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Morphometric analysis of cervical canal by computerized tomography (CT) scan in north Indians

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***Abstract*---**Introduction: Cervical spinal stenosis is a common disease that results in considerable morbidity and disability. It requires prompt diagnosis and treatment to prevent long-term disabilities secondary to irreversible spinal cord injury. The bodies of the cervical vertebrae are smaller in size compared with those of other vertebrae and function to protect the spinal cord, support the head, and allow movement of the head (in flexion, extension, and rotation). Material and Methods: This is a Case control prospective study conducted at Santosh Medical College, Ghaziabad and Mayo Institute of Medical Sciences, Barabanki, Uttar Pradesh. The present study was conducted in the Department of Anatomy and Radio diagnosis. Diagnosed cases of (Neck pain) with suspected cervical canal stenosis and facet joint arthrosis from OPD of Department of Orthopedics and Neurology of Santosh Medical referred to Radio diagnosis department for CT scan was chosen as subject. Result: In our study, results suggest gradual increase of spinal canal Sagittal vertebral body diameter (AP-V), from C3 (14.06±0.76) to C7 (14.44±0.75). Furthermore, in our study at the level of C7 (9.23±0.40) the Sagittal spinal cord diameter (AP-SC) increases and the smallest sagittal diameter of the canal were detected at the level of C3 (9.05±0.47). Additionally, in our study at the level of C7 (11.00±0.78) the Sagittal vertebral canal diameter (AP-VC) decreases after C6 (11.16±0.78) and the smallest Sagittal vertebral canal

diameter of the canal was detected at the level of C3 (10.97±0.78). Conclusion: CT scan can provide accurate cervical canal measurements that could serve as a useful guide in the determination of the cervical canal stenosis, replacing the old lateral plain x-ray technique. Further studies are required to apply the Torg-Pavlov ratio on the more accurate cervical CT scans.

***Keywords*---**computerized tomography, cervical canal stenosis, facet joint arthrosis.

introduction

Cervical spinal stenosis is a common disease that results in considerable morbidity and disability. It requires prompt diagnosis and treatment to prevent long-term disabilities secondary to irreversible spinal cord injury. [1] The bodies of the cervical vertebrae are smaller in size compared with those of other vertebrae and protect the spinal cord, support the head, and allow movement of the head (in flexion, extension, and rotation). [2] The vertebral column is a curved linkage of individual bones or vertebrae, consisting of 33 vertebral segments in adult. Although the usual number of vertebrae are 7 cervical, 12 thoracic, 5 lumber, 5 sacral and 4 Coccygeal, this total is subject to frequent variability. [3] Due to fusion of sacral and coccygeal segment of vertebral column the total number becomes 26. The cervical vertebrae consist of 7 bones, two of which, i.e. cervical vertebrae 1 (C1) and 2 (C2), are different in form compared to the other five. The cervical canal, which is situated posterior to the vertebral body, has an almost cylindrical shape, and within it is the spinal cord running along C1-7, and the brachial plexus, which passes outwards at C5-6. [4]

The spinal cord is an elongated and cylindrical part of central nervous system which is contained within the upper two-third of vertebral canal and is concerned with the reception of different modalities of sensory input, integrates and associates the information and processes reflex response of basic characters. [5] The human vertebral column protects the spinal cord and nerve roots. The seven cervical vertebrae have one characteristic feature i.e. presence of foramen transversarium affecting transverse process of each cervical vertebra. [6]

The third cervical vertebrae to six cervical vertebrae are typical and seventh are atypical but they bear almost common feature. First and second cervical vertebrae are atypical, because they bear different feature. [7] Cervical spine form the skeleton of the neck, it transmits weight of the upper body to pelvis and therefore is subjected to internal stress. A large proportion of adults suffer from neck pain at some points of their life and show altered ranges of spinal canal morphometry in various studies. The differences in values are may be due to genetic, hormonal and other factors. [8] Facet joint osteoarthritis (FJOA) is a clinical and pathological construct that involves the functional failure of the synovial facet joints. Although often viewed as a disease of articular cartilage loss and bony hypertrophy, the process of failure actually involves the whole

