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MID-SAGITTAL DIAMETER OF CERVICAL SPINE IN SOUTH INDIANS

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ABSTRACT Mid-sagittal diameter of 3rd to 7th cervical vertebrae, is the single most important measurement, which highly correlates with the risk of developing neurological deficit in patients with cervical spondylosis. Mid-sagittal diameter varies with the sex, race, geographical area, nutrition, built of the target population.

In this study, we measured the midsagittal diameter in x-ray cervical spine lateral view and in anatomical cervical bone specimens in our local population.

We found baseline value of mid-sagittal in our local population by measuring mid-sagittal diameter of C3 to C7 in cadavers. We found that, the midsagittal diameter highly correlates with the risk of developing cervical spondylotic myelopathy. Although radiographic measurement of midsagittal diameter gives magnification of approximately 22%, it can be safely used as a screening tool in outpatient department.

KEYWORDS : Mid-Saggital Diameter,X-Ray, Cervical Spine, Spondylotic Myleopathy

INTRODUCTION

Cervical spondylosis is a common degenerative disorder of the cervical spine. This affects almost every person over 40 years, the earlier or later. Pre-existing cervical canal narrowing, either congenital or acquired makes the patient vulnerable to neurological deficit with the onset of cervical spondylosis. Lindgren[1] was first to point out the importance of anteroposterior (midsagittal) diameter of the cervical canal. Midsagittal diameter is the single most measurement that highly correlates with the risk of developing neurological deficit in the middle life. Throughout the world, various authors studied the midsagittal diameter in their local population. We decided to measure the midsagittal diameter in our local population, using available resources within our premises.

AIM OF THE STUDY

- To find out normal mid-sagittal diameter in south Indian population.
- To analyse the utility of X-ray cervical spine in preliminary screening of cervical canal stenosis.
- To assess the magnification proportion of routine X- ray cervical spine lateral view used in our outpatient department.
- To analyse the mid-sagittal cervical canal size in cervical myelopathy patients and to compare this with those of cervical spondylosis patients who have no neurological deficit.

MATERIALS AND METHODS

The study was conducted between January 2006 to May 2008 in Madras Medical College and Government General Hospital, Chennai. Our study population consists of people from all over Tamilnadu and Southern Andhrapradesh.

We measured the midsagittal diameter of cervical spine by:

1. Radiographic method-using x-ray cervical spine lateral view.
2. Anatomical method-using dry bone specimens.

1. Radiographic method:

A total number of 206 patients were included in this study. Total number of males - 135. Total number of females - 71. Adult patients in age of 20 to 85 years were target population for study. The patients were divided into 3 groups based on clinical presentation and radiological investigations:

1. Normal patients.
2. Patients with cervical spondylosis.
3. Patients with cervical myelopathy.

The normal patients were selected from age group 20 to 50 years. They either have neck pain or presented with nonspecific complaints.

Patients with cervical spondylosis were selected between the age group 40 to 80. All these patients had radiological evidence of cervical spondylosis. Those patients with neurological deficit were carefully excluded.

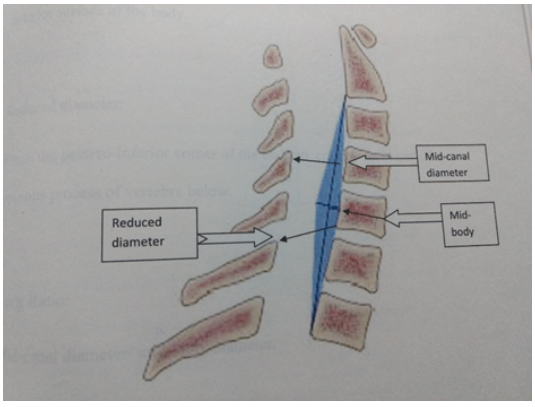
Patients with cervical spondylotic myelopathy were those having definitive clinical evidence of spastic quadriparesis — either myelopathy alone or myeloradiculopathy. All patients had MRI evidence of cervical spondylotic myelopathy. Other pathologies producing spastic quadriparesis are carefully excluded in these patients.

