Clinical Significance Of Occurrence Of Osteophytes and Its Effect On Sagittal Diameter Of The Cervical Spinal Canal In Indian Population: Morphometric And Radiological Analysis Of Cervical Spinal Canal

Dr. Rajesh Astik *, Dr. Urvi H. Dave **

*Associate Professor, **Tutor, Department of Anatomy, GSL Medical College, Rajahmundry, Andhra Pradesh, India

Abstracts: Backgroud: Osteophyte occurrence in cervical vertebral column is leading cause of cervical spondylosis. The aim of the present study was to estimate the average anatomical changes in cervical vertebral column due to occurrence of osteophytes and changes in the sagittal diameters of the cervical vertebral canal in Indian population to establish a clue to the underlying causes of the neck pain of unknown etiology. Methods: We dissected the cervical part of the vertebral column of 50 human adult cadavers (25 males and 25 females) and obtained 200 plain X-rays of lateral view of cervical spine of living patients (100 males and 100 females) for both morphometric and radiological analyses. Results: We found posterior osteophytes more frequently than anterior. The highest frequency of posterior osteophytes was found in the fifth cervical vertebra and of anterior osteophytes in the sixth cervical vertebra. The mean sagittal diameter of the cervical vertebral canal of cadavers ranged from 29.6 mm at C1 to 15.2 mm at C7 in males and 26.6 mm at C1 to 14.5 mm at C7 in females. The mean sagittal diameters of the cervical spinal canal in lateral radiograph of the cervical spine were ranged from 20.7 mm at C1 to 14.4 mm at C7 in males and from 19.9 mm at C1 to 13.4 mm at C7 in females. In general the sagittal diameters in female were less than that of male at all vertebral levels. The canal-body ratio at all vertebral levels was found to be less than 0.8 and was significant to develop cervical spondylotic myelopathy.Conclusion: This study has shown the effects of occurrence of osteophytes in cervical vertebra column and its impact on cervical spondylotic myelopathy. [Astik R et al NJIRM 2012; 3(2) : 45-50]

Key words: Cervical spinal canal, cervical spondylosis, dysphagia, morphometry, osteophyte

Author for correspondence: Dr. Rajesh B. Astik, Associate Professor, A-207, Department of Anatomy, SMIMER Medical College, Opp. Bombay Market, Umarwada, Surat, Gujarat. 395010. E-mail: astikrajesh@yahoo.co.in

Introduction: The occurrence of osteophytes in the vertebral column is an enigma to anatomists, clinician, anthropologists and other students of human body. Despite this interest, the real significance of osteophytes is as yet far from clear[1].

The cervical vertebral column is made up of seven cervical vertebrae; the intervening spaces between the vertebrae are filled up with intervertebral discs. With advancing age, shrinkage of the vertebral discs prompts the vertebrae to form osteophytes to stabilize the vertebrae. Osteophyte formation and other changes do not necessarily lead to symptoms, but after age of fifty, half of the population experiences symptoms of cervical spondylosis. Cervical spondylosis can cause cervical spondylotic myelopathy through stenosis or osteophyte related pressure on the spinal cord. The problems created by spondylosis can be exacerbated if a person has a naturally narrow spinal canal[1]. As spondylosis frequently involves cervical cord and osteophyte formation is one of the causes of cervical spondylosis, it is interesting to know how frequently the osteophytes affect the cervical segment of vertebral column; what the pattern of distribution of osteophytes is in the cervical vertebral column, and the effects of osteophyte formation on the spinal cord. This is the focus of the study.

Material And Methods : We studied the frequency of occurrence of osteophytes in 50 cadavers of Indian origin, 25 males and 25 females, over a period of three years. The dry bones were obtained from dissection room of the Department of Anatomy, GSL Medical College, Rajahmundry, Andhra Pradesh. The age range of the cadavers was 23-80 years, as per record; with mean age was 55 years. The cervical part of the vertebral columns was dissected. In all columns, the soft tissue was removed by heating in an alkaline solution and the fat was removed from the dried bones by immersion in ether following which the vertebrae were articulated and studied. There were no signs of trauma, degenerative changes or congenital anomalies in any of the vertebrae.

Each vertebra of each cervical vertebral column was examined. When osteophytes were found to be present, their exact distribution, whether situated on the anterolateral surface of the vertebral body or posteriorly (Fig 1) towards the vertebral canal, which might significantly narrow the sagittal diameter of the canal, were recorded.

