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# Measurement of cervical spinal canal diameter by radiographs to study the degree of cervical spinal canal stenosis in an Indian population; Predictive value of Torgs ratio to assess cervical spinal canal stenosis

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ABSTRACT

**Introduction:** Cervical myelopathy a debilitating degenerative condition occurs due to cervical spinal canal stenosis, the incidence of which increases significantly with age and is more common above the age of 50 years. Imaging of the spinal canal is an indispensable procedure for evaluation of cervical myelopathy and standard lateral radiographs remain the recommended initial imaging study of choice. The present study was undertaken to measure the cervical spinal canal diameter by lateral radiographs of the cervical spine and to study the degree of cervical spinal canal stenosis in symptomatic patients and asymptomatic cases. The canal body ratio and its reliability to assess cervical spinal canal stenosis and risk of cervical myelopathy was evaluated.
**Materials and Methods:** In this study 200 cases who presented to the radiology department for radiographs of cervical spine, were divided into symptomatic and asymptomatic cases and were grouped age wise. Measurements of the cervical vertebral body and cervical spinal canal were taken. Torg ratio was assessed. The measurements were analyzed statistically and results tabulated.
**Results:** Cervical spinal canal diameter was lower in symptomatic cases as compared to asymptomatic cases across all age groups and the lowest value was measured at C3 level. All the symptomatic cases had Torg ratio of less than 0.82, and that of C3 was lowest. The data analysis showed the sensitivity of the Torg ratio as 100%. 40% of patients above 50 years were symptomatic and had cervical spinal canal stenosis on lateral radiographs.
**Conclusions:** Our results suggest that plain films can estimate the cervical spinal canal midsagittal diameter and be used as a first step examination for the evaluation of cervical spinal stenosis. The importance of canal body ratio in lateral cervical radiographs for determining the stenosis of cervical spinal canal is confirmed.



## 1. Introduction

The spinal cord is enclosed by the Spinal canal within the vertebral column; the portion within the seven cervical vertebrae is enclosed by the cervical spinal canal.[1] The cervical spinal canal (Figure 1) is more than 12mm in diameter normally, less than 12mm is considered as evidence of stenosis.[2–5] On Lateral cervical radiographs it is the measurement between the mid-point of posterior vertebral body and spino laminar line (Figure 2). Measuring errors due to rotator effects of degenerative disease can be avoided by this method.[6]

Progressive narrowing of the cervical spinal canal can cause compression on the nerve roots.[7,8] It may be congenital or acquired. People with cervical canal stenosis are susceptible for spinal cord injury.[9] It can be caused by age related degenerative spondylosis in

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the spine,[10] more common in people who crossed the fifth decade of their life, that result in hypertrophy of the ligamentum flavum, uncovertebral joint hypertrophy, facet hypertrophy, and development of anterior spondylotic ridges all of which contribute to cervical spinal canal stenosis.[2,11,12] Less common causes of cervical stenosis are posterior longitudinal ligament ossification, post traumatic narrowing, tumors, and large acute herniated discs.[13–15] Patients with a congenitally narrow spinal canal are more prone to develop pathological changes in the cervical spine, leading to cervical myelopathy.[16,17]

People with cervical spinal stenosis become symptomatic once the spinal cord or nerves are compressed. Canal dimensions are determinants of symptom production and neurological compromise.[18] Cervical myelopathy results from the narrowing of the normal anteroposterior cervical spinal canal diameter to a critical threshold of less than 12mm[2,3] and usually develops over a long period of time and may include symptoms like altered sensations including tingling, numbness and radicular pain in the limbs, and decreased gross and fine motor skills of hand. It can lead to serious problems with the nervous system including bowel and bladder disturbances.[19] Diagnosis is usually based on symptoms and clinical findings and confirmed by imaging tests of the neck. Imaging tests include radiographs, magnetic resonance imaging, and computed tomography. The cervical spinal canal diameters which are narrower than normal in cervical spondylosis can be measured by lateral roentgenogram of the cervical spine.[20,21]

Torgs ratio[22] measured in lateral cervical radiographs for determining the cervical spinal canal stenosis is important and can be relied on as it corresponds to the values measured in dry cervical vertebrae[23–25] This ratio is independent of technical factor variables[22] such as different target distances, object to film distance, magnification errors common with radiographs, and it can be used as a predictor for cervical spondylotic neuropathy.[26]

The present study done in coordination with the department of radiology, the cervical spinal canal diameter in lateral radiographs was measured, Torgs ratio determined, and the degree of cervical spinal canal stenosis in symptomatic patients and asymptomatic cases was assessed.

