STUDY OF THE SPINAL CANAL OF UPPER CERVICAL SPINE

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ABSTRACT

Background: The anteroposterior and transverse diameter of cervical spinal canal is reported to have some variability among different populations. **Objective:** To determine the midsagittal (antero posterior) diameter at the inlet & outlet and coronal (transverse) diameter of cervical spinal canal in first cervical (atlas) and second cervical (axis) vertebrae. Additionally review of literature was conducted to compare the findings with previous reported findings. **Material and methods:** This descriptive study was conducted in Anatomy department of Sheikh Zayed Medical College, Rahim Yar Khan & Wah Medical College, Wah Cantt. Rawalpindi, Pakistan. Measurement of midsagittal & coronal diameter of spinal canal of first & second cervical vertebrae was carried on dried human spinal columns of Pakistani origin. **Results:** In atlas vertebra mean midsagittal inlet & outlet diameter was 32.96 & 30.46 mm respectively whereas coronal diameter was 27.89 mm. In axis vertebra mean midsagittal inlet & outlet diameter was 20.74 & 15.80 mm respectively with a coronal diameter of 22.73 mm. **Conclusion:** Measurement of sagittal and coronal diameter of upper cervical spinal canal is of great clinical significance. Larger sagittal diameter of spinal canal has a protective effect with respect to injury of the spinal cord, so further studies are suggested to standardized the values of spinal canal.

Key words: Atlas vertebra, axis vertebra , cervical spinal canal, midsagittal diameter, coronal diameter.

INTRODUCTION

The upper cervical spine is defined by cervical vertebrae, C1 (the atlas) and C2 (the axis). This region is distinct in anatomic shape and is more mobile than the lower cervical spine, the subaxial cervical spine (C3 through C7). The atlas, or first cervical vertebra, is so named because it supports the globe of the skull. Its appearance is quite different from the other cervical vertebrae. Most notably it has no body or spinous process, but instead consists of a ring of bone made up of two lateral masses joined at the front and back by the anterior arch and the posterior arch. The occipital condyles of the skull rest upon the lateral masses of C1. These articular facets allow most of the flexion and extension of the head on the neck as the occipital condyles articulate on the atlas.[1-3] The axis is the second cervical vertebra. Its most distinctive feature is a blunt tooth-like process, called the dens (Latin for "tooth") or odontoid process, which projects upward. The dens provides a kind of pivot and collar allowing the head and atlas to rotate around the dens. Most of the lateral rotation of the neck actually occurs at the C1-2 junction; the remaining motion of the cervical spine is distributed among the subaxial spine vertebral motion segments as a fractional amount (~7%) per level and is less in total than the C1-2 lateral rotation.[4] The morphology of vertebral column is influenced externally by mechanical and environmental factors and internally by genetic, hormonal and metabolic factors.[5] Different measurements of the normal range of the anteroposterior diameter of the spinal canal have been reported by authors.[6-10] Certain amount of discrepancy exists in these measurements that were obtained from lateral radiographs of the cervical spine. These discrepancies are described by Boijsen[9] and are due to measurement differences caused by different target distances, object-to-film distance, and magnification errors common with radiographs. It has been suggested by the Lee et al[11] that measurements made on the radiographic films could not reveal the exact and true dimensions of the spinal canal diameters and, therefore, anatomical specimens were studied for accurate measurements. There are few reports on the analysis of spinal canal of upper cervical spines using the anatomical specimens; this study aims to evaluate:

The midsagittal inlet & outlet diameter of the spinal canal in atlas and axis vertebrae and coronal or transverse diameter of the spinal canal in both atlas and axis vertebrae.