TABLE 1: The patient distribution in these 3 groups

Group	Male	Female
Normal	68	40
Cervical Spondylosis	42	21
Spondylotic myelopathy	25	10

X-ray cervical spine lateral view was taken in all these patients. We have followed the radiological technique used by Murone et al[2] and Payne et al[3]. Standard lateral radiographs were taken in neutral position of the cervical spine with a tube distance of 140 cm. The current in x-ray machine is kept constantly — 55 kilovolts and 100mA. These measures were kept constant throughout the study to reduce the magnification errors as far as possible. The measurements were taken with midline perforated ruler. Accuracy of the ruler was 0.5mm.

PICTURE 1: How to measure mid-canal diameter, mid-body diameter and reduced diameter



The midpoint of the posterior surface of the body of each cervical vertebra was pointed exactly. From this point, the nearest point on Spinolaminar line was located. The distance between these two points was taken. This measurement was marked as mid-canal diameter (MCD).

Then, the mid-point on the anterior surface of vertebral body was located. The distance between the anterior surface mid-point and posterior surface mid-point was measured and marked as body diameter (BD).

Then, the distance between the postero-inferior corner of each vertebral body and cranial most point in the base of spinous process of vertebra below at Spinolaminar line was measured. This measurement was marked as reduced diameter (RD) (Cailliet 1962)[4]. This reduced diameter measured only in cervical spondylosis patients and in cervical myelopathy patients.

These measurements were tabulated and analysed. The average of MCD was calculated at each level in all 3 groups. Then the Torg ratio was determined at each level. The results were compared with previous internationally published studies.

2. Anatomical method:

Whatever the measures taken, the magnification in x-rays is unavoidable. Hence, the measurement using x-rays is not anatomically accurate. To determine the exact anatomical measurements, we also studied 25 bone specimens from Institute of Anatomy, Madras Medical College. These specimens were taken from cadavers of unknown age but from adults and color coded for identifying C3 to C7. 15 male specimens and 10 female specimens are studied. Specimens showing evidence of degenerative changes including lipping and osteophyte formation were carefully excluded from the study. C3 to C7 vertebrae were included in the study. Totally 125 vertebrae were studied.

The midsagittal diameter was measured from each vertebra using Vernier caliper at midcanal level. The diameter of the body of each vertebra was also measured at mid body level. The measurements were properly charted and analyzed. The measurements at each level were compared with internationally published studies. Then, the mid-sagittal diameter at each level derived from radiographic and anatomical methods used in our study were compared to analyze the magnification proportion.

RESULTS

1. Radiographic Method:

A. Normal Group

a. Males:

68 males fall in this group.

TABLE 2: Mid-canal diameter in males by X-ray measurement

	C1 (cm)	C2	C3	C4	C5	C6	C7
Low	1.7	1.55	1.45	1.35	1.3	1.4	1.45
Mean	2.19±0.18 (SD)	1.99+0.17	1.72±0.16	1 64±0.16	1.68+0.15	1.68±0.13	1.73±0.12
High	2.5	2.4	2.1	1.9	2	1.95	2

SD - standard deviation.

The mean mid-canal diameter in males by radiographic method is 16.9mm.

TABLE 3:torg Ratio For Males By X-ray Measurement

	C3	C4	C5	C6	C7
Low	0.79	0.75	0.82	0.74	0.81
Mean	0.97	0.95	0.96	0.96	.95
High	1.17	1.17	1.22	1.27	1.27

The mean Torg ratio with radiographic method is 0.96.

b. Females:

40 female patients were studied.