## 2. Materials and Methods

This prospective study was done in the department of anatomy in coordination with department of radiology. This study was carried out among people who came to the radiology department for radiographic imaging of the cervical spine. The study was done for a period of two years. Informed consent was obtained from all subjects and a proforma was filled. Patients above 20 years of age were evaluated, and they were distributed at 10 year age intervals.

### 2.1. *Exclusion criteria*

1. People of age 20 years or less.
2. Cases with spinal deformities.
3. Cases who had history of trauma.
4. Cases with past history of neck surgery.

Patients included in this study were classified into two groups

1. Symptomatic group: with symptoms of cervical myelopathy altered sensation, numbness, or tingling, in the arms, hands and legs, decreased fine motor skills of hand.
2. Asymptomatic group: Cases coming for routine preoperative radiographic imaging of the cervical spine, thyroid cases, and those referred from department of otorhinolaryngology for adenoids.

The subjects were arranged as male and females in the following age groups

1. 21–30 years
2. 31–40 years
3. 41–50years
4. 51–60 years
5. More than 60 years

All cases underwent lateral radiographs of the cervical spine.

Typical cervical vertebrae, third to sixth cervical vertebra were studied. For each of the typical cervical vertebra.

1. The anteroposterior diameter of the respective cervical vertebral body at the mid vertebral level (Figure 2)
2. The sagittal spinal canal diameter from the mid -point of the posterior vertebral body to the spinolaminar line (Figure 2), were measured. The measurements were recorded in millimeter.

The ratio of the cervical spinal canal diameter to the anteroposterior diameter of the respective cervical vertebral body is known as Canal to body ratio, Torgs ratio, or Pavlov's ratio. Comparative evaluation of the cervical spinal canal diameter and canal to body ratio for each vertebral level from third to sixth cervical vertebrae in symptomatic and asymptomatic groups was done. The results were analyzed statistically using NCSS statistical software, 2019. Variables were assessed using student t -Test which compares and assesses significant variation between symptomatic and asymptomatic groups.

## 3. Results

Of the 200 patients who presented to the radiology department for radiographs of cervical spine, 44 were symptomatic. All subjects with symptoms of cervical myelopathy

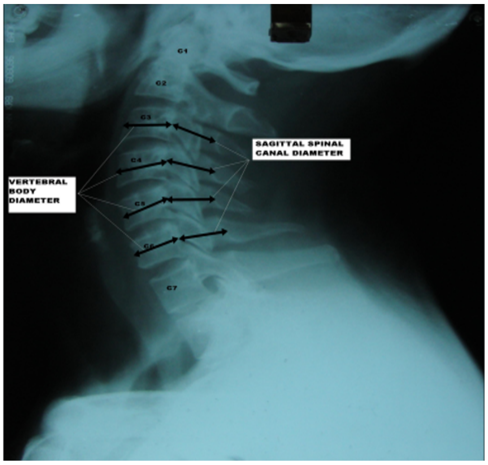


**Fig. 1:** Lateral radiograph of the cervical spine

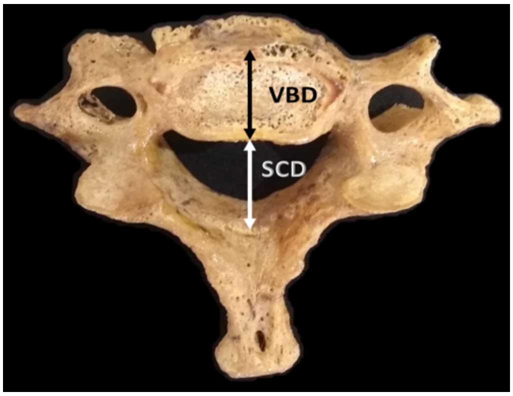


**Fig. 2:** Typical cervical vertebra superior aspect. VBD -The anteroposterior diameter of the cervical vertebral body; SCD- The sagittal spinal canal diameter.

had cervical spinal stenosis on lateral radiographs i.e., canal body ratio less than 0.82. The following observations were made from the study.

Out of 200 who presented for cervical spine radiographs, 48% were men, 52% were females all above 20 years of age (Table 1). 22% were symptomatic and 78% asymptomatic. In the age group of 51-60, 45%were symptomatic (Table 2).

