Morphometric Measurements of Cervical Spine using Computed Tomography

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Abstract

The cervical spine antomy exhibits wide variations. For cervical spine pathologies which require surgical treatment, the prior knowledge of these anatomic variations would reduce the surgical complications. The aim of the study is to perform CT based measurements of cervical transverse foramen and spinal canal in indian population which would be useful in providing road map and guidance for surgical interventions of cervical spine. This is a retrospective study. A total of 73 patients (49 males, 24 females, age range: 18-75 years) indicated for CT cervical spine from June 2018 to June 2019 were included. The sagittal spinal canal Diameter (dSSC), sagittal (TFs) and transversr diameters (TFt) of transverse foramen, distance between transverse foramen and spinal canal (dTF-SC) were measured at C1-C7 levels. We found that significant difference in sagittal spinal canal diameters at all the levels of cervical spine (C1-C7) between males and females ($p<0.01$). Our study also found significant difference in sagittal (TFs) and transverse (TFs) diameters of transverse foramen at all cervical levels in males and females between right and left side ($p<0.01$). Significant difference were noted for distance between transverse foramen and spinal canal (dTF-SC) at all the levels of cervical spine in males and females between right and left side ($p<0.01$). From our study we conclude that a thorough comprehension of cervical anatomy with CT- based measurements help in preoperative planning and reduce the complications in surgical interventions. Our study noticed significant reduction in distance between transverse foramen and spinal canal (dTF-SC) in both males and females on left side. Hence, care must be taken while performing surgical procedures of cervical spine on the left side in males and females at all cervical levels.

Keywords: *Cervical Spondylosis***,** *Spinal canal, transverse foramen, cervical myelopathy*

Introduction

The cervical vertebral structure is complex and has wide variations in anatomy. Cervical spondylosis is age related chronic degenerative disease of the spine with a prevalence of 13.76% [1]. Spinal canal stenosis is commonest factor leading to Cervical myelopathy and cord injury[2-5]. Cervical spine instrumentation procedures such as posterior and anterior stabilization for spondylosis and fractures requires prior knowledge of variations for reducing the surgical complications. Due to presence of verterbral artery the precise placement of screws is major requirement in most of the cervical spine interventions [6-9]. The literature also suggest wide variation in pedicle and lamina measurements, hence prior knowledge is required for selection of screws for fixation[10-12]. CT Plays important role in diagnosis of pathologies of cervical spine. In addition, it also provides accurate information regarding the measurements such as spinal canal diameter and vertebral body measurements[13-14]. There are many cadveric studies described cervical

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spine measurements[15-19]. The literature also reported ethinic differences in cervical spinal canal, vertebral measurements[20-21]. There are only few studies done on CT cervical spine measurements which are relevant for surgical procedures[22-24]. Hence, the purpose of the study is to perform CT based measurements of cervical transverse foramen and spinal canal in indian population which would be useful in providing road map and guidance for surgical interventions of cervical spine.

Materials and Method

The approval for study was obtained from Institutional Research Committee, School of Allied Health Sciences and Institutional Ethics Committee, Kasturba Hospital, Manipal. This is a retrospective study which included 73 patients indicated for CT cervical spine. Out of 73 patients, 49 were males and 24 were females. The age range of the study was 18-75 years (mean age 33.5±5.3 years) The CT cervical scans with fracture, neoplasm. Infection, congenital anomalies were excluded.

The CT cervical spine imaging was performed using 128 slice CT scanner (Philips Incisive 128 slice CT, Netherlands). Axial sections were obtained with 1 mm slice thickness.

CT Measurements

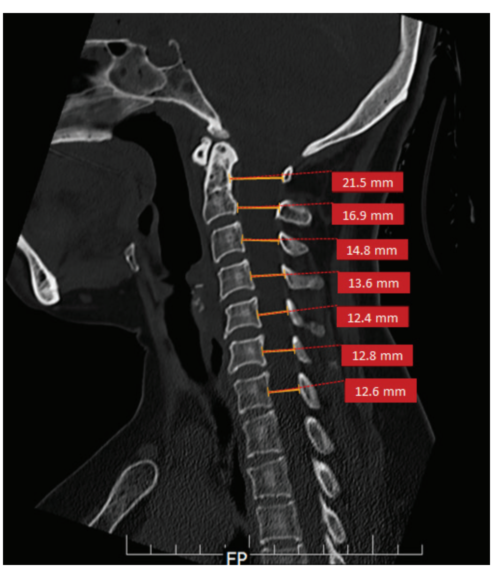

Figure 1: Mid-Sagittal image of CT Cervical spine showing Sagittal Spinal Canal Diameter (dSSC)

Spinal canal diameter (dSSC) was measured on mid sagittal section as antero posterior diameter from the back of each vertebral body to the nearest spinolaminar line (Figure 1).