joint, including the subchondral bone, cartilage, ligaments, capsule, synovium, and periarticular paraspinal muscles and soft tissues. [8] The facet joint itself is a component of a spinal 'motion segment' that also includes the intervertebral disc, which tends to degenerate in concert with the facet joint. As such, FJ OA is frequently associated with degenerative disc disease. [9] Stenosis may be congenitally present, but is most commonly acquired. The primary pathology in congenital stenosis, sometimes referred to as developmental spinal stenosis, is a skeletal hypoplasia in which the dimensions of the cervical canal are reduced. Conversely, an acquired spinal stenosis occurs in response to degenerative changes, which most commonly originate at the disc space level. These two pathologies are often found in tandem and they work synergistically to compress the spinal cord and produce clinical symptoms. [10] Thus study can also be extended in cases of congenital and acquired stenosis with facet joint arthrosis in relation to age, sex and body weight. The present study has been designed to assess the prevalence of cervical canal stenosis and facet joint arthrosis in patients presenting with neck pain and its correlation with age, sex and cervical spinal levels (C3-C7) by CT scan. [11] Therefore, we hypothesized that; Facet Joint arthrosis and cervical canal stenosis are major cause of age related neck pain in both sexes. The assessment of effectiveness of CT scan as a diagnostic tool for cervical pain due to cervical spine stenosis and facet joint arthrosis was also done in the present study which will improve the communication between the clinicians and radiologists. The outcomes of this study may be further extended as an independent study in larger sample size to determine the correlation of facet joint arthrosis and cervical canal stenosis with the age related neck pain, which may enlighten the path for further proceedings of the current research in both the sexes.

Material and Methods

Place of Study: Santosh Medical College, Ghaziabad and Mayo Institute of Medical Sciences, Barabanki, Uttar Pradesh.
Study type: Case control prospective study.

Cases

The definition of a case needs to be very specific strict criteria. Inclusion criteria for case **-** Age 20 years and above, Healthy according to the Questionnaire, Paresthesia associated with muscles of neck, Loss of sensibility corresponding to a dermatome, Atrophy of Muscles and rigidity of neck will be included in study. Exclusion criteria for case**-** Below 20 year age**,** Head or Spine surgery**,** Psychiatric disorder**,** Drug abuse**,** Tumour in neck, Pregnancy**,** Congenital anomalies related to spinal canal will be excluded from the study. Sources to select the cases - Hospital based or Population-based locating all cases (or a random sample) from a defined population.

Controls

Controls should be chosen who are similar in many ways to the cases except neck pain

Study population: Patients with either cervical spine stenosis or facet joint arthrosis or both (age 20 – 80 yrs of either gender) who are coming OPD of Mayo Institute of Medical sciences, Barabanki and Santosh Medical College and Hospital, NCR Delhi. Diagnosed cases of (Neck pain) with suspected cervical canal stenosis and facet joint arthrosis from OPD of department of Orthopaedics and Neurology referred to Rdiodiagnosis department of SMCH & MIMS for CT scan was chosen as subject. Whole age group of subject was further divided in different age groups.

CT scan Examination Antero-posterior diameter of Spinal Canal, Antero-posterior diameter of Vertebral Body, Cervical Facet Joints

Figure - Sagittal CT image of cervical spine
Showing measurements of Antero-posterior diameter of Vertebral Body

Figure- Sagittal CT image of cervical spine showingMeasurements of Antero-posterior diameter of Spinal Canal

Statistical Analysis Methods

Data were collected manually, Tabulated in MS windows excel sheet and data was analyzed by using Social Package for Social Sciences (SPSS) version 16. Testing of

hypothesis using parametric and non- parametric. To study the between group differences ANOVA with post hoc test was used.

Result

Table 1: Baseline demographics of study population

Category	Value
N	83
Gender, n (%)	
Male	41 (49.4)
Female	42 (50.6)
Age in years	
Mean ±SD	57.98±7.63
Range	40-74
Categories of age, n (%)	
40-50	14 (16.8)
51-60	36 (43.3)
61-70	30 (36.1)
>70	3 (3.6)
Height in cms	
Mean ±SD	167.18±8.37
Range	155.8-177.5
Weight in kg	
Mean ±SD	67.47±9.71
Range	49-87
Body mass index (BMI), kg/m2	
Mean ±SD	24.20±3.72
Range	16-33
Categories of weight, n (%)	
Healthy weight	43 (51.8)
Underweight	5 (6)
Overweight	22 (26.5)
Obese	4 (4.8)

Table 2: Sagittal vertebral body diameter (AP-V) measurement of study population

Cervical vertebrae		Value (mm)
N		83
C3	Mean±SD	14.06±0.76
	Min	12.28
	Max	15.55
C4	Mean±SD	14.25±0.75
	Min	12.48
	Max	15.75
C5	Mean±SD	14.48±0.75
	Min	12.71

	Max	15.98
C6	Mean±SD	14.63±0.75
	Min	12.86
	Max	16.13
C7	Mean±SD	14.44±0.75
	Min	12.67
	Max	15.94

Table 3: Statistical comparison of Sagittal vertebral body diameter from C3-C7

	C3	C4	C5	C6	C7
C3	-	t = 117.571 0.0001	t = 26.32 0.0001	t = 342.85 0.0001	t = 230.2 0.0001
C4	-	-	0.0001	0.0001	0.0001
C5	-	-	-	0.0001	0.0001
C6	-	-	-	-	0.0001
C7	-	-	-	-	-