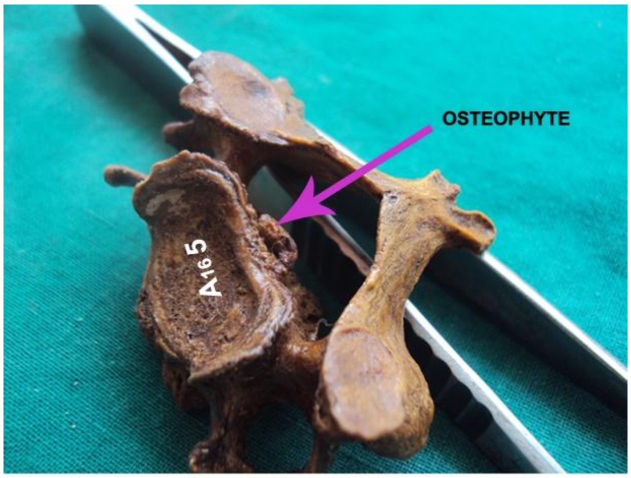


Figure-1 Posterior osteophyte on the fifth cervical vertebra projecting into the spinal canal, reducing the sagittal diameter of the spinal canal in a male specimen

The sagittal diameter of the cervical spinal canal from the upper part of the posterior surface of body to spino-laminar junction in the mid-line was measured in each dry cervical vertebra (Fig 2) to know the impact of osteophyte and its effect on sagittal diameter of the cervical spinal canal, and recorded in Table 1.

Figure-2 Measurement of the sagittal diameter of the cervical spinal canal in dry cervical vertebra

Table 1 Mean (in mm) of the sagittal diameter of the body of the vertebra, canal diameter and canal-body ratio

Level	Sagittal diameter of body of the vertebra (mm)		Sagittal diameter of Vertebral canal (mm)		Canal-body ratio	
	Male	Female	Male	Female	Male	Female
C1	--	--	29.6	26.6	--	--
C2	21.2	17.5	18.2	16.6	0.81	0.86
C3	20.2	17	16.6	16.0	0.82	0.85
C4	18.7	16.1	16.2	15.7	0.82	0.86
C5	19.1	16.9	16.6	16.2	0.83	0.84
C6	20.5	18.6	17.4	16.3	0.85	0.84
C7	17.7	14.9	15.2	14.5	0.84	0.86

For the correlation of the above findings on the dry vertebrae, lateral X-ray films of cervical spine were taken of 200 patients, 100 males and 100 females, 30-70 years of age, with the complain of pain in cervical region with or without the findings of cervical radiculopathy. No pregnant female was included in this study. The sagittal diameter of the cervical canal was measured from the middle of the posterior surface of the body representing the anterior surface of the spinal canal to the anterior-most point of fusion of the laminae and spinous process of the vertebra representing the posterior surface of the spinal canal at each vertebral level (Fig 3).

Figure-3 Measurement of sagittal diameter of the cervical spinal canal in X-ray neck lateral view

The data were recorded after correcting magnification (0.77) to render the radiological measurement relevant in clinical practice (Table 2).

In the case of the atlas, the measurement was taken from the posterior surface of the median atlanto-axial joint to the nearest point where the two limbs of the posterior arch of atlas unite.

The sagittal diameter of the each vertebral body was measured and canal-body ratio (Torg's Ratio) was calculated at each vertebral level in dry cervical vertebra and in lateral view X-ray of cervical spine. Torg's ratio of cervical vertebrae at all levels in dry bone and radiological study was compared (Table 3).

All the measurements in these studies were taken by using the sliding caliper. Measurements were carried out twice to exclude observer error and the means of the recorded values were determined.
Analysis of the data was done using the Statistical Package for Social Sciences (SPSS). Frequency distributions of all variables were produced using suitable tables. Student's t test was used for statistical analyses. A P value of less than 0.05 was considered statistically significant.

For the dissection of the cadavers, and for the investigations and materials which were used in the study, required permissions were taken from respective offices and departments of the institute and all the methods were followed in-line with international ethics and values.

Result: We found posterior osteophytes (60%) more frequently than anterior (40%) (Fig 1).

The incidence of occurrence of posterior osteophytes found at the levels of C5, C6 and C7 were 60%, 56% and 52% respectively; and the incidence of occurrence of anterior osteophytes found at the levels of C5, C6 and C7 were 40%, 55% and 50% respectively (Fig 4).

The occurrence of posterior and anterior osteophytes found to be significantly higher in the male specimens. We did not find posterior or anterior osteophyte affecting the first and second cervical vertebrae.