TABLE 4: Mid -canal diameter in females by X-ray measurement

	C1(cm)	C2	C3	C4	C5	C6	C7
Low	1.75	1.5	1.4	1.3	1.35	1.35	1.45
Mean	2.07± 0.18	1.84± 0.16	1.6± 0.14	1.53± 0.14	1.56± 0.15	1.61± 0.13	1.61± 0.12
High	2.4	2.2	1.85	1.8	1.9	1.9	1.9

The Mean mid-canal diameter in females (C3 to C7) is 15.8mm

TABLE 5: Torg Ratio In Females With X-ray Measurement

	C3	C4	C5	C6	C7
Low	0.82	0.85	0.82	0.88	0.91
Mean	1.03	1.03	1.04	1.06	1.05
High	1.29	1.32	1.28	1.36	1.33

The mean Torg ratio for females is 1.04

B. Cervical Spondylosis Group:

a. Males:

42 patients are studied.

TABLE 6: Midcanal In Spondylotic Males With X-ray Measurement

	C1 (cm)	C2	C3	C4	C5	C6	C7
Low	1.8	1.5	1.4	1.3	1.3	1.35	1.4
Mean	2.11± 0.16	1.96± 0.17	1.77+ 0.17	1.68± 0.17	1.54+ 0.14	1.61± 0.15	1.66± 0.11
High	2.4	2.3	2.2	2.2	1.9	1.9	1.9

The mean mid-sagittal diameter of these patients (C3 to C7) is 16.5.

TABLE 7: Reduced diameter in males with X-ray measurement:

	C2	C3	C4	C5	C6	C7
Low	1.65	1.6	1.2	1.3	1.2	1.4
Mean	1.8	1.72	1.59	1.44	1.5	1.56
High	2	1.9	1.8	1.7	1.75	1.7

Table 8: Torg Ratio in males with X-ray measurement

	C3	C4	C5	C6	C7
Low	0.75	0.74	0.68	0.78	0.78
Mean	1	0.98	0.89	0.91	0.9
High	1.18	1.21	1.14	1.13	1.2

The mean Torg ratio in cervical spondylosis males without neurological deficit is 0.94.

b. Females:

21 females are studied. The age distribution is given below.

TABLE 9: Mid canal diameter in females with X-ray measurement:

	C1 (cm)	C2	C3	C4	C5	C6	C7
Low	1.7	1.6	1.4	1.35	1.2	1.3	1.35
Mean	1.94+0.14	1.78±0.09	1.61±0.1	1.52+0.11	1.43±0.14	1.5+0.11	1.51+0.12
High	2.2	2	1.75	1.7	1.7	1.7	1.75

The mean mid-sagittal diameter in Spondylotic females without neurological deficit is 15.1mm.

TABLE 10: Reduced diameter in females with X-ray measurement:

	C2 (cm)	C3	C4	C5	C6	C7
Low	1.6	1.6	1.3	1.2	1.3	1.4
Mean	1.79	1.7	1.58	1.43	1.5	1.55
High	2	1.9	1.85	1.7	1.7	1.65

TABLE 11: Torg ratio in females with X-ray measurement

	C3	C4	C5	C6	C7
Low	0.88	0.82	0.75	0.81	0.83
Mean	1.03	1.02	0.94	0.96	0.95
High	1.21	1.23	1.14	1.17	1.09

The mean Torg ratio form cervical spondylosis females is 0.98.

C. Cervical Myelopathy Group:

a. Males

25 patients were studied.

TABLE 12: Mid-canal diameter in males with X-ray measurement

	C1 (cm)	C2	C3	C4	C5	C6	C7
Low	1.6	1.5	1.3	1.2	1.2	1.1	1.2
Mean	1 94+0 15	1 . 7 + 0 12	1 . 4 7 ± 0 09	1 39±0.09	1 . 3 6 ± 0 11	1 . 3 6 ± 0 11	1.38±0.11
High	2.2	2	1.7	1.55	1.6	1.6	1.6

The mean mid-sagittal diameter in cervical myelopathy male patients is (C3-C7) 13.9mm.

