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Determination of Level of Termination of Spinal cord (conus medullaris) in MRI

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ABSTRACT

Introduction: The termination of the conus medullaris is a crucial anatomical landmark in anatomy, and its exact location and variability are of great clinical significance. By knowing the exact location of the conus medullaris, we can avoid injury to the spinal cord during spinal procedures like spinal anesthesia, lumbar puncture, lumbar myelography, CSF sample collection, and others.

Methodology: The level of spinal cord termination was assessed from the mid-sagittal section of the T2 weighted MRI images. A total of 270 patients referred for MRI examinations of the lumbar spine for various clinical indications to the Radiology Department of Tribhuvan University Teaching Hospital (TUTH) were selected for the study.

Result: The most common level of termination of the spinal cord was found to be the L1/L2 intervertebral disc (77 patients). The level of termination of the spinal cord ranged from the lower 1/3rd of T12 vertebrae to the L2/L3 intervertebral disc. There was no statistically significant difference in the level of termination of the spinal cord with gender ($p>0.05$). There was a mild positive correlation between the level of termination of the spinal cord and age, which was statistically significant ($r=0.22$, $p=0.001$).

Conclusions: In this study, we studied the level of spinal cord termination in MRI and the most common level was found at the L1/L2 intervertebral disc.

Keywords: *Anaesthesia, Spinal; Magnetic Resonance Imaging; Nepal.*

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INTRODUCTION

The spinal cord is part of the central nervous system and is protected by the vertebrae of the spinal column.[1] The spinal cord terminates as a structure called the conus medullaris (CM), which is located at the level of the first or second lumbar vertebrae in most adults. Below the conus medullaris, the spinal cord continues as a bundle of nerve roots called cauda equina, which resembles a horse's tail in appearance. These nerve roots continue down through the lumbar, sacral, and coccygeal regions of the spinal column and provide innervation to the lower extremities, pelvic organ, and perineum.[2]

The CM is a cone-shaped, tapered end of the spinal cord located at the lowermost part of the spinal column.[3]

The CM is an important anatomical landmark for spinal cord surgery and lumbar puncture. During spinal surgery and lumbar puncture, it is essential to avoid damage to the conus medullaris, as this can cause severe neurological deficits. During a lumbar puncture, a needle is typically inserted below the level of the conus medullaris to avoid damage to the spinal cord.[4] The needle is inserted to obtain a sample of cerebrospinal fluid (CSF) for analysis or to administer medication.[5]

The purpose of this study was to determine the level of termination of the spinal cord in the adult population of in a tertiary hospital and provide a safe site for lumbar puncture during procedures like CSF collection and lumbar myelography.

METHODS

This was a quantitative cross-sectional study carried out in the Department of Radiology and Imaging, Tribhuvan University Teaching Hospital, Kathmandu, from August to October 2023. The study population consisted of a total of 270 patients who were referred for an MRI of the lumbar spine for various clinical indications. A purposive sampling method was used. Ethical clearance was obtained from the Institutional Review Council (IRC) of the Institute of Medicine {Reference No. 91 (6-11)E2 080/81}. Informed written consent was obtained from the subjects before the study. The privacy and confidentiality of the patients enrolled in this study were strictly maintained.

The patients referred to the radiology department for lumbar spine MRI for various clinical indications were included in the study. Patients with lesions in the lower thoracic and lumbar region, a history of lumbar surgery, those below 18 years, patients presented with scoliosis and other abnormalities obscuring the visualization of the conus and MRI images with artifacts were excluded.

MRI scans of the lumbar spine were obtained with Siemens Magnetom Amira 1.5T and Hitachi Airis Vento Open 0.3T with the standard protocol of the department. Mid-Sagittal T2 weighted images were used to visualize the entire spinal cord and measure the level of termination. The slice thickness, field of view (FOV), signal-to-noise ratio (SNR), and contrast-to-noise ratio (CNR) were kept the same for all of the patients.

