Original Article

Sagittal diameter of the lumbosacral spinal canal in normal (asymptomatic) adult Sudanese population 2014

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Abstract

Background: Although spinal stenosis has been recognized for many years as a clinical diagnosis, it has yet to be exactly defined and agreed upon. This lack of definition leads to difficulties in comparing and interpreting studies of prevalence, incidence and treatment. This could in part be to difference in spinal canal dimensions that exist between population groups. This is essential for the rational design and development of spinal implants and instrumentation such as pedicle screws and, in particular, with the evolution towards robotic surgery. **Objectives:** This study aims to determine the normal Anteroposterior diameter of the spinal canal in lumbosacral region among the adult Sudanese population using the MRI and to determine whether there are any differences related to age, sex and race regarding this diameter. **Material and Method:** The study was descriptive cross-sectional analytical study. MRI measurements were performed in Ribat Teaching Hospital for 142 normal Sudanese subjects to study the lumbosacral region. The data was collected through check list, analyzed by SPSS. **Results:** The majority of the participants were male (57%), young between 20and 28 years of age with mean height 168cm and mean weight 66 kilogram. The results showed that the longest mean AP diameter was at L1 (17.5±2.0mm) in male while (18.1±2.7) in female. The shortest mean AP diameter was at S1 (15.9±3.2mm) in male and (15.4±3.2) in female. The AP diameter gradually decreased from L1 to S1.there is no significant difference between both sexes. There is significant difference between people live in different zones. There is association between age, height and weight and the AP canal diameter.

Key words: Lumbosacral, spinal canal, Sudan

INTRODUCTION

Although spinal stenosis has been recognized for many years as a clinical diagnosis, it has yet to be exactly defined and agreed upon. This lack of definition leads to difficulties in comparing and interpreting studies of prevalence, incidence and treatment. This could in part be to difference in spinal canal dimensions that exist between population groups. Essential, for the rational design and development of spinal implants and instrumentation such as pedicle screws and in particular, with the evolution toward robotic surgery.

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The term lumbar spinal stenosis can refer to one or more of the following anatomic states: Narrowing of the intraspinal (central) canal, Narrowing of the lateral recess and narrowing of the neural foramen (Geisser *et al.*, 2007; Singh, 2005).[1,2]

Although many researchers have reported on the "normal" values of these radiographic parameters, these have often

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been inconsistent (Farfan *et al*., 1972; Torgerson and Dotter, 1976; Chen and Lee, 1997; Saraste *et al*., 1985; Tibrewal and Pearcy, 1985; Brinckmann *et al*., 1998; Chernukha *et al*., 1998; Nourbakhsh *et al*., 2001; Shao *et al*., 2002; Yochum and Rowe, 2005; Kim *et al*., 2006).[3-13]

The literature is also ambivalent with respect to an association between these radiographic parameters and certain anthropometric and demographic factors few studies have reported significant associations between some of the radiographic parameters and certain demographic and anthropometric factors (Amonoo-Kuofi, 1992; Nourbakhsh *et al*., 2001; Livshits *et al*., 2001; Murrie *et al*., 2003)[14-16] while other studies have found no such associations (Farfan *et al*., 1972; Milne and Lauder, 1974; Korovessis *et al*., 1998; Luoma *et al*., 2000),[3,17-19] few studies (Eisenstein, 1976; Fernand and Fox, 1985; Mosner *et al*., 1989)[20,21] have been conducted in order to determine any ethnic differences in the radiographic parameters of the lumbar spine.

Objectives

The study aims to:

- Determine the normal anteroposterior (AP) diameter of the spinal canal in the lumbosacral region among adult Sudanese population using the magnetic resonant image (MRI)
- Determine whether there are any differences related to age, sex and race regarding the normal AP diameter of lumbosacral spinal canal among adult Sudanese population.

MATERIALS AND METHODS

This study was descriptive cross-sectional analytical study.

The study population

Included MRI of 142 normal (asymptomatic) Sudanese subjects who were examined and diagnosed as normal from Khartoum state. The age of the participant in this study ranged from 20 to 45 years.

Exclusion criteria

Any subject with a history of trauma to the low back was excluded from the study also those who developed low back pain and/or lower-extremity pain, vertebral abnormalities, gross spinal pathology (e.g. spondylo–listhesis), previous spinal surgery, females who were pregnant or suspected to be pregnant all were excluded from the study. And those who refused to participate after the researcher explanation.

