▪ *Original Article*

Morphometric study of cervical spine vertebrae in eastern region Nepalese population

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Abstract

Objective: To ascertain the normal values of mid-sagittal vertebral body Diameter, mid-sagittal canal diameter and canal-body ratio in adult Nepalese population. **Methods**: In this consent based descriptive, clinico -radiological study of 100 individuals who volunteered to being subjected to lateral projection radiographs of cervical spine. The sagittal canal diameter (CD), sagittal vertebral body diameter (VBD) and the canal-body ratio (CBR) was recorded on lateral projection radiographs (film to tube distance at 183 cms) and analyzed statistically. **Results**: The mean vertebral body diameter was 17.81±1.73mm (male:18.30±1.64mm;female:17.05±1.61mm), mean canal diameter was 17.18±1.67mm (males:17.31±1.74mm; females: 16.97±1.56mm),the mean canal body ratio was 0.97±0.13 (males:0.95±0.13; females:1.00±0.13). In mongoloids mean body diameter is 18.23±1.58 mm, mean canal diameter is 16.87±1.77 mm. and mean canal body ratio is 0.93±0.13. In non-mongoloids the mean body diameter was 17.48±1.79 mm, mean canal diameter was 17.42±1.59 mm, and mean canal body ratio was 1.00±0.13. **Conclusion:** The vertebral body diameter was significantly larger in men as compared to women, and this difference was statistically significant at all vertebral levels ($p < 0.05$). The canal diameter was more in males than females but this difference was not statistically significant ($p > 0.05$). The canal body ratio was greater in females than in males at all levels but this was also not statistically significant ($p > 0.05$. The canal diameter was more in non-mongoloids as compared to mongoloids but this difference was not significant except at C2 level. Population in the eastern region of Nepal had values more nearer to Indian population but lesser than Europeans

Keywords: vertebral body diameter, canal diameter, canal body ratio, sagittal, cervical spine, Nepal

Introduction

It is known that subjects with radiological features suggestive of cervical spondylosis may be symptom free, while cervical myelopathy may occur even without much radiological changes. This is thought to be mainly due to the difference in size of the cervical spinal canal (CD), the vertebral body (VBD) and canal-body ratio (CBR) [1 - ,3]. Age, sex, race, height and weight of the subjects can also be the contributing factor [4 - 8]. Since no data is available for Nepalese population hence, in this radiological-radiological study an attempt is made to record the normal values of mid-sagittal vertebral body diameter, mid-sagittal canal diameter and canal-body ratio in adult Nepalese population and their variations with sex and race/ethnicity.

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Methods

In this descriptive clinico-radiological study 100 healthy adult individuals consenting to participate were subjected to lateral projection radiographs of cervical spine at B.P. Koirala Institute of Health Sciences (BPKIHS), Dharan, Nepal during September 2002 to May 2003. The BPKIHS is a university hospital and a major referral center in the eastern region of Nepal. Detailed history, clinical examination for assessing cervical spine dysfunction was performed. All those found to be having no signs and symptoms related to cervical spondylosis were included in the study and

were subjected to a lateral projection radiograph of cervical spine. Individuals less than age of 20 years, history of cervical spine injury, surgically intervened cervical spine or spinal cord, infective pathology, tumors and congenital /developmental cervical anomalies were excluded.

Each subject sat erect with his opposite shoulder touching the cassette film holder and his head held in a neutral position with 3 kg sandbags in each hand. The x-ray focus to film distance was kept at a constant distance of 183 cm with central rays focusing over the fourth cervical vertebra about 2.5 cm behind the mastoid process [9]. The sagittal canal diameter (CD), sagittal vertebral body diameter (VBD) and the canal-body ratio (CBR) were recorded. The sagittal diameter of the cervical spinal canal in each subject was measured between two fixed bony landmarks. The anterior point being the middle of the posterior surface of the vertebral body from C2-C6 and the posterior point being the anterior-most point on the cortical line at the fusion of the corresponding lamina and the spinous process

(Spino-laminar line). Likewise, the sagittal diameter of the vertebral body of the corresponding vertebra was measured from the middle of the anterior surface to the posterior surface of the vertebral body height. The canal-body ratio at each vertebral level was calculated by dividing the sagittal diameter of the cervical spinal canal by the sagittal diameter of the vertebral body [10,11]. Race, age and sex of the subjects were also noted.

Measurements were made directly on the radiograph after marking points or lines with a graphite film marker, which provided a very small well-defined point or line necessary for accurate measurement [12]. Measurements were made with a standard metallic ruler (precision ±0.5mm). Same ruler was used throughout the study. Each measurement of distance was rounded off to the nearest millimeter. The data was recorded and entered in a Microsoft excel file. The statistical analysis was done in Epi-info 2000 program.