TABLE 13: Reduced diameter in males with X-ray measurement

	C2	C3	C4	C5	C6	C7
Low	1.5	1.3	1.1	0.9	0.9	0.9
Mean	1.63	1.47	1.29	1.12	1.12	1.05
High	1.95	1.9	1.8	1.45	1.4	1.3

TABLE 14: Torg ratio in males with X-ray measurement

	C3	C4	C5	C6	C7
Low	0.72	0.69	0.6	0.65	0.62
Mean	0.82	0.79	0.75	0.75	0.73
High	0.94	0.9	0.91	0.94	0.88

The mean Torg ratio in cervical myelopathy males is 0.77.

b.Females:

10 patients were studied.

TABLE 15: Mid canal diameter in females with X-ray measurement

	C1(cm)	C2	C3	C4	C5	C6	C7
Low	1.65	1.35	1.25	1.25	1.2	1.1	1.2
Mean	1.77± 0.08	1.53± 0.11	1.37± 0.07	1.32± 0.06	1.29± 0.07	1.29+ 0.10	1 31+ 0.07
High	1.9	1.7	1.45	1.4	1.4	1.4	1.4

The mean mid-sagittal diameter in myelopathic females is (C3 to C7) 13.2mm

TABLE 16:Reduced diameter in females with X-ray measurement

	C2(cm)	C3	C4	C5	C6	C7
Low	1.4	1.2	1	0.9	0.8	0.9
Mean	1.64	1.45	1.2	1.1	1.03	1.06
High	1.8	1.6	1.3	1.2	1.2	1.2

TABLE 17: Torg Ratio in females with X-ray measurement

	C3	C4	C5	C6	C7
Low	0.76	0.69	0.71	0.65	0.74
Mean	0.86	0.83	0.83	0.82	0.81
High	1.04	1	1	1	0.93

The mean Torg ratio in myelopathic females is 0.83.

2. Anatomical method

A. Male Specimens

15 sets of cervical columns studied.

TABLE 18: Mid canal Diameter in male specimens

	C3 (cm)	C4	C5	C6	C7
SMALLEST	1.19	1.16	1.17	1.18	1.2
AVERAGE	1.36+ 0.14	1.33± 0.14	1.36+ 0.15	1.37± 0.14	1.39+ 0.12
LARGE	1.72	1.65	1.69	1.69	1.66

The mean mid-sagittal diameter in male specimens is 13.6mm.

TABLE 19: Torg Ratio in male specimens

	C3	C4	C5	C6	C7
Low	0.83	0.79	0.81	0.84	0.84
Mean	0.97	0.97	0.99	0.97	0.96
High	1.15	1.16	1.18	1.13	1.12

The mean Torg ratio in male specimens is 0.97.

B.Female specimens: 10 sets of cervical vertebral columns studied.

TABLE 20: Mid canal diameter in female specimens

	C3(cm)	C4	C5	C6	C7
Low	1.24	1.19	1.25	1.26	1.27
Mean	1.32+0.05	1.27±0.06	1.31±0.05	1.34+0.05	1.36±0.06
High	1.39	1.36	1.38	1.41	1.45

The mean mid-sagittal diameter in female specimens is 13.2mm.

TABLE 21: Torg Ratio in female specimens

	C3	C4	C5	C6	C7
Low	0.95	0.91	0.93	0.93	0.95
Mean	1.06	1.01	1.03	1.03	1
High	1.17	1.11	1.17	1.11	1.06

The mean Torg ratio in female specimens is 1.03.

DISCUSSION

The developmental stenosis of cervical spinal canal is a neurologically significant anomaly. Individuals with this anomaly are asymptomatic, until they develop cervical spondylosis or intervertebral disc prolapse. These patients are prone to develop spastic quadriplegia - the dreaded end result of cervical degenerative disorder.