The mean sagittal diameter of the cervical spinal canal (Fig 2) in both sexes was maximal at C1 & showed a gradual reduction down to C4. Thereafter there was a gradual but marginal increase to C6, but the diameter at C7 was less than that of C4. The mean sagittal diameter of the cervical spinal canal in female at all vertebral levels was less than that of males (Table 1).

The average sagittal diameter of the spinal canal was measured in male and female patients in lateral view X-ray spine (Fig 3) showed significantly narrow canal in female patients (Table 2).

Table 2 Comparison of average sagittal diameter of cervical canal between male and female patients in radiological study

Level	Mean canal diameter (mm)		t-test
	Male	Female	
C1	20.7	19.9	2.847**
C2	17.8	15.7	7.807**
C3	16.1	14.2	7.116**
C4	15.6	15.1	2.119**
C5	15.6	14.5	4.661**
C6	16.0	15.0	4.960**
C7	14.4	13.4	5.102**

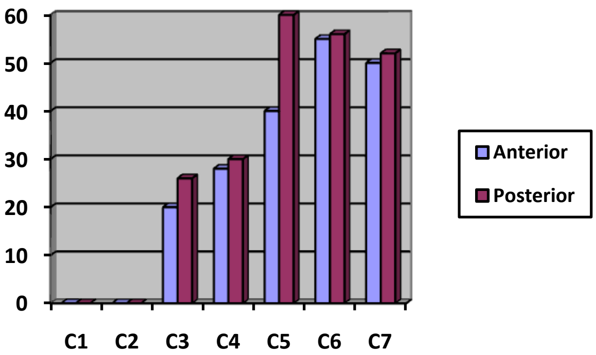
**significant difference

Marked reduction of canal-body ratio (Torg's ratio) was found at all cervical vertebral level in male and female patients as compared to dry cervical vertebral column of cadavers (Table 3).

Table 3 Comparison of canal-body ratio (CBR) of cervical vertebrae at different levels in dry bone (A) and radiological study (B)

Level	Male		Female	
	CBR (A)	CBR (B)	CBR (A)	CBR (B)
C2	0.81	0.80	0.86	0.80
C3	0.82	0.79	0.85	0.83
C4	0.82	0.77	0.86	0.76
C5	0.83	0.75	0.84	0.75
C6	0.85	0.75	0.84	0.74
C7	0.84	0.74	0.86	0.74

Figure 4 Percentage distributions of anterior and posterior osteophytes in cervical vertebral columns



Discussion: Some of the observations on the development of the osteophytes, particularly their frequency and distribution are comment able. These observations allow us to study an etiological interpretation of their development and to comment on their probable significance and functions.

Cervical myelopathy that may be a result of spinal cord compression can be caused by posterior osteophytes, disc protrusion or infolding of the ligament flava[2]. Degeneration of intervertebral discs or excessive compression forces on vertebral end-plates leads to development of osteophytes[1].

We found posterior osteophytes more frequently than anterior. The occurrence of posterior osteophytes at the levels of C5, C6 and C7 were 60%, 56% and 52% respectively. Anterior osteophytes, however less frequent than posterior, found at the levels of C5, C6 and C7 were 40%, 55% and 50% respectively (Fig 4). Hayashi et al.[3] found posterior osteophytes at the levels of C5 and C6 were 57.1% and 50% respectively; and anterior osteophytes at the levels of C5, C6 and C7 were 50%, 78.6% and 69% respectively. The occurrence of anterior osteophytes was higher than posterior in their study; however, the incidence of posterior osteophytes was higher in C5 and of anterior osteophytes in C6 vertebrae, which correlate with our findings. According to Oppenheimer[4], freer extension movements of cervical spine cause great pressure on the posterior part of cervical vertebrae. The summit of curvature in cervical column lies at the fifth cervical vertebra which is crossed by line of gravity, leading to highest incidence of posterior osteophytes in the fifth cervical vertebrae.

The occurrence of posterior and anterior osteophytes found to be significantly higher in the male specimens. Higher incidence of development of osteophytes in male may be due to greater pressure exerted on vertebral columns because of their greater body weight and harder physical work. We found incidence of occurrence of posterior and anterior osteophytes in 60% and 40% of the vertebral columns respectively. Vito[5] reported that 28% of patients with anterior cervical osteophytes complain of dysphagia. Osteophytic compression can occur at any vertebral level, but more common at C5-6 level, the site of the majority of cervical motion. We found anterior osteophytes more frequently at C6 level.

