining were of other or unknown tribes. Their ages ranged from 18years to 65years with a mean of 40.2 (SD±10.07)years.

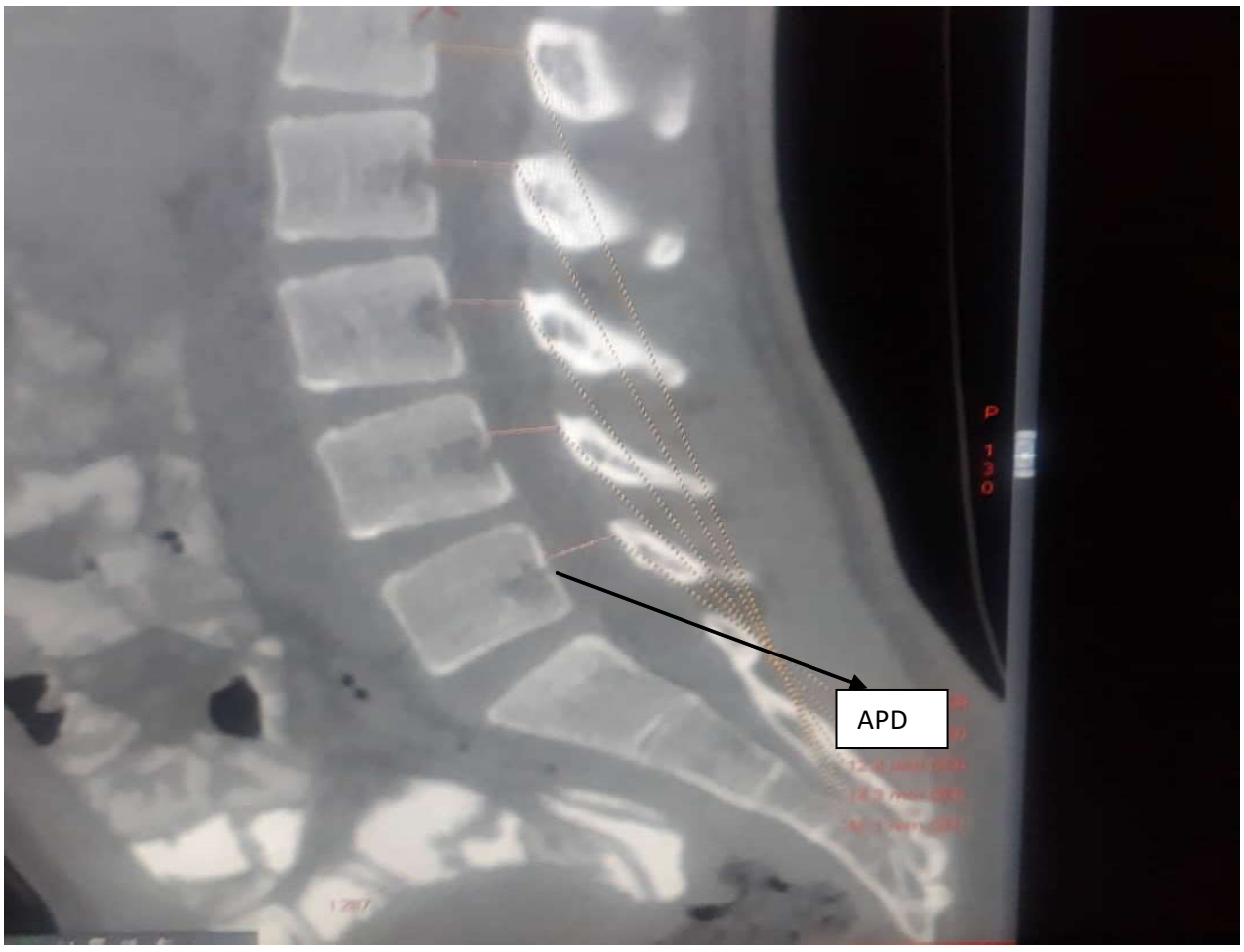

Fig.1: Mid-sagittal CT image showing the points of measurement of the APD

Fig. 2: Axial CT scan image showing point of measurement of the TD and VTD

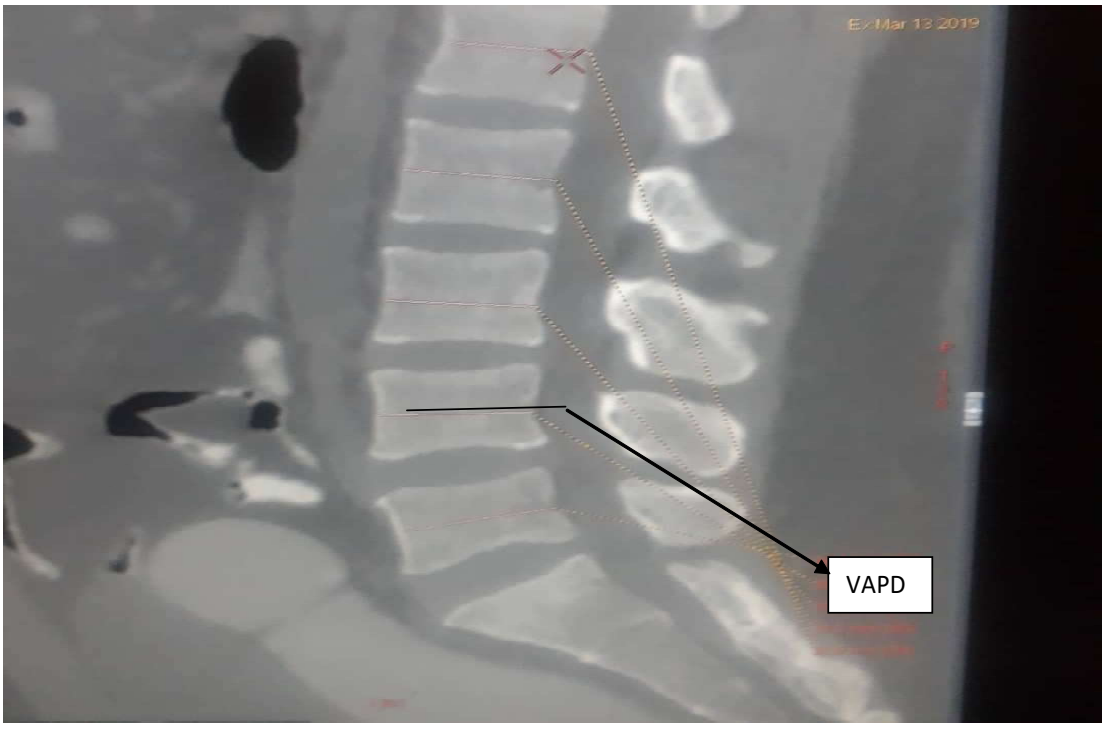

Fig.3: Mid-Sagittal CT scan image showing point of measurement of the VAPD

Antero-posterior diameter (APD)

The mean APD from L1 to L5 ranged from 12.3mm to 26.5mmwith a mean of 15.8(SD± 2) mm (Table 1). The mean APD for males was 15.7mm, whereas it was 15.9mm for females (p=0.4429). (Table 1)

Transverse diameter (TD)

The Mean TD was 25.82 (SD 2.4) mm. The mean TD for males was 26.64mm and 25.16mm for females (P= 0.0007) (Table 2).

Narrowest and widest points

The narrowest APD of the lumbar canal was at L3 for both sexes with a mean APD of 15.3mm in males and 14.9mm in females. The mean widest point of the canal in males was at L1 (16.4mm), whereas it was at L5 in females (16.5mm). Both sexes showed a decrease in canal size from L1-L3,and an increase from L3 to L5 (Table 3). The narrowest TD was at L1 while the widest point was at L5. When these means were cross-tabulated by sex, the TD was significantly wider in males from L1 to L3 but not significantly wider at L4 and L5 (Table 4).

Vertebral torg ratio

The mean ratio of the APD/VAPD, vertebral Torg ratio from L1 to L5 was 0.62.It decreased from 0.70

Table 1: Antero-posterior diameter (APD) in both sexes

	Obs	Total	Mean	Var	S.D	Min	Median	Max	Mode	Pvalue
APD	120	1897.54	15.81	3.9116	1.9778	12.30	15.57	26.5	15.52	
Female	66	1051.96	15.94	5.22	2.2848	12.30	15.65	26.5	14.26	0.4429
Male	54	845.58	15.66	2.3364	1.5285	12.86	15.53	19.72	15.52	

Obs: Number of observations, Var: Variance, S.D: Standard Deviation, Min: Minimum value, Max: Maximum value

