Dimensions of Cervical Spinal Canal and Vertebrae and Their Relevance in Clinical Practice

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Research Article

Abstract: There exist a direct correlation between the dimension of the spinal canal and its associated consequences after trauma. The dimensions of the canal can influence the possibility whether an individual will suffer prolonged effect, after a spinal injury in that area. And it will also influence the recovery time. Dimensions of dry bones of vertebrae can easily be obtained. However, from clinical point of view, obtaining the dimensions of vertebrae in livings is more important. So, in the present study, normal lateral radiographs of cervical spine of three hundred Western Maharashtra adult subjects with known age and known sex were studied. Third to seventh cervical vertebrae were studied in the present study. The parameters used in the study are viz. anteroposterior diameters of spinal canal and vertebral bodies. Making use of anteroposterior diameters of spinal canal and vertebral bodies, canal body ratio (Torg's ratio) was calculated. It was observed that the anteroposterior diameters of cervical spinal canal and vertebral bodies showed sexual dimorphism. Comparison of these vertebral dimensions with corresponding dimensions from other ethnic groups showed evidence of racial variation. These parameters can be used as reference values for evaluating various clinical conditions like spinal stenosis and intraspinal tumours in the cervical spine in Western Maharashtra population.

Key Words: spinal canal, vertebral bodies, canal body ratio, spinal stenosis, intraspinal tumours

Introduction:

The exact dimensions of cervical vertebral body and spinal canal are an important consideration in the diagnosis, prognosis and treatment of diseases related to cervical spine and spinal cord, such as spinal stenosis and intraspinal tumours, etc.Lindgren [1] was first, who pointed out the importance of anteroposterior (sagittal) diameter of the cervical spinal canal.

The careful study of plane radiographs of cervical spine can accurately estimate dimensions of vertebral body and spinal canal. Furthermore, it is easily available and more economical from patient's point of view. So, for the present study plain radiographs were used

There can be either narrowing or enlargement of spinal canal because of some pathological process. Spinal stenosis is understood to be a narrowing of the spinal canal. . [2]. The narrowing can be either congenital or acquired. And conditions like intraspinal tumor leads to enlargement of spinal canal. Similarly, there can be either increase or decrease in the dimensions of vertebral bodies. Hence it is important to know the normal dimensions of the vertebral bodies.

Several studies describing the dimensions of cervical spine have been done in Western countries. But, significant statistical differences have been found to exist between different population groups. Also, it is observed that there is racial variation in these dimensions. Similar studies describing the dimensions of cervical spine done in normal Indian subjects are relatively few. So, present work was undertaken to establish the normal dimensions of cervical vertebrae and spinal canal in the Western Maharashtra population.

Material and Methods:

For present study, normal lateral radiographs of cervical spine of three hundred adult subjects of known sex (one hundred and fifty males and one hundred and fifty females) and of known age group (between twenty five to forty years of age).from Western Maharashtra were utilized.

The radiographs of both sexes were taken with subjects standing straight in neutral relaxed position, forward facing to a defined point to prevent rotation of the neck, with shoulders relaxed and arms down. The distance between X-ray tube and film plate was 1.5 meter. The X-ray tube was focused on the fourth cervical vertebra. These radiographs were diagnosed as "normal" by experienced radiologists. The radiographs showing any obvious abnormality were excluded from the study.

The measurements were made by using scale calibrated to 0.5 mm. The dimensions of C3 to C7 cervical vertebrae were studied.