64% of the symptomatic cases were males, and 36% were females. 43% of the symptomatic cases were above the age of 50 years.

## 4. Discussion

The spinal canal dimensions within the cervical spine can be reduced due to various causes, congenital, acquired, or degenerative leading to compression of spinal cord and severe debilitating symptoms. Early detection and diagnosis are essential to actively manage the condition.

R Gepstein et al[27] reported that the only parameter which could be statistically correlated with its cross-sectional area was the antero posterior diameter of the spinal canal and thereby it is a reliable indicator of bony spinal canal size. Studies done by Lennard A Nadalo et al[25] proved that lateral views using conventional spinal radiology are most sensitive for central spinal canal stenosis which was proven in our present study where the degree of cervical spinal canal stenosis was assessed by measuring the sagittal spinal canal diameter of the cervical spine on lateral radiographs.

Mc Cormick WE et al[28] reported that congenital and degenerative changes in the cervical spine result in narrowing of the cervical spinal canal which in turn leads to cervical spondylotic myelopathy. In his studies he observed the increased incidence of degenerative spondylosis in people over the age of 40 years. In the present study it was found that the incidence of cervical spinal canal stenosis was highest in symptomatic patients above 50 years of age, 40% of patients in that age group were symptomatic; it was also observed that those presenting with symptoms of cervical myelopathy, 64% of symptomatic cases, were predominantly male (Table 2).

M Bechar et al[29] measured the cervical spinal canal diameter in x-rays in 11 patients with signs of myelopathy and found that the average canal diameter was significantly smaller than that in the control group of 100. Similar findings were observed in the present study, where the spinal canal diameter in the symptomatic group was of much lower value as compared to the asymptomatic cases across all age groups and lowest at the level of C3 (Table 3, Figure 3). Debois V et al[30] reported that the degree and severity of neurologic symptoms are inversely related to the sagittal diameter of the cervical vertebrae. The difference in the mean value of spinal canal diameter between asymptomatic and symptomatic groups was lowest at the C6 vertebral level, and highest at C3 vertebral level (Figure 3). The statistical analysis yielded student t-test value of 6.13 at C3 level and 2.45 at C6 level (Table 3).

KK Goura et al[23] in their study C3 to C7 cervical spine vertebra in 100 radiographs as well as 100 sets of dried cervical vertebra measured the mid sagittal diameter of spinal canal and anteroposterior diameter of vertebral bodies. They reported no significant difference between the values of Torgs ratio in radiographs and dried bones.

The Torg ratio was evaluated by Herzog RJ et al[31] as a method to detect significant cervical spinal stenosis and was shown to have a high sensitivity, in this study it was found that all the symptomatic cases had Torg ratio of less than 0.8 2 (Figure 4), our data analysis revealed the sensitivity of the Torg ratio as 100%.

Tan J et al[32] studied the x-rays of 47 patients with degenerative cervical spinal stenosis, all Torg ratios were smaller than normal value and that of C4 was the smallest.