Results

This study included 61 male and 39 females. Their age ranged from 20 years to 81 years with a mean age of 39.38±14.36 years. The height ranged from 137cms to 178 cms (mean159.54±8.18 cm). The weight ranged from 35-83 kg (mean 55.60±9.06 kg). There were 56 subjects of non-mongoloid race and 44 of mongoloid race. The final values of body diameter, canal diameter and canal body ratio at C2, C3, C4, C5, C6 levels are given in Table-1. The mean vertebral body diameter (VBD) was found to be 17.81±1.73mm, mean canal diameter (CD) was 17.181.67mm and mean canal – body ratio (CBR) was 0.97±0.13.

Table 1: Showing body diameter (VBD), canal diameter (CD) and canal body ratio (CBR)

Description	Vertebral Body Diameter (VBD) mm	Canal Diameter (CD) mm	Canal Body Ratio (CBR)
C2	17.30±1.63	19.80±2.11	1.15±0.17
C3	18.06±1.72	16.79±1.60	0.93±0.13
C4	17.91±1.74	16.42±1.68	0.92±0.14
C5	17.64±1.73	16.42±1.51	0.94±0.13
C6	18.17±1.86	16.48±1.49	0.91±0.12
Over all	**17.81±1.73mm**	**17.18±1.67mm**	**0.97±0.13**

The vertebral body diameter, canal diameter and canal body ratio in males and females recorded at various levels are shown in Table-2, Table-3 and Table-4 respectively. The average body diameter in males was 18.30±1.64mm and in females was 17.05±1.61mm. The average canal diameter in males was 17.31±1.74mm, and in females was 16.97±1.56mm respectively. The average canal body ratio in males was 0.95±0.13 and in females it was 1.00±0.13. The difference in values of vertebral body diameter between sex was highly significant ($p < 0.01$) at all vertebral levels (Table-2), whereas the canal diameter and the canal body ratio was not statistically significant ($p > 0.05$) at any level ($p > 0.05$) (Table-3) & (Table-4).

Table 2: Vertebral body diameter (VBD) in different sexes

Description	Sex (Mean±SD)		p-value (KW test)
	Male	Female	
VBD C2	17.74±1.41	16.62±1.73	0.0015*
VBD C3	18.59±1.66	17.23±1.49	0.0002*
VBD C4	18.46±1.60	17.05±1.62	0.0002*
VBD C5	18.08±1.67	16.95±1.61	0.0032*
VBD C6	18.66±1.86	17.41±1.60	0.0016*
Over all	**18.30±1.64mm**	**17.05±1.61mm**	**0.0013***

* Shows statistically significant values ($p < 0.05$)

Table 3: Canal diameter (CD) in different sexes:

Description	Sex (Mean±SD)		p-value (KW test)
	Male	Female	
CD C2	19.89±2.15	19.67±2.07	0.715
CD C3	16.90±1.64	16.62±1.55	0.303
CD C4	16.57±1.81	16.18±1.45	0.22
CD C5	16.56±1.60	16.21±1.34	0.41
CD C6	16.67±1.52	16.18±1.41	0.20
Over all	**17.31±1.74mm**	**16.97±1.56mm**	**0.36**

Table 4: Canal-body ratio (CBR) in males and females

Description	Sex (Mean±SD)		p-value (KW test)
	Male	Female	
CBR C2	1.12±0.15	1.19±0.19	0.12
CBR C3	0.91±0.13	0.97±0.12	0.07
CBR C4	0.90±0.14	0.95±0.13	0.12
CBR C5	0.92±0.13	0.96±0.13	0.19
CBR C6	0.90±0.12	0.93±0.12	0.19
Over all	**0.95±0.13**	**1.00±0.13**	**0.13**

Likewise, the variations in vertebral body diameter, canal diameter and canal body ratio in mongoloid and non-mongoloids at various levels are given in table 5, table 6, and table 7 respectively. The average vertebral body diameter in mongoloids was 18.23±1.58mm and in non-mongoloid was 17.48±1.79mm. The difference in values of vertebral body diameter at C2 level in Mongoloids and Non-mongoloids was only 0.56 mm, which was not statistically significant (p= 0.08) but at all other levels the difference was statistically significant (Table 5). The average canal diameter in Mongoloids was 16.87±1.77mm and in Non-mongoloids was 17.42±1.59mm. The canal diameter showed statistical significance only at C2 level (table-6). The average value of canal body ratio was 0.93±0.13 in mongoloids and 1.00±0.13 in non-mongoloids. The canal body ratio was statistically significant at all vertebral levels between Mongoloids and Non-mongoloids) (p-value=0.05) (Table-7).