A) The antero-posterior diameter of cervical spinal canal:

This is the minimum distance between midpoint of the posterior border of vertebral body shadow and shadow of spinolaminal junction of same vertebra. [As shown in PLATE - 1]

B) The antero-posterior diameter of vertebral body:

This is midvertebral distance between the mid-points on anterior border and posterior border of vertebral body shadow. [As shown in PLATE - 1]

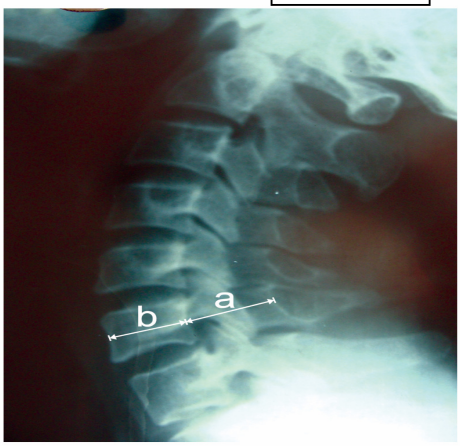
Using above measurements the 'canal body ratio' was obtained.

The 'canal body ratio' (Torg's ratio, Pavlov's ratio) [3]**:** [As shown in PLATE - 1]

This is a ratio of anteroposterior diameter of spinal canal and anteroposterior diameter of corresponding vertebral body. It was described by J. S. Torg, Helene Pavlov and coworkers. It is also called as Torg's ratio or Pavlov's ratio. It was obtained by using the following formula.

$$\text{Torg's Ratio} = \frac{\text{Anteroposterior diameter of spinal canal}}{\text{Anteroposterior diameter of vertebral body}}$$

PLATE - 1



X-Ray Cervical Spine Lateral View

a = Anteroposterior diameter of cervical spinal canal

b = Anteroposterior diameter of cervical vertebral body

Canal-Body Ratio = a/b
(Torg's Ratio)

Observations and Results:

Range, mean and standard deviation (S.D.) of each measurement was calculated. By using the formula "mean ± 3 S.D." calculated range was derived. This calculated range will cover 99.75% of sample population of this study. Any value lying outside the calculate range, suggest pathological condition of the spine and require further investigations and clinical evaluation.

The statistical significance of difference between means of males and females i.e., value of 'P' was calculated by applying 'Z' test [4].

The means of anteroposterior diameters of cervical spinal canal in males and females (Table No. 1), showed almost similar pattern in both sexes i.e., the anteroposterior diameter of the cervical spinal canal goes on decreasing from C3 to C5; thereafter it goes on increasing from C5 to C7. Smallest anteroposterior diameter of cervical spinal canal was found at the level of C5 vertebra and the largest diameter was found at the level of C3 vertebra, in both sexes. The mean anteroposterior diameter of spinal canal from C3 to C7 was 16.49 mm in males and 15.47 mm in females.

From the table no 2, it was observed that, in both males and females the pattern of anteroposterior diameter of vertebral bodies was almost similar to that of. anteroposterior diameter of spinal canal. The smallest and the largest anteroposterior diameter of vertebral body were found in C5 and C3 vertebra, respectively, in both sexes.

From the table no.3, it was observed that, the canal body ratio (Torg's ratio) was almost constant at each level of cervical spine, in both sexes. It was approximately 0.95 in males and 1.07 in females at all cervical vertebral levels from C3 to C7. The canal body ratio was comparatively more at lower cervical vertebral levels, in both sexes. This could be for the accommodation of normal cervical enlargement of spinal cord for innervations of upper limbs.

Table no. 1: Showing dimensions of anteroposterior diameters (in mms) of cervical spinal canal in both sexes.

Level	Sex group	Range	Mean	S. D.	Calculated range (Mean ± 3 S.D.)	Z - Value	P - Value
C3	M	13.0-21.0	16.93	±2.45	9.58 – 24.28	4.59	< 0.01
	F	13.0-20.0	15.8	±1.81	10.37 – 21.23		
C4	M	13.0-20.0	16.36	±2.27	9.55 – 23.17	4.23	< 0.01
	F	13.0-19.5	15.36	±1.81	9.93 – 20.79		
C5	M	13.0-20.0	16.06	±2.29	9.19 – 22.93	4.08	< 0.01
	F	13.0-19.5	15.12	±1.76	9.84 – 20.4		
C6	M	13.0-21.0	16.41	±2.45	9.06 – 23.76	4.29	< 0.01
	F	13.0-19.5	15.38	±1.8	9.98 – 20.78		
C7	M	13.0-21.0	16.69	±2.39	9.52 – 23.86	4.12	< 0.01
	F	13.0-20.0	15.7	±1.82	10.24 – 21.16		