Study area

All study participants live in Khartoum State. Khartoum is the capital of Sudan, now considered by the statisticians and anthropologist to be representative of all Sudan; regions and states.

Verbal informed consent was taken from the study participants. The sociodemographic data of the cases were obtained using check list.

Measurement method

Totally, 5112 measurements were recorded from normal Sudanese population. MRI measurements were performed in Ribat Teaching Hospital.

Magnetic resonant image scanner (Siemens, Germany) 1.5 tesla with the synergy spine coil was used. The images were taken using the following protocol: (1) T1-weighted for sagittal and axial planes, the intensity of the images were constructed with a TE/TR of 10/500 ms. (2) T2-weighted for axial and axial intensity of images were constructed with a TE/TR of 120/3500 ms. The slice thickness was 3 mm the images were taken from the upper and lower end plate of each vertebra from LI to S1, including section through the disc.

Mid-sagittal diameter of the spinal canal: Was done in the cross-sectional images of each of the lumbosacral vertebra by measuring the distance between the middle of the posterior edge of the vertebral body and the lamina posteriorly at the midline. Using the cursor of the mouse over an initial reference point These measurements of the vertebral foramina made according to Amonoo-Kuofi *et al*., [Figure 1, line A].

Statistical analysis

The general statistic for all the oseometric measurements providing the mean, standard deviation, mode, minimum and maximum values for all the measurements was calculated. Then the Independent *t*-test and Pearson Correlation were also carried out. Significant difference

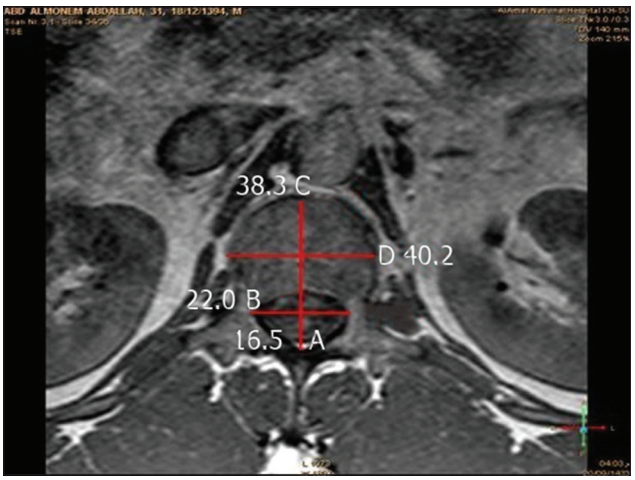

Figure 1: Spinal canal and vertebral body diameters

was set at $P < 0.05$. Analysis was conducted using SPSS (Statistical Package for Social Sciences) for windows, version 20.0.

RESULTS

Almost all data analyzed was found to be statistically normally distributed. The majority of subjects in this study were young adults 45.1%, age between 20 and 28 years old [Figure 2], the females were less than male 43% [Figure 3]. The mean height was 168 cm and the mean weight was 66 kg. Most of the subjects were from Khartoum and Central zones [Figure 4]. Most of the subjects were officers 31.7%.

Anteroposterior diameter of the spinal canal

The average spinal canal AP diameter at each level and according to gender is shown in Table 1. The longest mean AP diameter was at L1 (17.5 ± 2.0 mm) in male while (18.1 ± 2.7) in female. The shortest mean AP diameter was at S1 (15.9 ± 3.2 mm) in male and (15.4 ± 3.2) in female, the AP diameter gradually decreased from L1 to S1 in female while decrease from L1 to L4 in male then slightly increase at L5 and again decrease at S1 [Figure 5]. The female mean AP diameter was larger than the male. However, the different was statistically not significant at all lumbosacral levels [Table 1].