Table 4: Sagittal spinal cord diameter (AP-SC) measurement of study population

Cervical vertebrae		Value (mm)
N		83
C3	Mean±SD	9.05±0.47
	Min	7.93
	Max	10.01
C4	Mean±SD	9.14±0.45
	Min	8.05
	Max	9.95
C5	Mean±SD	9.27±0.44
	Min	8.19
	Max	9.97
C6	Mean±SD	9.34±0.40
	Min	8.30
	Max	10.00
C7	Mean±SD	9.23±0.40
	Min	8.19
	Max	9.89

Table 5: Statistical comparison of sagittal spinal cord diameter (AP-SC) from C3-C7

	C3	C4	C5	C6	C7
C3	-	t = 5.66 0.0001	t = 10.67 0.0001	t = 10.53 0.0001	t = 6.52 0.0001
C4	-	-	t = 10.21 0.0001	t = 8.64 0.0001	t = 3.72 0.0004
C5	-	-	-	t = 3.97	t =

				0.0001	2.3504 0.0212
C6	-	-	-	-	0.0001
C7	-	-	-	-	-

Table 6: Sagittal vertebral canal diameter (AP-VC) measurement of study population

Cervical vertebrae		Value (mm)
N		83
C3	Mean±SD	10.97±0.78
	Min	9.02
	Max	12.26
C4	Mean±SD	10.77±0.78
	Min	8.82
	Max	12.06
C5	Mean±SD	10.91±0.78
	Min	8.96
	Max	12.20
C6	Mean±SD	11.16±0.78
	Min	9.21
	Max	12.45
C7	Mean±SD	11.00±0.78
	Min	9.05
	Max	12.29

Table 7: Statistical comparison of sagittal vertebral canal diameter (AP-VC) from C3-C7

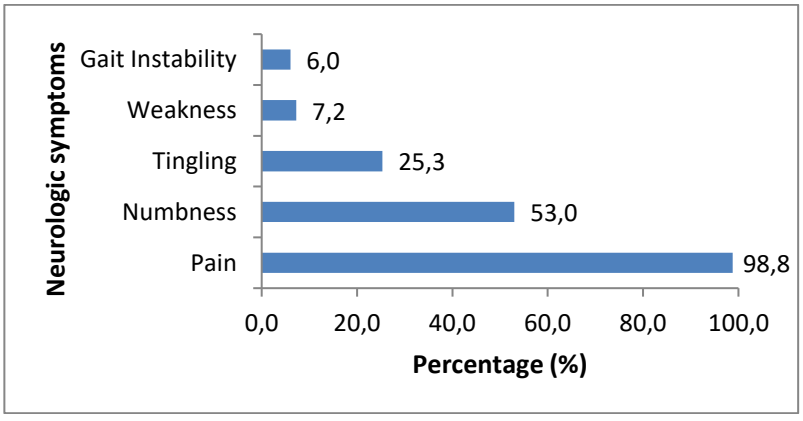
	C3	C4	C5	C6	C7
C3	-	t = 275.6 0.0001	t = 82.0 0.0001	t = 263.8 0.0001	t = 42.50 0.0001
C4	-	-	0.0001	0.0001	0.0001
C5	-	-	-	1.000	0.0001
C6	-	-	-	-	0.0001
C7	-	-	-	-	-

Table 8: Neck pain grading in the study population

Category	Frequency	Percentage
Pain Intensity		
3	31	37.4
4	38	45.8
5	14	16.9
Personal Care (Washing, Dressing, etc.)		
3	30	36.1
4	33	39.6
5	20	24.1

Lifting		
3	29	35.0
4	35	42.2
5	19	22.9
Reading		
3	34	41.0
4	33	39.6
5	16	19.3
Headaches		
3	34	41.0
4	33	39.6
5	16	19.3
Concentration		
3	29	35.0
4	33	39.6
5	21	25.3
Work		
3	32	38.6
4	31	37.4
5	20	24.1
Driving		
3	32	38.6
4	35	42.2
5	16	19.3
Sleeping		
3	34	41.0
4	33	39.6
5	16	19.3
Recreation		
3	28	33.7
4	34	41.0
5	21	25.3