Table no. 2: Showing dimensions of anteroposterior diameters (in mms) of cervical vertebral bodies in both sexes

Level	Sex group	Range	Mean	S. D.	Calculated range (Mean + 3 S.D.)	Z - Value	P - Value
C3	M	14.0-22.0	17.76	±2.44	10.44 – 25.08	11.12	< 0.01
	F	12.0-19.5	14.98	±1.93	9.19 – 20.77		
C4	M	13.5-21.0	17.28	±2.34	10.26 – 24.30	11.24	< 0.01
	F	11.5.-19.0	14.47	±2.02	8.41 – 20.53		
C5	M	13.5-21.0	16.87	±2.25	10.12 – 23.62	11.7	< 0.01
	F	11.0-19.0	14.06	±1.97	8.15 – 19.97		
C6	M	14.0-21.0	17.13	±2.27	10.52 – 23.94	11.27	< 0.01
	F	11.0-19.0	14.38	±1.98	8.44 – 20.32		
C7	M	14.5-22.0	17.45	±2.29	10.53 – 24.32	11.45	< 0.01
	F	11.5-19.0	14.7	±1.99	8.03 – 20.67		

Table no. 3: Showing canal body ratio in both sexes.

Level	Sex group	Mean	S. D.	Calculated range (Mean ± 3 S.D.)	Z- Value	P- Value
C3	M	0.95	±0.06	0.77 – 1.13	15.94	< 0.01
	F	1.06	±0.06	0.88 – 1.24		
C4	M	0.95	±0.06	0.77 – 1.13	15.89	< 0.01
	F	1.07	±0.07	0.86 – 1.28		
C5	M	0.95	±0.06	0.77 – 1.13	17.22	< 0.01
	F	1.08	±0.07	0.87 – 1.29		
C6	M	0.96	±0.06	0.78 – 1.14	15.89	< 0.01
	F	1.08	±0.07	0.87 – 1.29		
C7	M	0.96	±0.06	0.78 – 1.14	14.56	< 0.01
	F	1.07	±0.07	0.86 – 1.28		

Discussions:

The Anteroposterior Diameter of Cervical Spinal Canal:

The importance of measurement of the anteroposterior diameter of cervical spinal canal is well established.

The interpedicular distance (transverse diameter) of cervical spinal canal is nearly twice the anteroposterior diameter of the spinal canal. Therefore, there is more room for the spinal cord to expand sideways while less space to expand in the anteroposterior direction. For this reason, the anteroposterior diameter of cervical spinal canal is considered the most useful measurement. Also, Hwan-Mo Lee et al. [5] have mentioned that the anteroposterior diameter of cervical spinal canal is more useful than transverse diameter in the diagnosis of cervical spinal stenosis.

Lindgren. [1] believes that the measurement of the anteroposterior diameter of cervical spinal canal in plain lateral radiography is reliable, more so than the transverse diameter.

Enlargement of spinal canal is usually associated with abnormal flattening or even medial concavity of the vertebral surfaces bordering the canal. Local expansion is generally evident from comparison with adjacent levels. A difference of 3 mm or more in the dimensions of cervical spinal canal between adjacent vertebral levels is said to be abnormal (David Sutton) [6].

Knowledge of normal measurement of the anteroposterior diameter of cervical spinal canal helps in the diagnosis of various clinical conditions associated with cervical spine, such as stenosis, space occupying lesions, etc.

From the table no. 4, it was observed that, for males, values of anteroposterior diameters of spinal canal were highest in the work of Payne and Spillane [7] , and lowest in the work of Hashimoto and Tak [8]. The values of present study group fall in between the two. The differences noted in the studies of Gupta et al. [9], D. N. Verma et al. [10] and present study, were probably because of difference in the stature of people of these groups. The values of mean anteroposterior diameters of spinal canal in present study group were comparable with those of Higo et al [11]. Similar to males, there was variation in the anteroposterior diameter of spinal canal in females, among various studies done by different authors, in various ethnic groups. This difference could be due to racial variation. The findings of anteroposterior diameter of spinal canal of females in present study correlate well with the study of D. N. Verma et al [10].