For the exact location of the conus medullaris in each patient, the lumbar spine MRI was reviewed in the workstation. The conus medullaris was located in the mid sagittal T2 weighted images. After knowing the position of the conus medullaris, a perpendicular line was drawn from it. It was noted if the perpendicular line passed through the intervertebral disc. Moreover, if it passed through the vertebral body, then the vertebral body was equally divided into three segments by measuring the length of the vertebral body from the superior articular process to the inferior articular process and dividing it by 3, and the segment through which the perpendicular line passed through was noted.

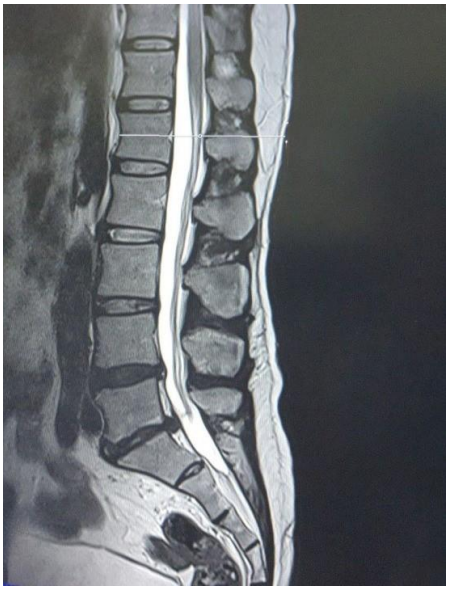

Figure 1: T2 weighted mid sagittal section showing position of conus medullaris

Data were collected on an Excel spreadsheet, and were analyzed with a statistical package for social studies (SPSS Version 26). The data were tested for normal distribution. The mean, standard deviation, and range were calculated. The variation in the location of conus medullaris with age and gender was analyzed. The independent sample t-test was used to compare data from male and female patients, and Karl's Pearson correlation was used to compare data obtained from different ages to check statistical significance at p= 0.05 level. The 95% confidence interval (CI) was used to evaluate the variation by gender and age. A P value <0.05 was considered statistically significant.

RESULTS

A total of 270 patients were enrolled in the study. Among them, 123 (46%) were male, and 147 (54%) were female. The mean age of the study population was 46.61±16.54 years. The minimum age of the population was 18 years, and the maximum age was 85 years.

In 270 participants of this study, the most common level of termination of spinal cord was found at L1/L2 intervertebral disc in 77 participants (28.5%). Likewise, in 48, it was at upper 1/3rd of L1 vertebrae; in 41, it was at middle 1/3rd of L1 vertebrae; in 34, it was at lower 1/3rd of L1 vertebrae; in 22, it was at middle 1/3rd of L2 vertebrae; in 20, it was at T12/L1 intervertebral disc; in 18, it was at upper 1/3rd of L2 vertebrae; in 7, it was at lower 1/3rd of T12 vertebrae and in 3, it was at L2/L3 intervertebral disc (Table 1).

The data were tested for normality using the Kolmogorov-Smirnov test. They were found to be normally distributed so parametric tests (independent sample t-test and Karl's Pearson correlation) were applied.

Table 1. Level of termination of spinal cord in male and female (n= 270)

Level of termination	Male		Female	
	Frequency	Percentage	Frequency	Percentage
L2/L3 intervertebral disc	1	0.8%	2	1.3%
Middle 1/3rd of L2	12	9.8%	10	6.8%
Upper 1/3rd of L1	8	6.5%	10	6.8%
L1/L2 intervertebral disc	33	26.9%	44	29.9%
Lower 1/3rd of L1	15	12.2%	19	12.9%
Middle 1/3rd of L1	17	13.8%	24	16.4%
Upper 1/3rd of L1	24	19.5%	24	16.4%
T12/L1 intervertebral disc	10	8.1%	10	6.8%
Lower 1/3rd of T12	3	2.4%	4	2.7%
Total	**123**	**100%**	**147**	**100**

There was no statistically significant difference in the level of termination of spinal cord with gender (P>0.05), t = 0.166
(Table 2).