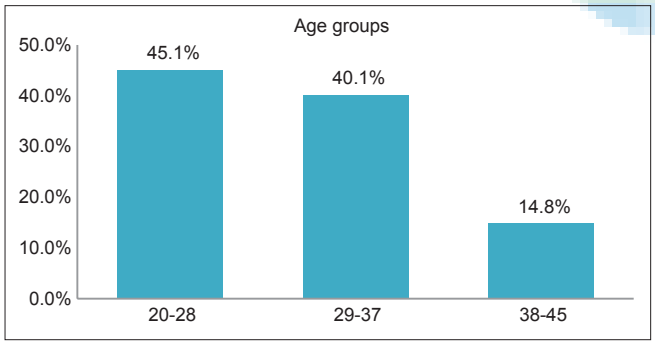

Figure 2: Age distribution of asymptomatic study subjects

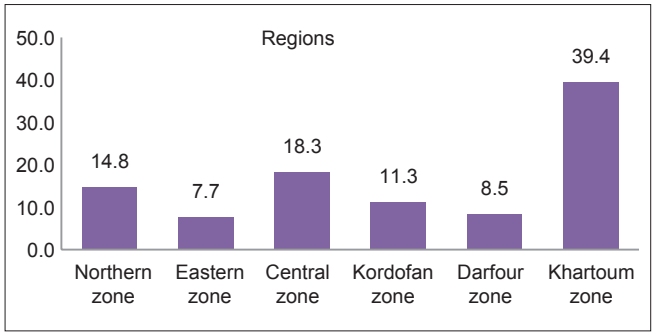

Figure 4: Distribution of asymptomatic study subjects in Sudan regions

Influence of age on anteroposterior diameters of the lumbosacral vertebrae

Table 2 shows there is association between age and lumbosacral vertebral dimensions at (LI, L3, L5, SI) spinal canal.

Influence of height and weight on dimensions of the lumbosacral vertebrae

Table 3 shows there is significant relationships between height or weight and lumbosacral vertebral at sagittal diameter of spinal canal (L3).

Table 1: Anteroposterior diameter of spinal canal of asymptomatic study subjects among both sexes

Sagittal diameter	Sex				*P* value
	Male		Female		
	Mean	Standard deviation	Mean	Standard deviation	
L1	17.5	2.0	18.1	2.7	0.177
L2	17.3	4.7	17.8	3.1	0.437
L3	16.2	2.6	17.1	3.2	0.059
L4	16.2	2.5	17.0	2.9	0.086
L5	16.7	2.7	17.0	2.5	0.475
S1	15.9	3.2	15.4	3.2	0.397