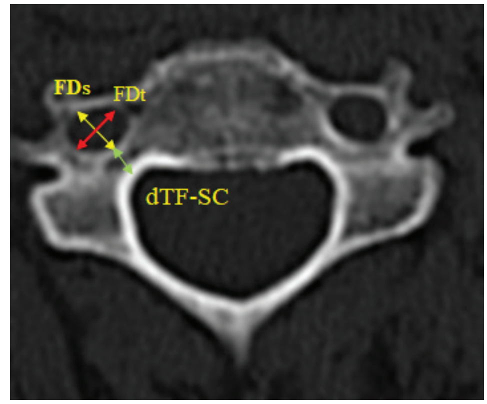

Figure 2: Axial image of CT Cervical spine showing Sagittal diameter of Transverse foramen (TFs) , transverse diameter of Transverse foramen (TFt) and Distance between transverse foramen and spinal canal (dTF-SC)

Sagittal (TFs) and transversr diameters of transverse foramen (TFt) were measured on axial section as antero posterior and cranio caudal diameters of transverse foramen respectively. Distance between transverse foramen and spinal canal (dTF-SC) was measured on axial image as antero posterior distance between them (Figure 2).

All the measurements were done using measuring tools in DICOM Imaging software of Mediff technology and were noted in millimeter (mm). The data were measured by two readers A and B to check for variability.

Statistical Analysis

The data analysis was done using statistical package for social sciences (SPSS) version 20.0. The Students paired t-test was performed for the three measurements to find significant difference between right and left side.

Findings

Seventy-three patients (49 were males and 24 were females) 511 vertebrae from C1-C7 were evaluated in this study. The measurements were done on right and left sides of vertebrae.

Sagittal Spinal Canal Diameter (dSSC)

The Canal diameter was noted wider at C1 level for both males and females. The CDs measured were narrower at C6 level in the males and at the level C4 in females . Significant differences in canal diameters were noted at all the levels of cervical spine (C1-C7) between males and females (Table 1).

Table 1: Showing the mean and standard deviation of Sagittal spinal canal diameter (dSSC) in males and females

Sagittal spinal canal diameter (dSSC) (in mm)			
Level	**Males**	**Females**	**p-value**
C1	22.5±1.38	20.7±1.33	<0.01
C2	16.8±1.17	15.3±1.19	<0.01
C3	14.2±1.19	12.9±1.16	<0.01
C4	13.9±1.18	12.2±1.17	<0.01
C5	13.6±1.19	12.4±1.13	<0.01
C6	13.5±1.20	12.9±1.17	<0.01
C7	13.7±1.21	13.0±1.17	<0.01

Sagittal (TFs) and transverse diameter (TFt) of transverse foramen

The sagittal diameter of transverse foramen (TFs) was noted narrower at C6, C7 level for males and females, on both sides. The diameter was widest at the C1 level for males and females on both sides. Significant differences were noted for sagittal diameter of transverse foramen (TFs) at all cervical levels in males and females between right and left side ($p<0.01$) (Table 2).

Table 2: Showing the mean and standard deviation of sagittal diameter (TFs) of transverse foramen in males and females for right and left side

Sagittal diameter of Transverse foramen in Males and Females (mm)					
	Males		**Females**		
Level	**Right**	**Left**	**Right**	**Left**	**p-value**
C1	6.6±1.11	6.8±1.20	6.1±0.90	6.5±0.90	<0.01
C2	6.2±1.11	6.3±1.11	5.8±1.00	6.0±0.90	<0.01
C3	5.8±0.70	5.9±0.70	5.4±0.70	5.6±0.70	<0.01
C4	5.5±0.60	5.7±0.60	5.2±0.70	5.5±0.70	<0.01
C5	5.7±0.60	6.0±0.60	5.6±0.70	5.9±0.60	<0.01
C6	5.3±1.00	5.5±1.00	5.1±1.00	5.3±1.00	<0.01
C7	5.0±0.90	5.3±0.80	4.9±1.00	5.2±0.90	<0.01

The transverse diameter of transverse foramen (TFt) was noted narrower at C6, C7 level for males and females, on both sides. The diameter was widest at the C1 level for males and females on both sides. Significant differences were noted for transverse diameter of transverse foramen (TFt) at all cervical levels in males and females between right and left side ($p<0.01$) (Table 3).

Table 3: Showing the mean and standard deviation of transverse diameter (TFt) of transverse foramen in males and females for right and left side

Transverse diameter of Transverse foramen in Males and Females (mm)					
	Males		**Females**		
Level	**Right**	**Left**	**Right**	**Left**	**p-value**
C1	6.6±1.00	6.8±1.10	6.3±0.90	6.6±0.80	<0.01
C2	5.9±0.80	6.2±0.80	6.0±0.70	6.3±0.80	<0.01
C3	5.5±0.60	5.9±0.70	5.5±0.60	5.8±0.60	<0.01
C4	5.4±0.70	5.6±0.70	5.1±0.70	5.2±0.80	<0.01
C5	5.7±0.60	5.9±0.60	5.5±0.70	5.8±0.60	<0.01
C6	5.6±0.80	5.8±1.00	5.4±0.90	5.6±0.70	<0.01
C7	5.0±0.90	5.3±0.80	6.3±0.90	6.6±0.80	<0.01

Distance between transverse foramen and spinal canal (dTF-SC)

The distance between transverse foramen and spinal canal (dTF-SC) was noted narrower at C3, C4,C5 level for males and at C4 level for females, on both sides. The distance was widest at the C1 level for males and females on both sides. Significant differences were noted for distance between transverse foramen and spinal canal (dTF-SC) at all the levels of cervical spine in males and females between right and left side ($p<0.01$) (Table 4).