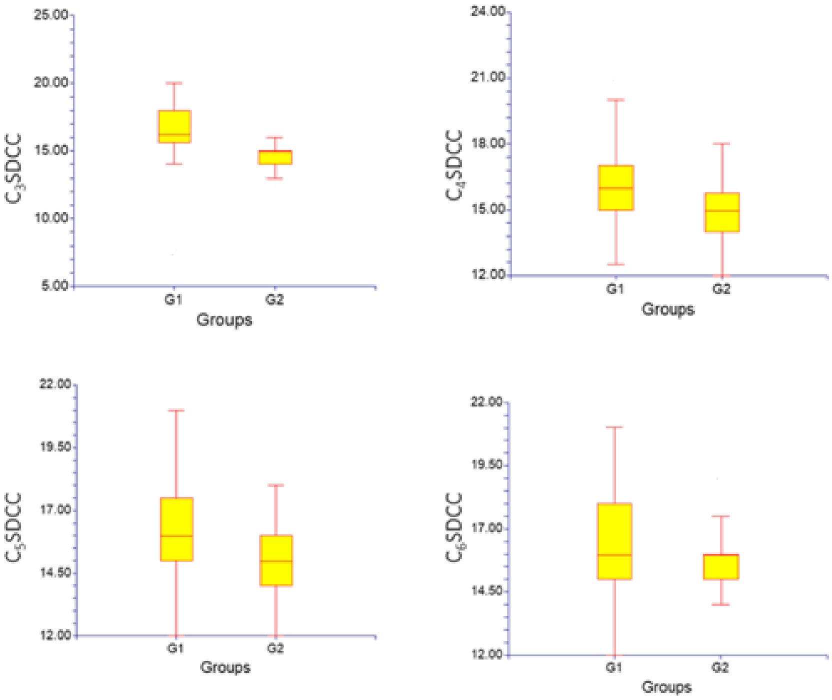


**Fig. 3:** Box plots showing correlations between spinal canal diameters of asymptomatic and symptomatic groups at various cervical vertebral levels. SDCC: Sagittal diameter of the cervical spinal canal, G1-Asymptomatic; G2-Symptomatic

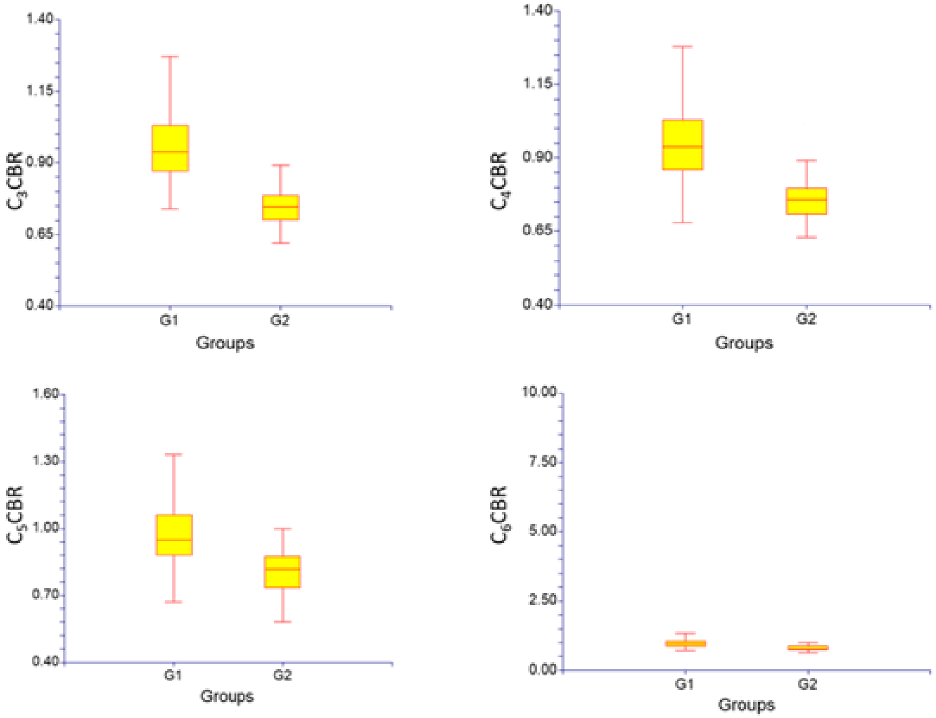


**Fig. 4:** Box plots showing correlations between canal body ratio of asymptomatic and symptomatic groups at various cervical vertebral levels. CBR: Canal body ratio; G1-Asymptomatic; G2-Symptomatic

**Table 1:** Age and sex distribution

| Age in years | Male | Female | Total |
|---|---|---|---|
| 21-30 | 22 | 25 | 47 |
| 31-40 | 25 | 42 | 67 |
| 41-50 | 17 | 22 | 39 |
| 51-60 | 19 | 10 | 29 |
| More than 60 | 14 | 04 | 18 |
| Total | 97 | 103 | 200 |

**Table 2:** Symptomatic and Asymptomatic cases - Age group distribution

| Age in years | Asymptomatic | | Symptomatic | | |
|---|---|---|---|---|---|
| | Male | Female | Male | Female | Total |
| 21-30 | 20 | 23 | 02 | 02 | 47 |
| 31-40 | 19 | 36 | 06 | 06 | 67 |
| 41-50 | 12 | 18 | 05 | 04 | 39 |
| 51-60 | 09 | 07 | 10 | 03 | 29 |
| More than 60 | 09 | 03 | 05 | 01 | 18 |
| Total | 156 | | 44 | | 200 |