It is widely accepted that a decrease in the sagittal diameter of the spinal canal, notably in relation to production of osteophytes, leads to reduction of the space for the spinal cord and hence producing symptoms and signs of cervical myelopathy. Therefore observation of the sagittal diameter of the spinal canal is an important clue to know spinal canal stenosis in cervical spondylosis[6-9].

Table 4 Comparison of mean sagittal diameter (in mm) of dry cervical vertebra with literature

Level	Johnbull and Anibeze[10]		Present study	
	Male	Female	Male	Female
C1	--	--	29.6	26.6
C2	--	--	18.2	16.6
C3	17.82	17.45	16.6	16.0
C4	17.14	16.40	16.2	15.7
C5	17.35	17.21	16.6	16.2
C6	17.35	17.13	17.4	16.3
C7	17.42	17.38	15.2	14.5

In dry bone study, the mean sagittal diameter showed a decrease from 29.6 mm at C1 to 15.2 mm at C7 in males and from 26.6 mm at C1 to 16.3 mm at C7 in females (Table 1). These findings coincide with Johnbull and Anibeze[10] who studied cervical spinal canal diameter in Nigerian population and reported similar findings (Table 4). The diameters were found significantly larger in males than in females. These findings clearly showed racial variations. Using 469 cadavers, Lee et al.[11] reported that the average sagittal cervical canal diameter (C3–C7) was 14.1 ± 1.6 mm, and that men had significantly larger diameters than women at all the levels. The average sagittal diameter of cervical spinal canals in lateral view X-ray cervical spine was compared with previous radiological studies (Table 5).

Table 5 Mean sagittal diameters (in mm) of cervical spinal canal in various radiological studies

Studies	No. of cases		C1	C2	C3	C4	C5	C6	C7
Payne & Spillane[7]	70	Male	21.5	19.9	18.6	17.5	17.8	18.8	17.8
		Female	21.6	19.8	17.9	17.3	17.1	17.0	16.6
Burrows[8]	300		22.9	20.3	18.5	17.7	17.7	17.5	17.3
Bhalla et al.[9]	30		--	19.40	16.45	16.50	16.55	16.93	17.20
Oon[12]	400		20.3	18.5	15.5	14.9	15.2	15.5	15.4
Wholey et al.[17]	480		21.4	19.2	19.1	--	18.5	--	17.5
Present study	Male	100	20.7	17.8	16.1	15.6	15.6	16.0	14.4
	Female	100	19.9	15.7	14.2	15.1	14.5	15.0	13.4

It was seen from the table that the sagittal diameter of the cervical canal was maximum at C1 and then decreased gradually to C4 or C5. Thereafter it either remained unchanged or increased marginally; the value at C7 in all reports was never more than that of C4 or C5, whichever was smaller. Exceptions to this generalization were the reports by Payne and Spillane[7] where the diameter of 17.8 mm at C7 in males was more than 17.5 mm recorded at C4 level and by Bhalla et al.[9] where the diameter of 17.2 mm at C7 was more than all the diameters recorded from C3 to C6. Oon[12] reported the narrowest diameter at the level of C4. Another interesting finding arising from the exercise is that the sagittal diameter of the cervical spinal canal in the present study was, on the average, 2 to 3 mm shorter than that found in western subjects. Oon[12] reported similar findings. These differences might be attributed to racial, ethnic and/or environmental factors. We found significant sexual differences in sagittal diameters (t-test value was more than 2.1 at all vertebral levels) (Table 2). In most of the European studies, sexual difference was not significant.

Wolf et al.[6] reported that the normal measurement of the sagittal diameter of the midcervical was about 13 mm. Values below 13 mm were significant and those above 15 mm were regarded as normal. Edward and LaRocca[13] stated that patients with a sagittal cervical spinal canal diameter of less than 10 mm had myelopathy; those with a diameter of 10–13 mm had premyelopathic changes; patients with a diameter of 13–17 mm were less prone to myelopathy but was prone to symptomatic cervical spondylosis; and those with a diameter of greater than 17 mm were not prone to development of cervical spondylosis. We found sagittal diameters of the cervical spinal canal at C3-C6 were 13-17 mm in both sexes.