Table 2: Transverse diameter (TD) in both sexes

	Obs	Total	Mean	Var	S.D	Min	Median	Max	Mode	Pvalue
TD	120	3098.66	25.82	5.9311	2.4354	20.06	25.56	32.58	24.22	
Female	66	1660.28	25.16	5.2259	2.2860	20.06	25.21	29.68	21.98	0.0007
Male	54	1438.38	26.64	5.6788	2.3830	21.72	26.77	32.58	32.58	

Obs: Number of observations, Var: Variance, S.D: Standard Deviation, Min: Minimum value, Max: Maximum value

Table 3: Antero-posterior diameter (APD) from L1-L5 by sex

						APD				
		Obs	Total	Mean	Var	S.D	Min	Median	Max	Mode
L1	F	66	1066.7	16.1621	3.7999	1.9493	13.00	15.85	23.90	15.00
	M	54	887.3	16.4315	1.7494	1.3226	14.40	16.25	20.20	15.00
L2	F	66	1044.3	15.8227	3.5076	1.8729	12.70	15.70	24.70	15.30
	M	54	832.8	15.4222	2.1870	1.4789	12.20	15.15	19.40	15.40
L3	F	66	1006.6	15.2515	5.7284	2.3934	11.90	14.70	27.20	13.20
	M	54	805.7	14.9204	2.8239	1.6805	11.10	14.75	18.50	13.70
L4	F	66	1056.2	16.0030	7.9240	2.8150	11.90	15.35	27.50	14.50
	M	54	831.5	15.3981	4.2662	2.0655	12.20	15.35	21.00	12.50
L5	F	66	1086	16.4545	11.5619	3.4003	11.20	16.10	29.20	17.10
	M	54	870.6	16.1222	6.8006	2.6078	12.40	15.45	24.40	15.00

Obs: Number of observations, Var: Variance, S.D: Standard Deviation, Min: Minimum value, Max: Maximum value

at L1 to 0.64 at L2 to the lowest value of 0.58 at L3 before increasing to 0.58 at L4 and 0.58 at L5.

Table 4: Transverse diameter (TD) from L1-L5 by sex

		Obs	Total	Mean	Var	TD S.D	Min	Median	Max	Mode
L1	F	66	1435.2	21.7455	3.5517	1.8846	17.00	22.10	25.90	22.30
	M	54	1260	23.3333	3.6223	1.9032	19.30	23.50	28.80	23.00
L2	F	66	1475.7	22.3591	3.4609	1.8604	18.40	22.10	26.90	24.40
	M	54	1275.5	23.6204	3.8986	1.9745	19.30	23.70	29.30	22.80
L3	F	66	1569.7	23.7833	4.3900	2.0952	19.40	23.80	28.20	24.10
	M	54	1354.4	25.0815	4.6774	2.1627	20.80	23.70	30.70	27.20
L4	F	66	1746.8	26.4667	8.9567	2.9928	20.60	26.20	33.70	24.40
	M	54	1492.9	27.6463	9.0731	3.0122	22.40	27.40	33.90	27.20
L5	F	66	2074	31.4242	15.9994	3.9999	22.50	30.85	41.40	28.40
	M	54	1809.1	33.5019	21.3870	4.6246	26.00	33.05	45.90	26.90

Obs: Number of observations, Var: Variance, S.D: Standard Deviation, Min: Minimum value, Max: Maximum value

Lumbar canal stenosis

There were sixteen APD measurements below 12.3mm (2SD below mean) in this study, making the prevalence of developmental LSS to be 2.67% (16/600). However, using Verbiest criteria of 12mm for lower limit of normal, the prevalence was 1.83% (11/600) as there were eleven measurements below 12mm.

Canal shape

The canal was oval in shape at L1 and L2, and trefoil shaped at L4 and L5. The transition from Oval to trefoil shape was at L3. About two-thirds of the subjects were oval at L3 whereasone-third were trefoil at this level.

Discussion

CT scan and MRI are the most accurate modalities for accessing the lumbar canal parameters. Before their advent, many studies had been done on the lumbar spine using plain radiographs and anatomical bone specimens to describe the normal dimensions and to evaluate lumbar canal stenosis, and these studies showed variations across races [17,18,20-22]. Some studies were done using symptomatic patients [17] while others were done on asymptomatic patients [18,19].