There is a lot of confusion in the literature regarding this critical sagittal diameter when x-ray cervical spine of lateral view is used to measure the mid-sagittal diameter. Boijsen5 has pointed out that this confusion is partially due to variation in radiographic technique [focus to film distance] and partly to variation in the body build of the subject [object to film distance]. The focus to film distance can be adjusted and standardized. But the object to film distance is not controllable. Hence, the mid-sagittal diameter measured using x-ray technique is not reliable for treatment purposes. But, this method can be used to get a rough idea about the cervical canal size of the patient in outpatient departments. In this study, we have analyzed the mid-sagittal diameter of cervical spinal canal using anatomical and radiographic methods to confirm the usefulness of x-rays in screening for developmental stenosis of spinal canal. We also analyzed the Torg et al.'s6 ratio method and compared it with direct measurement of mid-sagittal canal size.

1. Analysis of measurements obtained by anatomical method in normal population

We first compared the measurements obtained from bone specimens in our study to similar studies already in literature.

Table 22. Mid-sagittal diameter of cervical spinal canal

IN PAKISTANIS (Maqbool et al)[7]			OUR STUDY	
LEVEL	Male(mm)	Female(mm)	Male(mm)	Female(mm)
C3	15.1	14.8	13.6	13.2
C4	14.8	14.3	13.3	12.7
C5	15	14.6	13.6	13.1
C6	15.1	14.4	13.7	13.4
C7	15.3	14.6	13.9	13.6
Mean	15.1	14.5	13.6	13.2

Level	Korean (Lee et al)[8]		Japanese (Okamoto)[9]		Japanese (Hashimoto and Tak)[10]		White (Francis)[11]		Black (Francis)	
	M	F	M	F	M	F	M	F	M	F
C3	13.3	13.4	13.3	12.8	13.8	13.6	16.5	15.5	15.2	15.1
C4	12.8	12.9	12.6	12.4	13.3	12.9	15.4	14.8	148	14.5
C5	13.0	13.0	12.9	12.4	13.5	135	15.4	14.4	15.1	14.6
C6	13.2	12.9	13.3	12.4	13.9	13.5	15.4	14.1	15.2	14.4
C7	13.4	13.3	13.3	12.7	13.7	13.6	15.5	14.4	15.5	14.3

From the above chart we can come to the conclusion that:

1. The mid sagittal diameter of cervical canal in South Indian's has many similarities to that of Japanese and Koreans.
2. The mid-sagittal diameter of cervical canal of South Indians is 1 to 2mm smaller than that of Pakistanis and 2 to 3mm smaller than that of whites and blacks.
3. The mid-sagittal diameter is narrowest at the level of C4 in our population both in females and in males similar to all other studies.
4. The mean diameter of South Indian cervical canal in males is 13.6 mm and in females is 13.2 mm. Females have 0.4 mm smaller mid-sagittal diameter compared to males.
5. The mid sagittal diameter of cervical canal in South Indian's has many similarities to that of Japanese and Koreans.
6. The mid-sagittal diameter of cervical canal of South Indians is 1 to 2mm smaller than that of Pakistanis and 2 to 3mm smaller than that of whites and blacks.

7. The mid-sagittal diameter is narrowest at the level of C4 in our population both in females and in males similar to all other studies.
8. The mean diameter of South Indian cervical canal in males is 13.6 mm and in females is 13.2 mm. Females have 0.4 mm smaller mid-sagittal diameter compared to males.

Table 23: *.Comparison of Torg ratio:*

Level	Canal/body Ratio or Torg Ratio)					
	Our Study		Koreans (Lee et al)		Pakistanis (Athar Maqbool et al)	
	Male	Female	Male	Female	Male	Female
C3	0.97	1.06	0.92	0.97	0.94	1.06
C4	0.97	1.01	0.9	1.02	0.94	1.09
C5	0.99	1.03	0.94	1.02	0.94	1.09
C6	0.97	1.03	0.95	1.04	0.95	1.08
C7	0.96	1	0.96	1.05	0.96	1.07
Mean	0.97	1.03	0.93	1.02	0.95	1.08

The mean Torg ratio is 0.97 in males and 1.03 in females in our population. The Torg ratio is smallest at the level of C7 in our study population.

2. Analysis of measurements obtained by radiographic method in normal population

Various authors used different film -to- focus distances. So the comparison is quite difficult to obtain. The following table compares mid-sagittal diameter obtained by radiographic method.