Table 5: Body Diameter (VBD) in Mongoloids and Non-mongoloids

Description	Race (Mean±SD)		p-value (KW test)
	Mongoloid	Non-mongoloid	
VBD C2	17.61±1.47	17.05±1.72	0.08
VBD C3	18.57±1.62	17.66±1.71	0.004*
VBD C4	18.34±1.67	17.57±1.74	0.03*
VBD C5	18.02±1.61	17.34±1.77	0.05*
VBD C6	18.61±1.54	17.82±2.02	0.007*
Over all	**18.23±1.58mm**	**17.48±1.79mm**	**0.034***

* Shows statistically significant values ($p < 0.05$)

Table 6: Canal Diameter (CD) in Mongoloids and Non-mongoloids

Description	Race (Mean±SD)		p-value (KW test)
	Mongoloid	Non-mongoloid	
CD C2	19.20±2.13	20.27±2.00	0.01*
CD C3	16.48±1.85	17.04±1.35	0.13
CD C4	16.16±1.84	16.63±1.53	0.29
CD C5	16.23±1.55	16.57±1.46	0.21
CD C6	16.30±1.52	16.63±1.47	0.21
Over all	**16.87±1.77mm**	**17.42±1.59mm**	**0.17**

* Shows statistically significant values ($p < 0.05$)

Table 7: Canal Body Ratio (CBR) in Mongoloids and Non-mongoloids

Description	Race (Mean±SD)		p-value (KW test)
	Mongoloid	Non-mongoloid	
CBR C2	1.09±0.15	1.20±0.17	0.005*
CBR C3	0.89±0.14	0.97±0.11	0.006*
CBR C4	0.89±0.14	0.95±0.13	0.039*
CBR C5	0.90±0.12	0.96±0.13	0.043*
CBR C6	0.88±0.11	0.94±0.12	0.013*
Over all	**0.93±0.13**	**1.00±0.13**	**0.021***

* Shows statistically significant values ($p < 0.05$)

The mean vertebral body diameter was 17.81±1.73mm (male:18.30±1.64mm;female:17.05±1.61mm), mean canal diameter was 17.18±1.67mm (males:17.31±1.74 mm; females:16.97±1.56mm), the mean canal body ratio was 0.97±0.13 (males: 0.95±0.13; females:1.00±0.13) (Table 8). In mongoloids mean vertebral body diameter is 18.23±1.58 mm, mean canal diameter is 16.87±1.77 mm. and mean canal body ratio is 0.93±0.13 .In non-mongoloids the mean vertebral body diameter was 17.48±1.79 mm, mean canal diameter was 17.42±1.59 mm, and mean canal body ratio was 1.00±0.13 (Table 9).

Table 8: Body Diameter (VBD), Canal Diameter (CD) and Canal Body Ratio (CBR) in male and females

	Vertebral body diameter (mm)	Canal Diameter (mm)	Canal Body Ratio
Male	18.30±1.64	17.31±1.74	0.95±0.13
Female	17.05±1.61	16.97±1.56	1.00±0.13
p Value	0.0013*	0.36	0.13

* Shows statistically significant values ($p < 0.05$)

Table 9: Body Diameter, Canal Diameter and Canal Body Ratio in Mongoloids and Non-mongoloids

	Vertebral body diameter (mm)	Canal Diameter (mm)	Canal Body Ratio
Mongoloids	18.23±1.58	16.87±1.77	0.93±0.13
Non-Mongoloids	17.48±1.79	17.42±1.59	1.00±0.13.
p Value	0.034*	0.17	0.021*

* Shows statistically significant values ($p < 0.05$)

Discussion

Mid-sagittal vertebral body diameter, spinal canal diameter and canal-body ratio (Torg-Pavlov's ratio) has been reported from many countries like Japan, China, France, Italy, South Africa, Israel, etc.[2 - 8,13] These values are expected to differ a) with the type of subjects (cadaveric study or patients of cervical spondylosis / cervical myelopathy or in normal adults) , b) with the measuring technique(direct measuring devices like vernier calipers, by Computed tomography or by lateral projection radiographs with varying tube to film distance), c) with the age and sex and ethnicity of the subjects. We compared our results obtained by lateral projection radiographs (tube to film distance of 183cms in healthy adult Nepalese population.

Vertebral Body Diameter

This study showed that body diameter was always greater in men than women at all cervical levels and the difference was statistically significant ($p < 0.05$) and the smallest values were recorded at C5 vertebral level (Table-2). This is in accordance with the results reported in other studies [2,5]. The difference in Liguoro's study was much greater. Postacchini and Gepstein in their study on human skeletons reported values, which are lesser than our study (Table-10). This difference could be because the study was done on dry skeletal bones. In our study different ethnic races, mongoloid showed greater values than non-mongoloids and the smallest values at C5 level in both ethnic groups. This ethnic variation was also reported by Postacchini in his study on Italians and Asiatic Indians- Italians having greater values than Indians [9].