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Table no. 4: Showing comparison of mean anteroposterior diameters (in mms) of spinal canal in both sexes between previous studies and present study

SERIES	Male						Female				
	No.	C3	C4	C5	C6	C7	C3	C4	C5	C6	C7
Payne and Spillane 1959 (British)	-	18.6	17.5	17.8	18.8	17.8	17.9	17.3	17.1	17	16.6
Sato and Tsuru 1976 (Japanese)	47	16.1	15.6	15.9	16.4	16.3	16.1	15.5	15.7	15.7	15.5
Hashimoto and Tak 1977 (Japanese)	48	13.8	13.3	13.5	13.9	13.7	13.6	13	13.2	13.5	13.6
Gupta *et al* 1982 (Indian)	-	17.1	16.6	16.7	16.7	16.4	17.1	15.6	15.7	15.8	15.5
Higo *et al* 1984	104	17.3	16.8	16.7	16.8	16.9	16.5	15.8	15.8	16	16.1
Takashi Sasaki *et al* 1998 (Japanese)	505	16.1	15.6	15.7	16.2	16.4	15.4	14.9	14.9	15.3	15.5
D. N. Verma *et al* 1991 (Indian)	63	16.2	15.8	15.8	16.2	16.4	16	15.8	15.7	16	16.1
Present Study (Western Maharashtra)	150	16.9	16.4	16.1	16.4	16.7	15.8	15.4	15.1	15.4	15.7

Vertebral Body:

Growth of vertebral body and spinal canal in the cervical spine is related to genetic factors as well as postural and mechanical factors. Body of cervical vertebra from C3 to C7 is somewhat box-shaped. Remes VM et al. [12] have mentioned that the vertebral bodies grow relatively more in height than the depth, most actively at puberty. But the anteroposterior diameter of vertebral body is always greater than height.

The Issachar Gilad and Moshe Nissan,. [13] mentioned that in males(Table no. 5), anteroposterior diameters of vertebral bodies increases gradually from C2 to C7 level, forming a pyramid, whereas in the present study anteroposterior diameters of vertebral bodies go on decreasing from C3 to C5, there after it increases from C5 to C7, in both sexes.

Table no. 5: Showing comparison of mean anteroposterior diameters (in mms) of vertebral bodies between previous studies and present study.

SERIES	Instrumentation	Sex	No.	C3	C4	C5	C6	C7
Issachar Gilad *et al* 1985	Radiographs	M	141	15.2	15.65	15.8	16.3	16.35
Present Study (Western Maharashtra)	Radiographs	M	150	17.76	17.28	16.87	17.13	17.45
		F	150	14.98	14.47	14.06	14.38	14.7

The Canal Body Ratio (Torg's ratio, Pavlov's ratio):

Torg et al [3] have mentioned that canal body ratio is reliable for diagnosing cervical spinal stenosis. Because it is independent of magnification factors caused by differences in the target distance, object to film distance, or body type. Torg et al. [3] have reported that, measurement of canal body ratio less than 0.82 indicated significant spinal stenosis. Hwan-Mo Lee et al. [5] have concluded that canal body ratio is more reliable for determination of spinal stenosis or prognosis of cervical spinal cord injury than the direct measuring of the anteroposterior diameter of cervical spinal canal.

In the present study, average canal body ratio for males and females was found to be 0.95 and 1.07 respectively. From the table no 6, it was clear that, findings of canal body ratio in both sexes in present study, more or less correlate well with the findings of Madhur Gupta et al. [14]. It was observed that, in all studies, including present study, females showed a larger canal to body ratio than the males but the values of mean anteroposterior diameter of spinal canal in females were comparatively smaller than males. Thus, larger canal to body ratio in females than males can be attributed to the smaller anteroposterior diameter of vertebral bodies in females than males.