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MATERIAL & METHODS

The upper cervical vertebrae, C1 (atlas) and C2 (axis), of fifty sets of dried human spinal columns stored in the Anatomy department of Sheikh Zayed Medical College, Rahim Yar Khan and Anatomy department of Wah Medical College, Wah Cantt, Rawalpindi were used for this study. All subjects were adults, age range was between 25 and 60 years. Before taking the measurements, all the samples were inspected to ensure that the vertebrae were intact and free from osteophytes or any other vertebral abnormality.

In this descriptive study, the following parameters were determined in the vertebrae:

1. The midsagittal (anteroposterior) inlet, outlet, and coronal (transverse) diameters of the spinal canal in C1. (Fig. I)
2. Coronal (transverse) diameter in C2. (Fig. II)
3. In C2 vertebra, spinal canal inlet & spinal canal outlet midsagittal diameters. (Fig. III)

To carry out these linear measurements sliding vernier caliper (Peacock Co., Tokyo, Japan) was used. The accuracy was 0.01 mm.

Fig. I:(A**).** Midsagittal (anteroposterior) diameter of spinal canal inlet of Atlas (C1) Vertebra.
(B).Midsagittal (anteroposterior) diameter of spinal canal outlet of Atlas (C1) Vertebra.
(C).Coronal (transverse) diameter of spinal canal of Atlas (C1) Vertebra.
Fig. II: (A). Midsagittal diameter of inlet of C2 and (B) outlet
Fig. III: Coronal diameter of C2

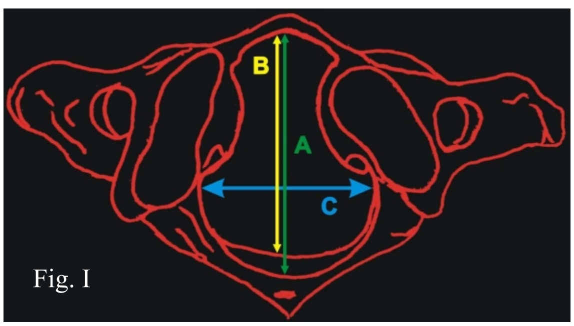

Fig. I

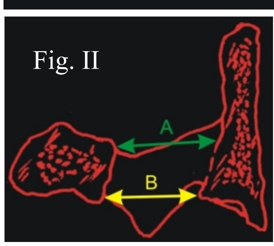

Fig. II

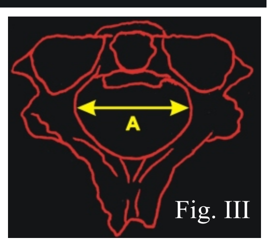

Fig. III

RESULTS

Measurements in midsagittal and coronal diameter of spinal canal in C1:

Midsagittal (anteroposterior) inlet diameter of spinal canal, was 27.90 mm to 38.25 mm. The mean value was 32.96 mm with a standard deviation of 2.19. Midsagittal (anteroposterior) outlet diameter was 25.70 mm to 35.35 mm. The mean value was 30.46 mm with a standard deviation of 2.17. Coronal (transverse) was 22.45 mm to 32.80 mm. The mean value was 27.89 mm with a standard deviation of 2.23 (Table-I).

Measurements in midsagittal and coronal diameter of spinal canal in C2:

Midsagittal spinal canal inlet diameter was 17.55 mm to 26.90 mm. The mean value was 20.74 mm with a standard deviation 2.06. Midsagittal spinal canal outlet diameter was 12.45 mm to 21.40 mm. The mean value was 15.80 mm with a standard deviation of 1.81.

Coronal (transverse) spinal canal diameter was 18.70 mm to 25.40 mm. The mean value was 22.73 mm with a standard deviation of 1.60 (Table-I).

Table I: Anatomic Parameters of C1 & C2 Spinal Canal.