Table 10: Vertebral Body Diameter in different studies

	Liguoro (France)		Postacchini (Rome)		Gepstein (Israel)	Present Study (Nepal)	
	M	F	Italian	Indian		M	F
C2	19	16	-	-	14.3	17.74	16.62
C3	19	16	14.3	13.8	14.9	18.59	17.23
C4	19	16	14.4	14.0	15.2	18.46	17.05
C5	14	13	14.7	14.5	15.7	18.08	16.95
C6	19	17	15.4	15.1	15.4	18.66	17.41
Mean	18	15.6	14.7	14.35	15.1	18.31	17.05

Canal Diameter

The mean canal diameter in our study showed males (17.31 mm) had greater values than females (16.97 mm) at all vertebral levels and overall, but this difference was not statistically significant ($p > 0.05$) (Table-3). These values are very near to Gupta's study on the Indian population (males-17.34: females 16.32 mm) indicating similarity in canal diameter in Nepalese and Indian subjects (Table-11). Nepalese population had larger canal diameter (from 4.2 mm –2mm) than Koreans, Israeli and South African blacks and white population. The larger difference with Korean and Israeli values might be because in both of the study the values were measured in dried skeletons. The smallest values in present study was at C4 and C5 which corresponds with other studies reporting smallest values at either C4 [7,8,14] or at C5 [13] . Only South African blacks [7] showed minimum values at C3 vertebral level (Table-11). In present study non-mongoloids had larger canal diameter than mongoloids at all vertebral levels but this difference was statistically significant at C2 level only (Table-7). Such a racial difference was also shown in South African study [7] where whites had larger canal diameter than blacks but this difference was not significant ($p > 0.05$).

Table 11: Established Canal Diameter in different studies

	Gupta (Indian)		Lee (Korean)		Gepstein (Israel)	Cecil Taitz (SA Blacks)		Cecil Taitz (SA Whites)		Present Study (Nepalese)	
	M	F	M	F		M	F	M	F	M	F
C2	19.66	18.60	13.3	13.3	17.2	15.3	15.2	16.2	15.7	19.89	19.67
C3	17.07	16.13	12.8	12.9	14.6	13.5	13.4	13.9	13.9	16.90	16.62
C4	16.59	15.60	13.0	13.0	14.4	13.4	13.4	14.2	13.7	16.57	16.18
C5	16.65	15.72	13.2	13.1	14.3	13.5	13.5	14.4	13.8	16.56	16.21
C6	16.73	15.54	13.4	13.4	14.4	13.7	13.6	14.4	13.4	16.67	16.18
Mean	17.34	16.32	13.1	13.1	14.98	13.9	13.8	14.6	14.1	17.31	16.97

Canal Body Ratio

The canal- body ratio (CBR) that was stated to be the most reliable value by different authors [10,11,14] to determine the canal narrowing and development of clinical symptoms was calculated for Nepalese adult population.

The canal body ratio in males was always showed smaller values than females like other studies [14] but this difference was very small and did not show any statistical significance ($p > 0.05$). The values were similar to other studies [4,14] but Japanese study [2] showed much smaller canal body ratio in Japanese population (Table-12). The canal body ratio in Nepalese population showed a marked difference between mongoloids and non-mongoloids at all vertebral levels, which was statistically significant ($p < 0.05$) (Table-7). The Korean, Chinese and Japanese studies did not included C2 vertebral level in their study.

Table 12: Canal Body Ratio (CBR) in different studies

	Hukuda (Japan)	Chen (Chinese)		Lee (Korean		Present Study (Nepalese)	
		<55yrs	>55yrs	M	F	M	F
C2	-	-	-	-	-	1.12	1.19
C3	0.78	0.94	0.93	0.92	0.97	0.91	0.97
C4	0.62	0.95	0.89	0.90	1.02	0.90	0.95
C5	0.62	0.97	0.88	0.94	1.02	0.92	0.96
C6	0.62	0.97	0.91	0.95	1.04	0.90	0.93
Mean	0.66	0.95	0.90	0.93	1.01	0.95	1.00

Conclusions

The vertebral body diameter was significantly larger in men as compared to women, and this difference was statistically significant ($p < 0.05$) at all vertebral levels. The canal diameter was bigger in males than females but this difference was not statistically significant ($p > 0.05$). The canal body ratio was greater in females than in males at all levels but this also was not statistically significant ($p > 0.05$). The canal diameter was bigger in Non-mongoloids as compared to mongoloids but this difference was not significant except at C2 level. Population in the eastern region of Nepal had values more near to Indian population but smaller than Europeans.

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