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Research Article

MRI STUDY ON SPINAL CANAL CONTENT IN WESTERN MAHARASHTRIAN POPULATION

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ABSTRACT

The morphology of the spinal canal content has been studied since the invention of myelography. However, most studies have measured the diameters of the spinal cord only, not the size of the subarachnoid space. The present study complements the current data on the morphology of the spinal contents, and in particular, the spinal subarachnoid space, by analyzing MRI images. **Objective**: To study morphology of the dural sac, spinal cord & subarachnoid space using MRI. To define the inner geometrical dimensions of spinal canal content that confine the maneuver of an endoscope inserted in cervical spine. 3. To have comprehensive knowledge of the anatomy of cervical spinal canal. **Method**: Based on MRI images of the spine from 60 normal patients of age between 25-60 years, the dimensions of spinal cord, dural sac & subarachnoid space were measured at mid-vertebral & intervertebral level from C1-C7 vertebrae. The parameters measured were transverse, sagittal diameter of spinal cord & dural sac. The subarachnoid space was measured as anterior, posterior, right, left distance between spinal cord and dura mater. **Results**: It was found that at each selected transverse level, the subarachnoid space tends to be symmetrical on the right and left sides of the cord, and measures 3.38 mm on an average. However, the anterior and posterior segment, measured on the mid-sagittal plane are generally asymmetric & varies greatly in size ranging 1mm to 6mm with mean 2.57 of anterior & 2.59 of posterior. These measurements match those found in previous studies. The coefficient of variance for the dimensions of the subarachnoid space is as high as 36.16%, while that for the dimensions of the spinal cord (transverse & sagittal) are11.08%&13.28%respectively. **Conclusion**: The findings presented here, expand our knowledge of morphology of spinal canal and show that a thecaloscope must be smaller than 3.38 mm in diameter.

Keywords: Subarachnoid space, Dural sac, Spinal canal, MRI

INTRODUCTION

The morphology of the spinal canal content has been studied since the invention of myelography. However, most studies have measured the diameters of the spinal cord only, not the size of the subarachnoid space. [1-3] The aim of this investigation is to detail the dimensions of the subarachnoid space as a prerequisite for development of an intradural endoscope for the cervical subarachnoid space. Also a detailed anatomy of the spinal canal content is of much importance as it may form a developmental basis for spinal canal stenosis. Researchers found a significant correlation between the morphometry of cervical spinal canal content and the pathological changes seen in cervical spine. [2-5]

So the study is designed to have a composite knowledge of cervical spinal canal content. The present study complements the current data on the morphology of the spinal contents, and in particular,

the spinal subarachnoid space, by analyzing MRI images taken from normal examinations.

Present study is guided by the need to develop subarachnoid endoscope for its visualization & treatment. When the review of the literatures has been taken, we found out that no study has been conducted on Indian population and also available data was discreet. So the present study was carried out.

Objective: To study morphology of the dural sac, spinal cord & subarachnoid space using MRI. To define the inner geometrical dimensions of spinal canal content that confine the maneuver of an endoscope inserted in cervical spine. 3. To have comprehensive knowledge of the anatomy of cervical spinal canal.

MATERIALS & METHOD

A study was conducted in Dept of Radiology, BJGMC. Pune. The data was obtained retrospectively from normal MRI of 60 patients. A study was carried on normal MRI images of 60 adult patients, 30 males and 30 females belonging to a Western Maharashtrian population. The images have been studied retrospectively. The patients were ranged in age from 25 to 60 years. The geometrical dimensions of the dural sac and the subarachnoid space, from the first cervical vertebra (C1) to the 7th cervical vertebra (C7), have been measured. Normal vertebral and intervertebral discs were included, degenerative cases have been omitted.

The following parameters are studied:

Dimensions of dural sac: Transverse diameter (mm) of dural sac (DS tra), Sagittal diameter (mm) of dural sac (DS sag).

Dimensions of spinal cord: Transverse diameter (mm) of spinal cord (SC tra), Sagittal diameter (mm) of spinal cord (SC sag).

Dimensions of subarachnoid space (SAS): Measured from pia mater to arachnoid mater on its anterior, posterior, right & left lateral region. Measurements are denoted as: SAS anterior, SAS posterior, SAS Rt lateral, SAS Lt lat

For each segment, the dimensions have been obtained at the mid-height of the vertebra and at the level of the adjacent disc (for example: at the mid-height of the 4th cervical vertebra C4 and the adjacent intervertebral disc – C4/C5).

MRI imaging, using a 1.5 T Elscint system was performed on the axial and sagittal planes for each patient. The dimensions of the spinal cord and the subarachnoid space were measured on the axial image. The measurements have been taken at the mid-sagittal and mid-coronal virtual lines on the transversal image and they were based on the T2 weighted images, which better delineate the borders of both the spinal cord and the dural sac.

Mean and range are calculated for each parameter. Any difference between male and female parameters is found by applying unpaired t-test.