Values	C1			C2		
	Midsagittal Inlet Diameter (mm)	Midsagittal Outlet Diameter (mm)	Coronal Diameter (mm)	Midsagittal Inlet Diameter (mm)	Midsagittal Outlet Diameter (mm)	Coronal Diameter (mm)
Mean	32.96	30.46	27.89	20.74	15.80	22.73
Minimum	27.90	25.70	22.45	17.55	12.45	18.70
Maximum	38.25	35.35	32.80	26.90	21.40	25.40
Standard deviation	2.19	2.17	2.23	2.06	1.81	1.60

DISCUSSION

The spinal canal extends from the foramen magnum to the sacral hiatus. In the cervical and lumbar regions, which exhibit free mobility, it is large. Stenosis (narrowing) of the spinal canal may occur at single or multiple spinal levels and mainly affects the cervical and lumbar regions. Severe spinal stenosis may compress the spinal cord and compromise its arterial supply. Localized stenosis may present with the clinical features of spinal nerve compression or stretching of nerve roots over a prolapsed disc which cause ischemia and may provoke more damage to these structures.[5]

Table II: Normal Range of Variations in Midsagittal (Anteroposterior) Diameter of Spinal Canal of C1 (Atlas) & C2 (Axis) Vertebrae of Various Studies measured by Plain Radiographs

Studies	Focus-film distance	Number of Cases	C1		C2	
			Mean (mm)	Range (mm)	Mean (mm)	Range (mm)
Boijsen (1954)	1.5 m (59 in.)	200	-----	19 - 32	-----	16 - 27
Wolf, Khilnani & Malis (1956)	72 in.	200	-----	16 - 30	-----	15 - 27
Payne and Spillane (1957)	72 in.	90	-----	16 - 26	-----	15 - 23
Burrows (1963)	72 in.	300	22.9	16 - 27	20.3	15 - 25
Oon (1974)	72 in.	400	20.3	15 - 27	18.5	15 - 23.5

Table III:
Midsagittal (Anteroposterior) & Coronal (Transverse) Diameters of Spinal Canal for Atlas & Axis Vertebrae by Various Studies measured on Dried Bones

Studies	No. of sets of dried bones	C1						C2					
		Maximum Midsagittal (Inlet) Diameter		Minimum Midsagittal (Outlet) Diameter		Coronal Diameter (Canal Width)		Spinal Canal Inlet		Spinal Canal Outlet		Coronal Diameter (Canal Width)	
		Mean (mm)	Rang (mm)	Mean (mm)	Range (mm)	Mean (mm)	Range (mm)	Mean (mm)	Range (mm)	Mean (mm)	Range (mm)	Mean (mm)	Range (mm)
Mazzara & Fielding (1988)	103	-----	-----	30.1	25.5 -36.0	28.8	22.0 – 38.0	19.0	12.9 – 32.2	-----	-----	22.8	19.0 – 26.5
Panjabi et al (1991)	12	-----	-----	-----	-----	-----	-----	21.0				24.5	
Xu et al (1995)	30	-----	-----	-----	-----	-----	-----	18.0	15 – 22	15.3	13 – 19	21.9	18 – 26
Sengul & Kadioglu (2006)	40	46.2	38.2 – 77.5	31.4	23.7 – 46.3	28.7	25.2 – 33.5	20.8	11.5 – 28.9	17.7	-----	24.5	20.7 – 28.3
Maqbool et al (Present Study)	50	32.96	27.90-38.25	30.46	25.70 – 35.35	27.89	22.45 – 32.80	20.74	17.55 – 26.90	15.80	12.45 – 21.40	22.73	18.70 – 25.40

Many researchers working in different areas of the world have been determining the mean diameter of the cervical spinal canal at different vertebral levels in normal subjects, so that the clinicians may be able to diagnose cervical spinal stenosis by consulting these reference values. Most of these workers have employed different methods of investigation like plain radiography,[12-15] computerized tomography (CT) scanning,[16] and magnetic resonance imaging (MRI)[17] on living subjects or cadavers, while others have carried out actual measurements on dried bony specimens.[11,18,19,20,21]