**Table 3:** Students t–test value and probability level of means of Sagittal spinal canal diameter (SDCC)

| Vertebral level | Groups | Number | Mean (+ SD) | Students t-test value | Probability Level |
|---|---|---|---|---|---|
| C3SDCC | Asymptomatic | 156 | 16.52 + 1.76 | 6.13 | < 0.001 |
| | Symptomatic | 44 | 14.81 + 1.11 | | |
| C4SDCC | Asymptomatic | 156 | 16.24 + 1.62 | 5.39 | < 0.001 |
| | Symptomatic | 44 | 14.82 + 1.24 | | |
| C5SDCC | Asymptomatic | 156 | 16.27 + 1.67 | 3.76 | < 0.001 |
| | Symptomatic | 44 | 15.22 + 1.53 | | |
| C6SDCC | Asymptomatic | 156 | 16.41 + 1.63 | 2.45 | = 0.015 |
| | Symptomatic | 44 | 15.75 + 1.41 | | |

**Table 4:** Students t – test value and probability level of means of Canal body ratio(CBR)

| Vertebral level | Groups | Number | Mean (+ SD) | Students t-test value | Probability Level |
|---|---|---|---|---|---|
| C3CBR | Asymptomatic | 156 | 0.96 + 0.11 | 12.02 | < 0.001 |
| | Symptomatic | 44 | 0.74 + 1.11 | | |
| C4CBR | Asymptomatic | 156 | 0.96 + 0.12 | 9.79 | < 0.001 |
| | Symptomatic | 44 | 0.76 + 9.67 | | |
| C5CBR | Asymptomatic | 156 | 0.98 + 0.14 | 7.48 | < 0.001 |
| | Symptomatic | 44 | 0.80 + 0.13 | | |
| C6CBR | Asymptomatic | 156 | 1.02 + 0.65 | 2.11 | = 0.036 |
| | Symptomatic | 44 | 0.87 + 0.12 | | |

Yue WM et al[26] reported that the Torg ratio can be used to predict the likelihood of developing cervical spondylotic myelopathy as it was significantly lower in patients with cervical spondylotic myelopathy. He made these observations based on his comparative radiologic studies between cases with cervical spondylotic myelopathy and nonspondylotic, nonmyelopathic cases. In the present study we found that Torg ratio in patients with cervical myelopathy was less than those in asymptomatic cases, and that of C3 was smallest (Table 4, Figure 4). The difference in the means of Torgs ratio between symptomatic and asymptomatic groups was lowest at the C6 vertebral level and highest at C3 (Figure 4). The statistical analysis yielded student t-test value of 12.02 at C3 level and 2.11 at C6 level (Table 4).

Zhang L et al[33] examined the lateral radiographic plain films on 68 cases, 23 males and 45 females. The average Pavlov's ratio of C3 – C7 was 0.807 in females and 0.781 in males, significantly lower than those of healthy control group. In the present study the average Pavlov's ratio in symptomatic cases to be 0.779.

Senol U et al[34] examined and compared plain film measurements with anatomical measurements of 75 cervical vertebral canals (15 sets of C3-C7) and concluded that plain films can accurately estimate cervical spinal canal mid-sagittal diameter at the uppermost pedicle level and be used as a first step examination for the assessment of cervical spinal canal stenosis. The incidence of cervical spinal stenosis, in the present study, was observed in people over 50 years of age.

Cervical spinal canal diameter was lower in symptomatic cases as compared to asymptomatic cases across all age groups and the lowest value was measured in C3. All the symptomatic cases had Torg ratio of less than 0.82 and lowest at C3 level. The data analysis showed the sensitivity of the Torg ratio as 100%.

## 5. Conclusion

In the evaluation of cervical spinal canal stenosis imaging of the cervical spinal canal is of paramount importance. Lateral radiographs of the cervical spine are the recommended initial imaging study of choice in assessing the degree of spinal canal stenosis.

Lateral radiographs of the cervical spine can be used as a screening tool especially in people older than 50 years of age to detect cervical spinal canal stenosis as the incidence of canal stenosis increases significantly with age. Degenerative changes if any can be seen, and further evaluation can be done by magnetic resonance imaging and computed tomography.

Our results suggest that plain films can be used to estimate the cervical vertebral body diameter and cervical spinal canal midsagittal diameter, Torgs ratio derived, and the presence of cervical spinal canal stenosis can be determined.

The importance of Torgs ratio as a reliable tool for determining the stenosis of cervical spinal canal is confirmed.

## 6. Source of Funding

None.

## 7. Conflict of Interest

None.

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