RESULTS

Table 1: Transverse & sagittal diameter of dural sac, spinal cord and subarachnoid space (in mm) (N=60)

		Mean± SD	RANGE
Dural Sac	Sag	13.83± 1.65	10.46-18.59
	Trans	19.23±1.76	13.52-24.58
Spinal Cord	Sag	6.979±0.92	04.16-10.24
	Trans	11.89±1.31	06.06-15.36
Subarachnoid Space	Ant	2.578±0.82	01.07-05.67
	Post	2.598±0.93	01.12-06.10
	Rt lat	3.382±0.79	01.47-06.06
	Lt lat	3.381±0.79	01.47-06.16

Sag: Sagital, Trans: Transverse, Ant: Anterior, post: Posterior, Rt lat: Right lateral, Lt lat: Left lateral

Table 1 demonstrates the mean, standard deviation of Transverse &sagittal diameter of dural sac spinal cord and subarachnoid space.

When the dimensions of subarachnoid space at a given level are considered we found that there is wide variation between ant & post diameter ranging between 1 to 6 mm while the diameters of right & left side are almost equal.

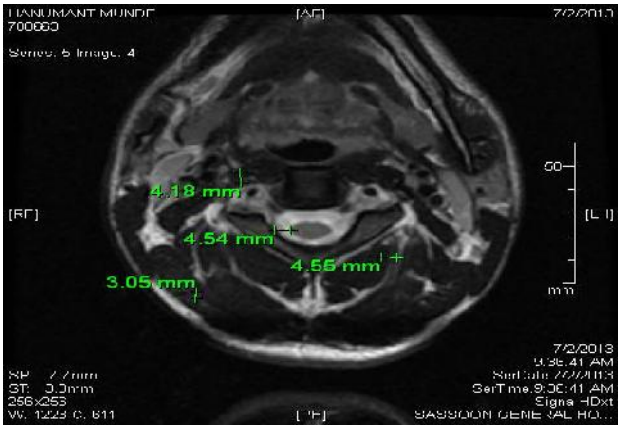

Fig 1: Showing the dimensions of subarachnoid space (SAS anterior -4.18mm, SAS posterior – 3.05mm, SAS Rt lat-4.55mm SAS Lt lat-4.54mm)

Table 2: Dimensions of spinal cord to show cervical enlargement (in mm)

Level	Spinal canal sagittal diameter	Spinal canal transverse diameter
c1	7.815	11.33
c2	7.685	11.41
c2-3	7.651	11.46
c3	7.338	11.66
C3-4	7.222	12.31
C4	7.064	12.73
C4-5	7.022	12.9
C5	6.908	13.04
C5-6	6.623	12.67
C6	6.434	11.93
C6-7	6.102	11.16
C7	5.799	10.29

The sagittal diameter of spinal cord decreases monotonically. The Transeverse diameter is largest at C5 level & the site of cervical enlargement is C4-5 to C5.

Table 3: Showing Mean values for subarachnoid spaces (in mm)

level	Anterior	Posterior	Rt lat	Lt lat
c1	2.711	3.744	4.439	4.448
c2	2.929	3.353	4.111	4.102
c2-3	2.639	2.584	3.767	3.762
c3	2.652	2.208	3.464	3.461
C3-4	2.278	2.406	3.116	3.114
C4	2.249	2.42	3.001	3.002
C4-5	2.197	2.376	2.984	2.981
C5	2.332	2.493	3.144	3.147
C5-6	2.318	2.338	2.833	2.833
C6	2.739	2.387	3.166	3.164
C6-7	2.652	2.273	3.005	3.006
C7	3.247	2.681	3.555	3.556

From the Table-3 it is clear that the right & left lateral subarachnoid spaces are almost equal, while the anterior & posterior spaces are asymmetrical.

Dimensions of dural sac: To determine the accuracy of the measurements of the spinal cord and subarachnoid space, the dimensions of the dural sac as a whole were measured. Table 4; illustrates the transverse and sagittal diameters of the dural sac. The bulge noted in the cervical spinal cord can be observed also in the dural sac. But the correlation between changes in the diameter of spinal cord with the changes in the diameter of dural sac, is statistically non-significant ($p>0.05$).

Table 4: Showing mean values for dural sac (values in mm)

level	Sagittal	Transverse
C1	14.39	20.8
C2	13.82	20.19
C2-3	12.58	19.7
C3	12	19.25
C3-4	11.51	18.97
C4	11.54	19.31
C4-5	11.29	19.01
C5	11.45	19.64
C5-6	11.15	18.97
C6	11.37	18.95
C6-7	11.14	17.95
C7	11.7	18.06

Table 5: Transverse &sagittal diameter of dural sac, spinal cord and subarachnoid space (in mm) (MALE)

		Male		Female	
		MEAN ± SD	RANGE	MEAN± SD	RANGE
Dural Sac(DS)	Sag	13.67±1.806	10.460-18.59	12.89±1.474	9.080-16.68
	Trans	19.45±1.662	15.50-24.58	19.01±1.833	13.52-23.13
Spinal Cord(SC)	Sag	7.087±1.054	4.160-10.24	6.871±0.7650	4.930-8.730
	Trans	12.07±1.328	6.060-15.07	11.71±1.284	7.140-15.36
Subarachnoid Space(SAS)	Ant	2.555±0.8207	1.070-5.670	2.552±0.9458	1.120-5.80
	Post	2.643±0.9318	1.190-6.100	2.602±0.8225	1.130-5.140
	Rt lat	3.395±0.8123	2.270-6.060	3.369±0.7801	1.470-5.820
	Lt lat	3.394±0.8114	2.270-6.160	3.368±0.7795	1.470-5.820

When we compared the values for male & female we found out that the values for female are slightly smaller as compared to males but the difference is statistically insignificant.