TABLE 24: Comparison of X-ray measurements:

Author (Year)	Focus-film distance (m)	Sex	No. of cases	Sagittal diameter [mean, mm)						
				C-1	C-2	C-3	C-4	C-5	C-6	C-7
Burrows (1963)[12]	1.83	total	300	22.9	20.3	18.5	17.7	17.7	17 5	17.3
Nagashima (1973)[13]	1.5	total	200	20	17.5	15.1	14.7	14.3	14.4	14.5
Sato and Tsuru (1976)[14]	1.2	total	96	21.4	19	16.1	15.5	15.8	16	15.9
		M	47	22	19	16.1	15.6	15.9	164	16.3
		F	49	20.9	18 9	16.1	15.5	157	15 7	15.5
Hashimoto and Tak $$ (1977)	1.2	total	92	18.6	16.3	13.7	13.2	13.4	13.7	13.7
		M	48	18.7	165	13.8	13.3	13.5	13.9	13.7
		F	44	18.5	16.1	13.6	13	13.2	13.5	13.6
Higo et al (1984)[15]	1.5	M	104	22.7	19.5	17.3	16.8	16 7	16.8	16.9
		F	93	21	18.1	16 5	15.8	15.8	16	16.1
Sasaki et al $$ (1998)[16]	1.5	total	997	21	18	15.8	15.2	15.3	15.7	15.9
		M	505	21.4	18.4	16.1	15.6	15.7	16.2	16.4
		F	492	20.5	17.5	15.4	14.9	14.9	15.3	15.5
Ourstudy	1.4	total	108	21.3	19.5	16.6	15.8	16.2	16 5	16.7
		M	68	21.9	19.9	17.2	16.4	16.8	16.8	17.3
		F	40	20.7	Ï8.4	16	15.3	15.6	16.1	16.1
Payne and Spillane(1957)	1.5	M	15	21.8	20.2	18.8	17.6	17.8	178	17.8
		F	15	21.6	19.8	17.9	17.3	17.1	70	16.6
($$ - Corrected for Magnification)										

The above shown studies are all conducted in Japanese except our study which is conducted on South Indians and Payne and Spillane which is British.

By radiographic method,

1. The mean diameter [male and female combined] in South Indians is given below:

C1-21.3 (mm)	C2-19.5	C3-16.6	C4- 15.8	C5-16.2	C6-16.5	C7- 16.7

2. Our measurements are very similar to Higo et al measurements in Japanese.
3. Compared to Payne and Spillane's measurements in whites, the south Indians' cervical canal is narrower.

TABLE 25: Comparison mid-canal diameter of Anatomical measurement with Radiographic measurement:

LEVEL		C3	C4	C5	C6	C7	COMBINED
Anatomic	M(mm)	13.6	13.3	13.6	13.7	13.9	13.6
method							
	F	13.2	12.7	13.1	13.4	13.6	13.2
	Mean	13.4	13	13.3	13.6	13.8	13.4
Radiographic	M	17.2	16.4	16.8	16.8	17.3	16.9
method							
	F	16	15.3	15.6	16.1	16.1	15.8
	Mean	16.6	15.9	16.2	16.5	16.7	16.4

b. Comparison of diameter of the vertebrae:

The diameter of the body of the vertebrae are compared to verify the amount of magnification.

The mean diameter of body by:

1. anatomical method =13.5 mm
4. The male: female difference of mid-sagittal diameter in our population using radiographic technique is 1.15 mm.

3. Comparison of measurements obtained by radiographic and anatomical methods

a. Comparison of mid-sagittal diameter•.

The mean mid-sagittal diameter from C3 to C7 male and female combined :

1. by anatomical method =13.4 mm
2. by radiographic method= 16.4 mm.

The magnification is approximately 3 mm or 22.4%.

2. radiographic method =16.6 mm

The magnification is approximately 3.1 mm or 22.9%.