Table 4: Showing the mean and standard deviation of distance between transverse foramen and spinal canal (dTF-SC) in males and females for right and left side

Distance between transverse foramen and spinal canal in males and females (mm)					
	Males		**Females**		
Level	**Right**	**Left**	**Right**	**Left**	**p-value**
C1	9.2±1.80	8.9±1.80	8.2±1.50	8.0±1.60	<0.01
C2	4.6±1.10	4.3±1.12	4.8±1.11	4.6±0.90	<0.01
C3	4.6±0.80	4.4±0.80	4.3±1.00	4.1±1.00	<0.01
C4	4.5±0.70	4.4±1.70	4.2±0.80	4.0±0.80	<0.01
C5	4.5±0.80	4.3±0.90	4.7±0.80	4.6±0.90	<0.01
C6	5.0±0.50	4.9±0.60	4.9±0.70	4.7±0.80	<0.01
C7	5.2±0.60	5.0±0.90	5.2±0.60	5.0±0.60	<0.01

Discussion

The literature states wide variations in anatomy of cervical vertebrae[10-12]. There also ethnic differences in spinal canal and vertebral measurements [20-21]. Due to necessity of surgery in cervical spine pathologies such as trauma, degenerative and inflammatory conditions, the prior preoperative knowledge of anatomical variations is utmost important for the surgeon. The diameter of the cervical spinal canal is vital and any reduction in the measurement might lead to myelomalacia secondary to spondylosis[2-5]. There are limited studies performed using CT, which is gold standard and provide road map for preoperative planning[15-19].

In our study, the spinal canal diameter (dSSC) was noted wider at C1 level for both males and females. The spinal canal diameter declined gradually from C1-C6 and increased at C7 level. The findings of our study are partially contrary to the studies conducted by Binit Sureka et al., Evangelopoulos et al. [25-26] . Study done by Ambuj Kumar et al[27] have also observed decline in cervical spinal canal diameter from C1-C4, inaddition our study has shown decline in dSSC till C6 Level and increased at C7 level.

The literature suggests that the diameters of the vetebral arteries are of unequal size and the left side vertebral artery is often larger compared with right sided vertebral artery[28]. Significant differences were noted for sagittal diameter of transverse foramen (TFs) at all cervical levels in males and females between right and left side ($p<0.01$). Significant differences were noted for transverse diameter of transverse foramen (TFt) at all cervical levels in males between right and left side ($p<0.01$). Significant difference were noted for (TFs) at C3 level in females between right and left side ($p<0.01$). We also significantly noticed the diameters of transverse foramen larger on left side in males and females which supports the literature that left sided vertebral is larger than right. These measurements would provide the surgeon to choose appropriate side for placement of screws and also the knowledge about the various screw sizes to be used for fixation procedures.The findings of our study are slightly different to the results of recent studies done by Binit Sureka et al., Evangelopoulos et al.[25-26]. They have stated increase in diameter of transverse foramen on left side only in females compared to males. However, our study noticed increased diameter of transverse foramen in both males and females on left side.

In our study,Significant differences were noted for distance between transverse foramen and spinal canal (dTF-SC) at all the levels of cervical spine in males and females between right and left side ($p<0.01$). The findings of our study are slightly different to the results of studies done by Binit Sureka et al., Evangelopoulos et al.[25-26] . They have stated decrease in distance between transverse foramen and spinal canal (dTF-SC) on left side only in females compared to males. However, our study noticed decreased distance between transverse foramen and spinal canal in both males and females on left side.

Our study would add new contribution to the literature that the diameter of transverse foramen is larger on left side in both males and females at all the cervical levels. Hence care must be taken will doing fixation of screws in males and females especially in left side

There are few pitfalls in our study. Firstly the sample size opted for the study is substantial. Secondly, we have not included the pediatric age group who are more prone for anatomical variations. Thirdly, we did not compare the transverse foramen and distance between the foramen and spinal canal between the genders.

Conclusion

Multidetector CT examination would provide precise measurements of anatomical structure of cervical spine and helps in identifying the variations. The CT preoperative measurements would be helpful in providing road map and mitigate the possible damage to vertebral artery and neural structures while performing surgery. The measurements from our study recommends adequate care to be given while performing surgeries on left side of cervical vertebrae for males and females

Conflicts of Interests: No potential conflicts of interest

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Ethical Clearence: The approval for study was obtained from Institutional Ethics Committee, Kasturba

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