DISCUSSION

Endoscopic visualization of various anatomical areas for diagnostic as well as therapeutic purposes is an everyday expanding field in modern medicine. But endoscopic visualization of the spinal canal contents is still limited, partly because of the technical problems associated with developing a miniature device that fits into and which can be safely steered inside the delicate and hazardous area of the spinal canal and the subarachnoid space in cervical region.

Meeting these challenges requires a thorough understanding of the spinal canal morphology for which accurate measurement of its different compartments is very important.

There have been several studies on the dimensions of the dural sac, the subarachnoid space, and the spinal cord. These studies have either been carried out on cadavers, or have used radiological methods such as myelography, CT-myelography, and MRI[1-7]

The present study complements the current data on the morphology of the spinal contents, and in particular, the spinal subarachnoid space, by analyzing MRI images taken from normal examinations. These data are essential for designing intradural instruments such as intradural endoscope (thecaloscope) and intradural robotic instruments, as well as for understanding the normal spinal anatomy.

Thijssen et al[1] studied morphology of the cervical spinal cord on computed Myelography, sample size was 20. They evaluated the subjects for transverse & sagittal diameter of spinal cord. Thijseen et al study is correlating well with present study. The decreasing diameter pattern is identical. The slightly higher side in Thijssen study may be due to different methodology and also because of racial differences.

Table 6: Showing comparison between H.O.M.Thijssen et al[1] & present study

Level	H.O.M.Thijssen		Present study	
	Transverse	Sagittal	Transverse	Sagittal
C1	10.4	7.2	11.33	7.815
C2	10.9	6.5	11.41	7.685
C3	11.3	6.2	11.66	7.338
C4	11.7	6.0	12.73	7.064
C5	11.8	6.2	13.04	6.908
C6	10.5	6.4	11.93	6.434
C7	9.3	6.8	10.29	5.799

Comparison between the studies demonstrated that the transverse diameter increases towards the middle cervical spine and is likewise maximum at C4 and C5 level.

Table 7: Showing comparison between sagittal & transverse diameters of spinal cord from the study done by Y.U.Yu et al[2] and present study

level	Sagittal diameter		Transverse diameter		Ratio (sag/tr)	
	Yu et al[2]	Present study	Yu et al[2]	present study	Yu et al[2]	Present study
C2-3	7.8	7.651	12.8	11.77	0.62	0.68
C3-4	7.5	7.222	13.4	12.48	0.56	0.59
C4-5	7.1	7.022	13.8	12.93	0.52	0.54
C5-6	6.9	6.623	13.4	12.9	0.52	0.52
C6-7	6.8	6.102	12.6	11.24	0.54	0.53
C7-T1	7.0	-	10.9		0.66	-

Y.U.Yu et al[2] studied 36 normal individuals on CAM for four parameters that is sagittal diameter. Transverse diameter, area & circularity of spinal cord.

The pattern of values is identical, the ratio is quite comparable. Maximum transverse diameter in both the studies is at C4-5 level.

One can also evaluate the dimensions of the spinal cord by finding the ratio between the transverse diameter of the spinal cord and that of the dural sac[8].in our study we found that the ratio(Trans SC/DS) is 0.65.

Table 8: Showing the comparison between Zaroor et al[6] and present study

	Range	Mean
Zaroor etal[6]	0.44-0.72	0.66
Present study	0.44-0.62	0.65

From the table it is quite evident that the present study is correlated with Zarror et al study.

Lee et al[9] reported that the average sagittal cervical canal diameter (C3-C7) in 469 cadaver specimen was 14.15+1.6mm, but in the current study, we found that average sagittal canal diameter (DS) from C1-C7to be 13.83+1.6mm, lesser value in our study is because we have not taken extradural space measurements. So we strongly believe that our study correlates with Lee et al study.

Zaroor et al[6] stated that the mean of transverse subarachnoid space is 2.5mm while in our study it is 3.38mm. The observed difference may be attributed to racial, geographical difference; also inter-observer error may be the reason.

CONCLUSION

We carefully measured all the parameters from normal 60 MRI. We found out that the subarachnoid space in right and left lateral region is symmetrical. The mean value is 3.38mm. The mean of transverse and sagittal diameter of dural sac is 19.23mm and 13.83mm resp. also the mean of transverse and sagittal diameter of spinal cord is 11.89mm and 6.97mm resp.

From the point of view of developing a thecaloscope or intradural robotic device care should be taken so as its diameter should not be exceeding that of 3.38mm.

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Conflict of interest: None

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