One limitation with CT scan on asymptomatic individuals is the radiation exposure. As such, a number of these studies had small sample sizes. One such CT scan study on Caucasians reviewed only 60 adults to evaluate the spinal canal [24]. Other similar studies on asymptomatic individuals reviewed 34 adults [25] and 39 adults [26] respectively.

Among asymptomatic people of black heritage, two studies were found using either of these two modalities. Amadou and colleagues used CT scan of 500 individuals while Elhassan used MRI of 128 individuals [18,19]. In this prospective study by Amadou *et al*, 500 asymptomatic individuals in reproductive age group were exposed to radiation in order to ascertain the normal spinal canal diameter in people of black heritage. This ethical concern was not properly addressed in their publication.

Therefore, this study evaluated the lumbar spinal canal of Nigerians using abdominal CT scan images. The use of abdominal CT for assessing the lumbar canal has recently been reported in another study where these images were used as controls in a study to determine the prevalence of LSS in patients with low back pain [27].

Patients presenting for abdominal CT scans present as a result of abdominal symptoms such as pain and not low back pain. However, some are likely to have back pain. Even then, only a small fraction will likely have back pain as a result of canal stenosis. More so, while reviewing these images, patients with abnormalities in the lumbar spine were excluded. These include significant degenerative features such as marginal and posterior osteophytes. The closeness of these results to that by Amadou is a vindication of this method.

The mean age of 40.2 years in this study is comparable to that of Amadou et al [18] (38years) but much higher than that by Elhassan *et al* (20-28years) [19]. This may be as a result of how these patients were selected. The sex distribution however

is reversed. There were more males in both the Amadou and Elhassan studies with the former being 54% male and the latter being 57% male [18,19]. In this study, males were 45%.

The mean APD in this study (15.8mm) appears less than that reported among Caucasians by Eisenstein (16mm) [6] and very similar to that reported by Amadou *et al* [18] among Togolese of West Africa (15.41mm+/- 0.55). However, without access to the SD of these studies, definite conclusions on differences cannot be made. There was no significant sex difference in this diameter, also consistent with the Amadou study [18].

However, the TD in this study appears wider than in the Togolese study [18]. The mean is 25.82mm (SD ± 2.4) in this study compared to 23.27+/- 1.67 (range =13.68-33.68). This discrepancy may be as a result of differences in the method of measuring this parameter.In this study, the TD was measured between the inner borders of the pedicles at the point of maximum pedicle width. However, the Togolese study [18] did not specify the exact level on the pedicle where the TD measurement was taken and as such, may not have been a consistent reference point.

The narrowest point (APD) of the canal in this study is at L3. There is a gradual decrease from L1 to L3 then an increase from L4 to L5 in both sexes. This mid-lumbar narrowing was also reported by Amonoo-Kuofi [16], Azu *et al* [28] and Kang et al [29]. However, this pattern was not seen in the Eisenstein study of both Caucasian and Negroid bone specimens which found the narrowest point to be at L2 and L4 [3] or in the MRI study on Sudanese which showed a gradual decrease from L1 to L5 [19]. The mid-lumbar narrowing was also not seen in an MRI study on asymptomatic Indians which found the narrowest point to be at L4 [30].

The prevalence of developmental LSS in this study (2.67%) is twice as high as that reported by Eisenstein(1.3%) [3]. This value (2.67%) is the prevalence of developmental (congenital) LSS since the subjects are not known to be symptomatic and the images used did not show degenerative features. These are individuals with constitutionally narrow APD. This is in keeping with Eisenstein's finding that the canal in black people was marginally smaller than in whites. No APD value was below 10mm.

As regards canal shape, only two canal types were found. These are the oval shape at L1 and L2 and the trefoil shape at L4 and L5. There appears to be a transition of these two shapes at L3 as only L3 had either of these configurations. This is in contrast to a study among Turks which showed three main types and even more distinct sub variants [31].

The sample size in this study is not large enough to detect differences among the ethnic groups in Nigerians. There are already reports of differences among people of different regions in a country [19]. This may also be the case in Nigeria considering the large population of more than 180 million and three main ethnic groups which are phenotypically distinct.

Conclusion

The normal diameters of the Lumbar canal in Nigerians is 15.8 (SD±2.0)mm for AP and 25.82 (SD±2.4)mm for transverse. The narrowest point of the lumbar canal is at L3 and the prevalence of developmental lumbar canal stenosis is 2.67%.

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Received = 28th November 2019
Accepted = 20th October 2020