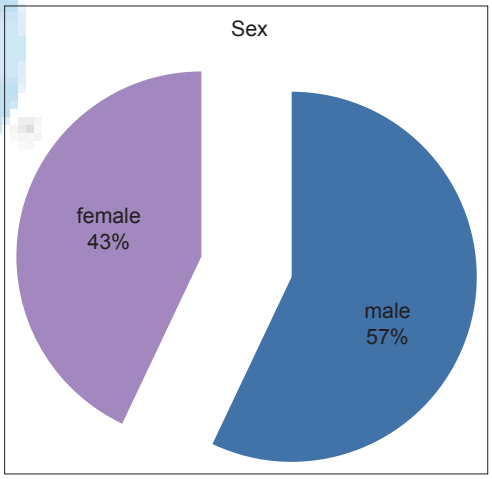

Figure 3: Sex distributions of asymptomatic study subjects

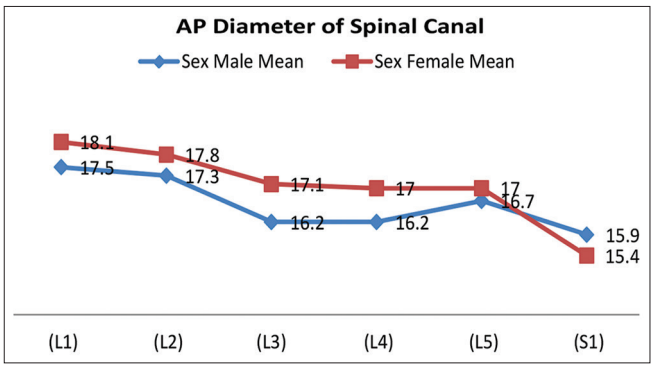

Figure 5: Anteroposterior diameter of spinal Cana

Table 2: Association between age groups and AP vertebral canal diameters

Plane	Age group	*N*	Mean	Std. deviation	95% confidence interval for mean		*P* value
					Lower bound	Upper bound	
Sagittal diameter (L1)	20-28	64	18.2031	2.51105	17.5759	18.8304	0.031
	29-37	57	17.6491	2.17207	17.0728	18.2255	
	38-45	21	16.6905	1.82453	15.8600	17.5210	
	Total	142	17.7570	2.32975	17.3705	18.1435	
Sagittal diameter (L2)	20-28	64	17.7297	2.77132	17.0374	18.4219	0.329
	29-37	57	17.7491	5.53863	16.2795	19.2187	
	38-45	21	16.3048	1.98179	15.4027	17.2069	
	Total	142	17.5268	4.05380	16.8542	18.1993	
Sagittal diameter (L3)	20-28	64	17.1734	3.10055	16.3989	17.9479	0.041
	29-37	57	16.3158	2.79833	15.5733	17.0583	
	38-45	21	15.4667	1.92363	14.5910	16.3423	
	Total	142	16.5768	2.88148	16.0987	17.0548	
Sagittal diameter (L4)	20-28	64	17.0797	2.95222	16.3422	17.8171	0.059
	29-37	57	15.9175	2.56794	15.2362	16.5989	
	38-45	21	16.3429	1.94668	15.4567	17.2290	
	Total	142	16.5042	2.71000	16.0546	16.9538	
Sagittal diameter (L5)	20-28	64	17.4344	2.58286	16.7892	18.0796	0.026
	29-37	57	16.4509	2.64144	15.7500	17.1517	
	38-45	21	15.9238	2.15845	14.9413	16.9063	
	Total	142	16.8162	2.59974	16.3849	17.2475	
Sagittal diameter (S1)	20-28	64	16.2953	3.01680	15.5417	17.0489	0.040
	29-37	57	15.4246	3.17295	14.5827	16.2665	
	38-45	21	14.3667	3.26823	12.8790	15.8543	
	Total	142	15.6606	3.16777	15.1350	16.1861	

AP: Anteroposterior

Table 3: Association between weight, height and AP vertebral canal diameters

	Height	Weight
Sagittal diameter (L1)		
Pearson correlation	0.035	0.085
Sig. (2-tailed)	0.682	0.313
N	142	142
Sagittal diameter (L2)		
Pearson correlation	0.002	−0.031
Sig. (2-tailed)	0.979	0.710
N	142	142
Sagittal diameter (L3)		
Pearson correlation	−0.040	0.002
Sig. (2-tailed)	0.638	0.982
N	142	142
Sagittal diameter (L4)		
Pearson correlation	0.004	0.015
Sig. (2-tailed)	0.966	0.858
N	142	142
Sagittal diameter (L5)		
Pearson correlation	0.069	0.054
Sig. (2-tailed)	0.414	0.520
N	142	142
Sagittal diameter (S1)		
Pearson correlation	0.102	0.093
Sig. (2-tailed)	0.225	0.272
N	142	142

AP: Anteroposterior

There is the difference exists between the lumbosacral vertebral AP diameter among subjects studied from different Sudanese zones, however, this difference is statistically significant at sagittal canal diameter (L3) [Table 4].

DISCUSSION

Accurate anatomic descriptions of vertebral anatomy are necessary for the diagnosis of various spinal diseases. Several previous studies have investigated the morphometry of the vertebrae using different experimental techniques such as direct measurements, roentgenography with plain films, computed tomography (CT), and MRI (Mohammed El-Rakhawy, 2010; Tarek Aly, and; Osama Amin, 2013; Miabi2 MMaZ, [2007]).[22-24]

In our setting, it is not applicable to obtain large scale representative cadaveric study and obtain appropriate lumbar measurements. Both CT scan and X-ray are harmful for the human, and they have ethical limitations. Moreover, the X-ray needs to be multiplied by magnification correction factor.

In the current study, MRI was used, which is considered the mainstay imaging investigation in patients suspected with spinal canal disease. MRI defines the bony anatomy and visualizes soft tissues and neural structures; the data