Mazzara and Fielding[18] carried out their study in 103 normal adult atlas and axis vertebrae and found that mean sagittal diameter of atlas was 30.1 mm and the mean coronal diameter was 28.8 mm, whereas the mean sagittal diameter of the axis was 19.0 mm and the mean coronal diameter was 22.8 mm. Our study reveals that the mean midsagittal (anteroposterior) inlet & outlet diameter of atlas vertebra in Pakistanis is 32.96 mm & 30.46 mm respectively and mean coronal (transverse) diameter is 27.89 mm; whereas in axis vertebra mean midsagittal inlet & outlet diameter is 20.74 mm & 15.80 mm respectively and coronal diameter is 22.73 mm. Comparison of our figures with those of Mazzara and Fielding shows that the midsagittal diameter of atlas & axis is slightly larger in our population than those of Americans. In our study midsagittal diameter of atlas & axis are taken at two places whereas Mazzara & Fielding had not taken such diameter at two places.

Xu et al[20] measured the spinal canal of thirty dried second cervical vertebrae of adult males and found that the mean canal inlet (midsagittal) diameter was 18.0 mm and mean canal outlet (midsagittal) diameter was 15.3 mm whereas mean spinal canal width (coronal diameter) was 21.9 mm in Americans. When compared with Xu et al, the diameter of spinal canal in upper cervical vertebrae in our population is slightly larger.

The measurements of midsagittal diameter of spinal canal of atlas & axis vertebrae of various studies measured by plain radiographs are shown in Table-II. By evaluating these readings with our findings, it is obvious that the size of the cervical spinal canal is larger in our population.

Oon CL[22] measured the sagittal diameter of atlas & axis vertebrae by radiographs of the ethnic group which included mostly Chinese, Malays and Indians. His study showed narrower spinal canal diameter when compared with our population and with western subjects (Table III). He stated that a narrow cervical canal constitutes a definite handicap and his subjects are probably more prone to myelopathic changes.

In another study, Sengul and Kadioglue[21] examined forty human dried atlas and axis vertebrae for sagittal and coronal diameters of the spinal canal in Turkish population. The results mentioned in their study show slightly larger diameters when compared with our study (Table III) which might be due to ethnic variation. Their mean value of maximum midsagittal diameter of spinal canal at C1 is much higher than ours which necessitates further investigation.

Matsuura et al[16] used computerized tomography to measure sagittal and transverse diameters in forty-two patients who had an injury of the spinal cord and they found that these patients had narrower sagittal diameters of the canal than those in a control group of 100 normal patients who had no history of cervical trauma. Eismont et al[23] showed that patients who had a permanent injury of the spinal cord had a narrower diameter of the spinal canal than those who did not have an injury of the spinal cord. Kang et al[24] demonstrated a significant association between the actual space available for the spinal cord at the level of the injury and the severity of the injury. Patients who have a larger sagittal diameter of the canal may be more frequently spared from permanent injury of the spinal cord after a fracture or dislocation of the cervical spine than those who have a narrower canal. The sagittal diameter of the spinal canal has a direct relation with the degree of injury of the spinal cord in cervical fractures and dislocations. It would appear that a large spinal canal has a protective effect with respect to injury of the spinal cord, but injury of the cord may occur if the osseous displacement during or after the injury is severe enough.

Tierney et al[25] believe in measuring the space available for the cord (SAC) in the spinal canal for identifying stenosis; because stenosis is the spinal canal's encroachment on the spinal cord and spinal cord size varies among individuals. The standardized values of SAC in different populations are lacking and direct the researchers to work in this field.

CONCLUSION

Measurement of sagittal and coronal diameter of upper cervical spinal canal is of great clinical significance. Our findings showed that in our study subjects sagittal and coronal diameter of upper cervical spinal canal are slightly larger. Larger sagittal diameter of spinal canal has a protective effect with respect to injury of the spinal cord, so further studies are suggested to standardized the values of spinal canal.

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