Assessment of the diameter of the cervical canal from plain radiographs is unreliable because direct measurements are subject to variation due to magnification. In an attempt to bypass this difficulty Torg et al.[14] used anatomical landmarks to define the stenotic cervical canal. The ratio of the sagittal diameter of the cervical canal divided by the corresponding diameter of the vertebral body was measured and became known as the 'Torg ratio' or the 'canal-to-body ratio'. Torg et al.[14] used this ratio to assess the presence of stenosis of the canal as a predisposing factor for cervical neuropraxia and concluded that a ratio of 0.82 or less indicated stenosis and correlated with a history of episodes of cervical neuropraxia. Pavlov et al.[15] and Castro et al.[16] suggested a ratio of less than 0.80 and 0.70 respectively indicated significant cervical canal stenosis and an increased risk for neurologic injury. We compared Torg's ratio of cervical vertebrae at all levels in dry bone and radiological study (Table 3), and found that the ratio was significantly lower in patients than dry cervical vertebral columns.

Conclusion: The amount of free space available for the spinal cord in narrow canal is small and any additional narrowing of the canal increases the possibility of pressure upon it. The available space in the spinal canal is further reduced by the presence of posterior osteophyte which project into the spinal canal. The present study has shown a narrower depth of the cervical vertebral canal in Indian population. This study has also shown that the ratio between the depth of body and cervical vertebral canal may be important to predict any vertebral anomalies, and a useful guide to diagnose cervical canal stenosis.

Acknowledgement: Our sincere thanks to all the people who helped and supported during the writing of this manuscript. We would thank our institution for allowing us to dissect cadaver and faculty members without whom this manuscript would have been a distant reality.

References:

1. Nathan H. Osteophytes of the vertebral column: An Anatomical study of their development according to age, race, and sex with considerations as to their etiology and significance. J Bone Joint Surg Am. 1962; 44: 243-268.
2. Epstein JA, Carras R, Epstein BS, Levine LS. Myelopathy in cervical spondylosis with vertebral subluxation and hyperlordosis. J Neurosurg. 1970; 32(4):421-426.
3. Hayashi H, Okada K, Hashimoto J, Tada K, Ueno R. Cervical spondylotic myelopathy in the aged patient. A radiographic evaluation of the aging changes in the cervical spine and etiologic factors of myelopathy. Spine (Phila Pa 1976). 1988; 13(6):618-625.
4. Oppenheimer A. Calcification and ossification of vertebral ligaments (sponsylitis ossificans ligamentosa): Roentgen study of pathogenesis and clinical significance. Radiology. 1942; 38: 160-173.
5. Vito DJ. Cervical osteophytic dysphagia: single and combined mechanisms. Dysphagia. 1998; 13(1): 58-61.
6. Wolf BS, Khilnani M and Malis L. The sagittal diameter of the bony cervical spinal canal and its significance in cervical spondylosis. J. Mt Sinai Hosp N Y. 1956; 23(3): 283-292.
7. Payne EE, Spillane JD. The cervical spine: An anatomico-pathological study of 70 specimens (using a special technique) with particular reference to the problem of cervical spondylosis. B*rain.* 1957; 80(4): 571-596.
8. Burrows EH. The sagittal diameter of the spinal canal in cervical spondylosis. Clin Radiol. 1963; 14: 77-86.
9. Bhalla SP, Lall SK, Sodhi JS, Negi ON. Comparative values of intervertebral space, spinal canal and intervertebral foramina in normal and in cases of cervical spondylosis in Indian population. Indian Journal of Radiology. 1977; 31: 170-175.
10. *Johnbull TO, Anibeze CIP.* A Cadaveric Study of the Morphometry of the Cervical Spinal Canal in Nigerians. Journal of Experimental and Clinical Anatomy. 2009; 8: 19-21.
11. Lee MJ, Cassinelli EH, Riew KD. Prevalence of cervical spine stenosis: anatomic study in cadavers. J Bone Joint Surg Am. 2007; 89(2):376–380.
12. Oon CL. The sagittal diameter of the cervical spinal canal. Singapore Medical Journal. 1974; 15(3): 218-222.
13. Edwards WC, LaRocca H. The developmental segmental sagittal diameter of the cervical spinal canal in patients with cervical spondylosis. Spine. 1983; 8(1):20–27.
14. Torg JS, Pavlov H, Genuario SE et al. Neurapraxia of the cervical spinal cord with transient quadriplegia. J Bone Joint Surg Am. 1986; 68(9):1354-1370.
15. Pavlov H, Torg JS, Robie B, Jahre C. Cervical spinal stenosis: determination with vertebral body ratio method. Radiology. 1987; 164(3): 771–775.
16. Castro FP, Ricciardi J, Brunet ME, Busch MT, Whitecloud TS III: Stingers, the Torg ratio, and the cervical spine. Am J Sports Med. 1997; 25(5):603–608.