TABLE 26: Comparison of body diameter by anatomical method vs radiographic method:

LEVEL		C3	C4	C5	C6	C7	COMBINED MEAN
Anatomic	M(mm)	14	13.8	13.8	14.1	14.5	14
method							
	F	12.5	12.6	12.8	13.1	13.6	13
	Mean	13.3	13.2	133	136	14.1	13.5
Radiographic	M	17.9	17.4	17.6	17.7	18.3	17.8
method							
	F	15.6	15.1	15.2	15.4	15.5	15.4
	Mean	16.75	16.25	16.4	16.55	16.9	16.6

Hence we conclude that with our method of X-ray cervical spine lateral view has approximately 3 mm magnification at each level.

C. Comparison of Torg ratio:

Table 27: *Comparison of Torg ratio:*

	Sex	C3	C4	C5	C6	C7
Torg ratio - Anatomical method	M	0.97	0.97	0.99	0.97	0.96
	F	1.06	1.01	1.03	1.03	1
Torg ratio - Radiographic method	M	0.97	0.95	0.96	0.96	0.95
	F	1.03	1.03	1.04	1.06	1,05

Torg ratio obtained by radiographic and anatomical methods in our study show good correlation as seen from above tabulation:

1. Females have large Torg ratio compared to males at all levels due to their smaller vertebral body size.
2. Torg ratio is smallest at C7 level in majority of our patient.

IV. Comparison of mid-sagittal diameter of cervical canal in cervical spondylosis and cervical myelopathy patients using radiographic method

Table 28: *Comparison of mid-sagittal diameter:*

LEVEL	Sex	Cl	C2	C3	C4	C5	C6	C7	COMBINED MEAN C3-C7
Cervical Spondylosis	M (mm)	21.1	19.6	17.7	16.8	15.4	16.1	16.6	16.52
	F	19.4	17.8	16.1	15.2	14.3	15	15.1	15.14
	Mean	20.25	18.7	16.9	16	14.85	15.55	15.85	15.83
Cervical Myelopathy	M	19.4	17	14.7	13.9	13.6	13.6	13.8	13.92
	F	17.7	15.3	13.7	13.2	12.9	12.9	13.1	13.16
	Mean	18.55	16.15	14.2	13.55	13.25	13.25	13.45	13.54
Normal Group	M	21.9	19.9	17.2	16.4	16.8	16.8	17.3	16.9
	F	20.7	18.4	16	15.3	15.6	16.1	16.1	15.82
	Mean	21.3	19.5	16.6	15.8	16.2	16.5	16.7	16.36

1. Compared to normal population, the cervical spondylosis group has only marginal reduction in the canal size (0.53mm).
2. Compared to normal population, the cervical myelopathy group has significant reduction in the mid-sagittal canal size (3.2mm).

It is difficult to comment on critical diameter below which the patient develop cervical myelopathy. But many of our patients with cervical myelopathy have less than 13 mm mid-canal diameter. Younger patients with narrow mid-canal diameter develop cervical myelopathy earlier with minimal encroachment of canal with cervical spondylosis. On the other hand, patients with adequate mid-canal diameter tend to develop myelopathy when they have significant disc prolapse at one or more levels or they have significant degenerative subluxation at one or more levels.

Table 29:*Comparison of reduced diameter:*

LEVEL	Sex	C2	C3	C4	C5	C6	C7
Cervical Spondylosis	M(mm)	18	17.2	15.9	14.4	15	15.6
	F	17.9	17	15.8	14.3	15	15.5
Cervical Myelopathy	M	16.3	14.7	12.9	11.2	11.2	10.5
	F	16.4	14.5	12	11	10.3	16.4

The reduced diameter, measured from posteroinferior corner of corresponding vertebra to the nearest point on Spinolaminar line of adjacent vertebra below, is very sensitive indicator of level of pathology. It falls rapidly at the level of cervical spondylosis. Since Luscka's joint is located at posterolateral corner of cervical vertebra and the osteophyte formation starts here, it clearly shows the level of pathology. It also shows the actual diameter available for cord at mid-sagittal plane.