Table no. 6: Showing comparison of canal body ratio between previous studies and present study.

AUTHOR	CANAL BODY RATIO											
	MALE						FEMALE					
	C3	C4	C5	C6	C7	Avg.	C3	C4	C5	C6	C7	Avg.
Nirod Medhi *et al*.1997 (North East Region of India)	0.92	0.92	0.94	0.92	-	-	0.96	0.95	0.96	0.94	-	-
Madhur Gupta *et al* 1998 (North India)	1.01	0.97	0.95	0.94	0.86	0.95	1.05	1.01	1.04	1	0.97	1.01
Present Study (Western Maharashtra)	0.95	0.95	0.95	0.96	0.96	0.95	1.06	1.07	1.08	1.08	1.07	1.07

From the table no. 7, it was observed that in both sexes the values of anteroposterior diameter of cervical spinal canal and/or canal body ratios, less than the lower limits of the calculated range suggest spinal canal stenosis. The stenosis may be either congenital or acquired. It may be associated with conditions like degenerative changes in the vertebrae, osteophytosis, herniation of intervertebral disc, ossification of posterior longitudinal ligament (OPLL) and cervical spondylosis, etc. [15].

Similarly, the values of anteroposterior diameter of the cervical spinal canal and/or canal body ratios, greater than the upper limits of the calculated range suggest some pathological lesion (like space occupying lesions etc) at the particular segmental level. Thus, the value of anteroposterior diameter of the cervical spinal canal and/or canal body ratios beyond the upper and lower limit of calculated range, suggests some pathology at that particular vertebral level. Such cases need further investigations and clinical evaluation.

Table No 7: Showing upper and lower limits of Calculated range for anteroposterior diameter (in mms) of cervical spinal canal and Canal Body Ratio, in males and females.

Vertebral level	Values suggestive of Spinal Stenosisi.e., Values < (Mean-3 S.D.)				Values suggestive of Space Occupying Lesioni.e., Values > (Mean+3 S.D.)			
	Anteroposterior diameter (in mms) of Cervical Spinal Canal		Canal Body Ratio.		Anteroposterior diameter (in mms) of Cervical Spinal Canal		Canal Body Ratio.	
	Male	Female	Male	Female	Male	Female	Male	Female
C3	< 9.58	< 10.37	< 0.77	< 0.88	> 24.28	> 21.23	> 1.13	> 1.24
C4	< 9.55	< 9.93	< 0.77	< 0.86	> 23.17	> 20.79	> 1.13	> 1.28
C5	< 9.19	< 9.84	< 0.77	< 0.87	> 22.93	> 20.40	> 1.13	> 1.29
C6	< 9.06	< 9.98	< 0.78	< 0.87	> 23.76	> 20.78	> 1.14	> 1.29
C7	< 9.52	< 10.24	< 0.78	< 0.86	> 23.86	> 21.16	> 1.14	> 1.28

Summary and Conclusions:

In the present study, normal lateral radiographs of cervical spine of three hundred Western Maharashtra adult subjects with known age and known sex were studied. Third to seventh cervical vertebrae were studied in the present study. The parameters used in the study are viz. anteroposterior diameters of spinal canal and vertebral bodies. Making use of anteroposterior diameters of spinal canal and vertebral bodies, canal body ratio (Torg's ratio) was calculated.

It was found that the anteroposterior diameters of cervical spinal canal and vertebral bodies showed statistically significant difference in males and females, indicating the sexual dimorphism. The canal body ratio also showed the sexual dimorphism. Comparison of these vertebral dimensions with corresponding dimensions from other ethnic groups showed evidence of racial variation. Furthermore, careful study of these parameters and ratio, can be used in radiological detection of clinical conditions like bony spinal canal stenosis, some cases of intraspinal tumours, etc. These parameters can be used as reference values for evaluating various clinical conditions in the cervical spine in Western Maharashtra population.

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