Figure 5- Percentage of neurologic symptom



Discussion

Degenerative cervical spine diseases narrow spinal canal's vital space, thus influencing proper function of neural elements at the level of the stenosis. The risk for the onset of neurological symptoms, even with low energy trauma, becomes greater in patients with progressed stenotic changes [12]. Several radiological techniques have been applied to measure canal's sagittal diameter and detect a correlation with cervical myelopathy with the aim to establish a potent predicting factor [13]. Application of Torg-Pavlov's ratio on plain x-rays is a widespread, low cost technique [14]. Herzog *et al*, evaluating Torg-Pavlov ratio reported a high sensitivity but a poor positive predictive value [15]. On the other hand, CT-scan and MRI perform accurate measurements on the anatomical structures of the cervical spine, thus avoiding technical errors that could lead to false calculations. [16].In our study Eighty-three patients were enrolled with an average age of 57.98±7.63 years. This last factor may be often related to the amount of heavy work done before the age of 20. Previous cross-sectional studies have demonstrated that age related changes in cervical spine are widely present even in asymptomatic healthy individuals. According to Freedman BA et al, 37 patients were enrolled who met the diagnostic criteria for myelopathy or myeloradiculopathy were enrolled in the "myelopathic" group with an average age of 64.4±13.4 years. Leclaire R [17] conducted CT of cervical spine in such subjects and reported degenerative changes in 40 years of age and older subjects. Kornick C [18] conducted of cervical spine in 89 healthy subjects using a 0.1 MRI imager. Abnormal findings were recognized in 62% of the cases 40 years of age and older whereas the abnormal findings were rare in subjects younger than 40 years of age. [19] In our study, 49.4% of males and 50.6% of females were enrolled. According to Kalichman et al. showed a high prevalence of Facet joint osteoarthritis (FJOA) in a community-based population (59.6% of males and 6.7% of females) which increases with age and reaches 89.2% in individuals over 60 years old. Risk factors for Facet joint osteoarthritis (FJOA) include: age, sex, spinal level, facet orientation (sagittally oriented) and associated background of intervertebral disc degeneration. However, the association between degenerative changes in the Facet joint osteoarthritis (FJOA) and symptomatic low back pain remains unclear and subject of an ongoing debate. [20] In our study, results suggest gradual increase of spinal canal Sagittal vertebral body diameter (AP-V), from C3 (14.06±0.76) to C7 (14.44±0.75). At the level of C7 the sagittal diameter increases and the smallest sagittal diameter of the canal was detected at the level of C3. This was observed in both study groups (males, females). Similar findings have been reported by Song *et al.* in their study on spinal stenosis and neurological outcome in traumatic cervical spine injury [23]. However, when comparing these findings to other, more clinically related studies, one must be aware that in case of degenerative changes the smallest sagittal diameter is mostly determined by the presence of osteophytes and therefore not necessarily has to be at the level of the anatomically smallest diameter. [21] Furthermore, in our study at the level of C7 (9.23±0.40) the Sagittal spinal cord diameter (AP-SC) increases and the smallest sagittal diameter of the canal was detected at the level of C3 (9.05±0.47). This hypothesis has also been proposed by Duan *et al.* on their work on vertebral artery course and function at the craniocervical junction [24]. This observation could serve as an important tool for all treating physicians and

especially for those performing a surgical approach on the cervical spine since it could provide important data not only for the surgical approach (selection of the side, right or left), but also for the surgical technique (size and orientation of screws) to be applied. [25] Additionally, in our study at the level of C7 (11.00±0.78) the Sagittal vertebral canal diameter (AP-VC) decreases after C6 (11.16±0.78) and the smallest Sagittal vertebral canal diameter of the canal was detected at the level of C3 (10.97±0.78). Features associated with spinal degeneration such as intervertebral disc degeneration, facet joint OA, spondylolysis, spondylolisthesis, spinal stenosis, and degenerative changes in paraspinal muscles are often identified on advanced imaging studies but are also commonly seen in asymptomatic individuals [26]. In the present community-based study, we have found no association between most CT-evaluated spinal degeneration features, except spinal stenosis, and the occurrence of neck pain.

Limitations

First, because this is a case control study, conclusions regarding increasing prevalence of spinal degeneration features with increasing age are inferred by examining individuals in different age groups rather than following a sample population longitudinally. Second, although the cross-sectional design of this study allows evaluating associations between degeneration features, it cannot be used for evaluation of causal relationships. Third, for age-specific prevalence of spinal degeneration features, we did not do multiple comparison tests. Each feature is a distinct structure, and as such it can be argued that we are testing unique associations. Even so, we recognize that multiple testing is a potential source of positive associations that occur by chance. Fourth, Radiography of the spine is insensitive for detection of spinal stenosis based on changes in soft tissues of the spine.

Conclusion

CT scan can provide accurate cervical canal measurements that could serve as a useful guide in the determination of the cervical canal stenosis, replacing the old lateral plain x-ray technique. Further studies are required to apply the Torg-Pavlov ratio on the more accurate cervical CT scans. Moreover, our measurements on the transverse foramen diameters may provide important information to the spinal surgeons on the dimensions of the foramen and on its geometrical changes according to the cervical level, thus facilitating the preoperative planning and avoiding possible trauma to the vertebral arteries during tissue dissection and instrument application.

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