The reduced diameter of less than 12 mm almost always present in one or more levels in patients with cervical myelopathy as suggested by Murone et al.

TABLE 30. Comparison of Torg ratio:

		C3	C4	C5	C6	C7	Mean
Cervical Spondylosis	M	1	0.98	0.89	0.91	0.9	0.94
	F	1.03	1.02	0.94	0.96	0.95	0.98
Cervical Myelopathy	M	0.82	0.79	0.75	0.75	0.73	0.79
	F	0.86	0.83	0.83	0.82	0.81	0.83
Normal Group	M	0.97	0.95	0.96	0.96	0.95	0.96
	F	1.03	1.03	1.04	1.06	1.05	1.04

Torg ratio is popularised by Torg and Pavlov. It has been told that the ratio method overcomes the magnification problem. When we analyze the Torg ratio value in our study population we found that:

1. Females have higher mean Torg ratio compared to the males at all levels of the cervical spine.
2. The average Torg ratio for the normal males in our study population is -0.96 and for normal females -1.04
3. Patients with cervical myelopathy have mean Torg ratio of 0.79 for males and 0.83 for females.
4. When we look back into the values what we have, many of our patients with Torg ratio of less than 0.8 at one or more levels are clinically normal. Even patients with mean Torg ratio below 0.8 are also clinically normal. Hence, it is difficult to conclude a critical Torg ratio below which patient definitely develops myelopathy. But we can safely conclude that patients with low Torg ratio below 0.8 are prone to develop cervical Spondylotic myelopathy.

CONCLUSION

1. The midsagittal diameter of cervical spine measured from bone specimens in South Indian population has many similarities to the measurements obtained in Japanese and Koreans. The mid-sagittal diameter of our population is significantly smaller compared to Pakistanis, Europeans and Africans.
2. The mean diameter of South Indian cervical canal (C3-C7) in males is 13.6 mm and in females is 13.2 mm. Females have 0.4 mm smaller mid-sagittal diameter compared to males. The mid body diameter difference between males and females show significant difference of 1.5 mm. The mid-sagittal diameter is narrowest at the level of C4 in our population. The mean Torg ratio is 0.97 in males and 1.03 in females in our population. The Torg ratio is smallest at the level of C7 in our study population.
3. The mid-sagittal diameter obtained by radiographic method shows significant magnification of about 3 mm or about 22% in average with our technique.
4. The radiographic method of measurement is difficult to compare with other population since difference in techniques used by different authors. But the measurements obtained with our study show significant similarities to that of measurements obtained by Japanese authors.
5. The mid-sagittal diameter obtained with radiographic method is (C3- C7) is 16.9mm in males and 1.58 mm in females.
6. The Torg ratio in females is higher than males in all levels in normal population as with other studies. The Torg ratio obtained with anatomic and radiographic methods are very similar indicating that our techniques are correct.
7. Torg ratio cannot accurately predict the patients at risk of cervical myelopathy. Many of our patients with Torg ratio below 0.8 are without neurological deficit. But those patients with Torg ratio below 0.8 are definitely within the arena of risky cervical myelopathy.
8. The radiographic method of analysing the mid-sagittal diameter can be used for screening in outpatient departments to detect significant cervical canal stenosis. These patients can be analysed further using sophisticated investigations like MRI and CT scan regarding treatment purposes. But, for clear reasons, this radiographic method alone cannot be used as a sole means to detect cervical canal stenosis.
9. The cut-off mid-sagittal diameter below which the patient tends to develop the neurological deficit is not possible to establish with our study using radiographic method. It may vary patient to patient, but we can safely conclude that patients with canal size below 13 mm are at risk of neurological deficit, when our radiographic techniques are followed.
10. The reduced diameter is very sensitive measurement to cervical spondylosis. It falls steeply at the level of cervical spondylosis. The reduced diameter below 12 mm indicates patients at risk of neurological deficit in our study.

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