Table 2. Correlation between conus level and sex

Variable	Sex	P value	t-value
Level of termination of spinal cord	Male	0.868	0.166
	Female		

There was positive correlation (r=0.224, p = 0.001) between the level of termination of spinal cord and age (Table 3).

Table 3. Correlation between conus level and age

Variable	P value	r-value
Level of termination of spinal cord	0.001	0.224

DISCUSSION

We evaluated the location of the termination of the spinal cord (conus medullaris) and correlated it with the patient's age and gender in MRI scans of the lumbar spine.

This study was conducted in MRI because MRI has better contrast resolution, and the position of the conus medullaris can be easily identified on a sagittal T2 weighted MRI image. MRI also has multi-planetary capability, and there is no use of ionizing radiation.

In this study, the most common level of termination of the spinal cord and conus medullaris (CM) was found to be the L1/L2 intervertebral disc level, and the level of termination of the spinal cord ranged from the lower 1/3rd of T12 vertebrae to L2/L3 intervertebral disc level. There was no statistically significant difference in CM position with gender (p>0.05). There was a mild positive correlation (r=+0.224) between the level of termination of the spinal cord and age, which was statistically significant (p=0.001). The most common level of termination of the spinal cord in males and females was at the same level, i.e., at the L1/L2 intervertebral disc level.

Sevinc et al. performed a similar study in which they found that the most common level of termination of the spinal cord was at the L1/L2 intervertebral disc, which was similar to our study. The differences between the distribution of CM levels in males and females were not statistically significant, which was also similar to our study (p=0.868). The distribution of CM location in their study ranged from the T11-T12 intervertebral disc level to L2-L3 intervertebral disc level, which was not similar to our study. This may be due to the limited sample size of our study and the different body habitus of our population.[4]

In a study performed by Karabulut et al., there was no statistically significant difference in CM position with gender, and there was a significant difference in CM position with increasing age, supporting the finding of our study. They found that the CM level ranged from T12 vertebrae to L2-L3 intervertebral disc, which was similar to our study. There was no statistically significant difference in the mean CM position related to gender, which was similar to our study. There was a significant difference (p=0.036) between increasing age and conus medullaris position in female patients. In our study, too, there was a mild positive correlation between CM position and age, which was statistically significant.[6]

In a study by Demiryürek et al., there was a statistically significant difference in CM position with gender and no statistically significant difference in CM position with age. They found that the range of CM level was from T11–T12 intervertebral disk space to the upper third of L3. The level of CM was most commonly located at the T12–L1 intervertebral disc level; however, in our study, it was at the L1/L2 intervertebral disc level. There was a

significant statistical difference in CM levels between male and female study groups; however, in our study, there was no statistically significant difference between CM position and gender. No significant difference in the conus medullaris level was found with increasing age, unlike the findings of our study.[7]

In a study by Sharma et al., the position of CM varied between the upper third of the T12 vertebral body to the L2- L3 disc level, which was similar to the finding of our study. In their study, the mean position was at the mid-third of the L1 vertebral body. In females, the CM tip was located relatively lower in comparison to males, but the gender difference was not statistically significant, which was also similar to the finding of our study.[8]

In many studies it was found that the level of termination of the spinal cord in infants is lower, and with increasing age, the CM position gets higher, which supports the findings of our study.[6,9,10]

The main limitation of our study is the small sample size and short duration of the study. There may be some observer bias during the measurement of the level of termination of the spinal cord (conus medullaris). Another limitation is that the data were collected from a single center which may not fully represent the entire Nepalese population. Multicenter trials could provide more accurate results.

CONCLUSION

We evaluated the level of termination of the spinal cord in T2 weighted MRI. Our findings were similar to various other studies. The findings of this study can help provide safe puncture sites for procedures like lumbar puncture in context to the Nepalese population.

CONFLICT OF INTEREST

None

SOURCES OF FUNDING

None

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