Table 4: Association between regions and vertebral canal AP diameters

Plane	Region	*N*	Mean	Std. deviation	95% confidence interval for mean		*P* value
					Lower bound	Upper bound	
Sagittal diameter (L1)	Northern	21	17.2	2.4	16.1	18.3	0.120
	Eastern	11	18.1	1.4	17.2	19.1	
	Central	26	18.0	2.1	17.2	18.9	
	Kordofan	16	17.1	2.1	16.0	18.3	
	Darfour	12	16.5	2.9	14.6	18.3	
	Khartoum	56	18.2	2.4	17.6	18.9	
	Total	142	17.8	2.3	17.4	18.1	
Sagittal diameter (L2)	Northern	21	18.2	8.6	14.3	22.2	0.498
	Eastern	11	18.2	1.8	17.0	19.4	
	Central	26	17.5	2.4	16.5	18.5	
	Kordofan	16	16.7	2.6	15.3	18.1	
	Darfour	12	15.7	3.2	13.6	17.7	
	Khartoum	56	17.8	2.6	17.1	18.5	
	Total	142	17.5	4.1	16.9	18.2	
Sagittal diameter (L3)	Northern	21	15.8	2.7	14.6	17.0	0.038
	Eastern	11	17.0	1.6	15.9	18.1	
	Central	26	17.1	3.0	15.9	18.3	
	Kordofan	16	15.8	2.8	14.3	17.3	
	Darfour	12	14.6	3.1	12.7	16.6	
	Khartoum	56	17.2	2.9	16.4	18.0	
	Total	142	16.6	2.9	16.1	17.1	
Sagittal diameter (L4)	Northern	21	15.8	2.8	14.5	17.1	0.074
	Eastern	11	16.4	1.4	15.5	17.3	
	Central	26	17.1	2.6	16.1	18.2	
	Kordofan	16	16.1	2.7	14.7	17.5	
	Darfour	12	14.8	2.9	13.0	16.6	
	Khartoum	56	17.0	2.8	16.2	17.7	
	Total	142	16.5	2.7	16.1	17.0	
Sagittal diameter (L5)	Northern	21	16.1	3.0	14.8	17.5	0.185
	Eastern	11	17.1	1.5	16.1	18.1	
	Central	26	17.3	2.7	16.2	18.5	
	Kordofan	16	16.3	2.8	14.8	17.8	
	Darfour	12	15.5	2.7	13.8	17.2	
	Khartoum	56	17.2	2.4	16.6	17.8	
	Total	142	16.8	2.6	16.4	17.2	
Sagittal diameter (S1)	Northern	21	15.3	3.5	13.7	16.9	0.126
	Eastern	11	16.1	2.5	14.4	17.8	
	Central	26	16.3	2.7	15.2	17.3	
	Kordofan	16	15.1	2.9	13.5	16.6	
	Darfour	12	13.5	2.8	11.7	15.2	
	Khartoum	56	16.1	3.4	15.2	17.0	
	Total	142	15.7	3.2	15.1	16.2	

AP: Anteroposterior

were collected with the assistance of an expert radiology technician who is working for >15 years. And all the measurements were done by the researcher under the supervisions of the research supervisors who are experts' consultants and specialists in the field.

Doing the measurements in the axial sections of the vertebrae allowed the best view for studying the normal morphology of the vertebra.

Morphometric studies of the lumbar vertebral canal report racial and ethnic variation, apart from age and sex differences in the canal size[25,26,22] (Amonoo-Kuofi, [1982]; Eisenstein, 1976.; Navkirat Bajwa, *et al*., 2013; Mohammed El-Rakhawy, 2010).

Table 5 ascertains the difference between Sudanese AP canal diameter and the AP diameters of other population African, Arabs, and other races.

Table 5: Different mean AP spinal canal diameters of different countries

	Egypt	Saudi Arabia	Nigeria	South Africa	Korea	China	Turkish	Iran
L1	16.75	NA	16.6	18	15.4	NA	NA	NA
L2	15.85	NA	15.8	17	14.3	NA	NA	NA
L3	15.09	16.6	14.9	16	13.6	15.92	15.92	NA
L4	15.46	16.7	15.6	16	14.0	15.60	15.60	14
L5	16.36	17.8	16.0	18	14.6	16.46	16.46	15

AP: Anteroposterior, NA: Not available

The sagittal diameter of the vertebral canal in the current study is larger than those of Egyptian, Nigerian and Korean smaller than the Saudian. However, the pattern of changes in AP diameter was similar to our result [Table 5].

CONCLUSION

The study concluded that longest mean AP diameter was at L1 that gradually decreased from L1 to S1. There was no significant statistical difference between both sexes. Moreover, there were significant statistical differences exist between AP canal diameter and the age, weight, height of the study participant and the different Sudanese regions.

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