

ORIGINAL ARTICLES

Changes of cerebrospinal fluid in the upper neck area with age using diffusion weighted MR imaging

Ichiro Ogura*, Takaaki Oda, Mikiko Sue, Yoshihiko Sasaki

Radiology, The Nippon Dental University Niigata Hospital, Chuo-ku, Niigata, Japan

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ABSTRACT

Purpose: Few studies have concerned the absolute apparent diffusion coefficient (ADC) values in the normal cerebrospinal fluid in the upper neck area and the effect of aging on diffusion. The purpose of this study was to evaluate changes of cerebrospinal fluid in the upper neck area with age using diffusion weighted MR imaging (DWI).

Methods and methods: Our study included 160 patients who underwent MR imaging for oral and maxillofacial diseases. All patients were examined by DWI with 2 b values (0 and 800 sec/mm²) at 1.5 Tesla and ADC maps. The cerebrospinal fluid and spinal cord in the upper neck area were analyzed using the ADC values and age.

Results: ADC value of cerebrospinal fluid was significantly correlated to ADC value of spinal cord ($R^2 = 0.141$, $p = .000$). ADC value of spinal cord had no relation to age ($R^2 = 0.015$, $p = .125$). ADC value of cerebrospinal fluid had significant relation to age ($R^2 = 0.026$, $p = .042$).

Conclusions: We indicated the changes of cerebrospinal fluid in the upper neck area with age using DWI. The data reported herein are representative, and the ADC values can be used for reference in future studies and in clinical settings.

Key Words: Diffusion magnetic resonance imaging, Spinal cord, Cerebrospinal fluid, Aging

1. INTRODUCTION

Studies of cerebrospinal fluid analyses may provide biomarkers for dementia sub-typing and also may provide clues about brain disease pathogenesis.^[1] These biomarker studies are even more important as there are clearly many diseases in addition to Alzheimer's disease that underlie the clinical syndrome of dementia.^[2] Moreover, neuroradiology suggest a strong relationship between amyotrophic lateral sclerosis progression and spinal cord atrophy by MR imaging.^[3]

Diffusion weighted MR imaging (DWI) is a fast sequence constructed from fast advanced spin echo and echo-planar imaging (EPI).^[4] DWI allows a quantitative index of water diffusivity for each voxel that provides visualization of

the microscopic motion of water molecules within tissues.^[5] Furthermore, some reports showed the application of DWI with calculation of apparent diffusion coefficient (ADC) in the differentiation between malignant and benign diseases in head and neck.^[6-10]

Studies regarding absolute ADC values in the normal human brain and the effect of aging on diffusion are scarce, and only a few reports involving small numbers of subjects have been published.^[11] Moreover, age is an important factor for spinal cord injury and repair.^[12,13] However, to the best of our knowledge, there are not clear studies in the changes of cerebrospinal fluid in head and neck with age using DWI. We evaluated the changes of cerebrospinal fluid in the upper

*Correspondence: Ichiro Ogura; Email: ogura@ngt.ndu.ac.jp; Address: Radiology, The Nippon Dental University Niigata Hospital, 1-8 Hamaura-cho, Chuo-ku, Niigata, Japan.

neck area with age using DWI.

2. PATIENTS AND METHODS

Our study included 160 patients (80 male, 80 female; aged 8-90 years, mean age 63.6 years) who had MR imaging for oral and maxillofacial diseases at The Nippon Dental University Niigata Hospital from October 2016 to May 2017 after providing written informed consent.

All patients were examined using a MR unit with a head coil

(EXCELART; Toshiba, Japan) by DWI with 2 b values (0 and 800 sec/mm² with an EPI sequence) at 1.5 Tesla. The following technical parameters were used: TR 8476 msec, TE 80 msec. The ADC maps were automatically computed from the DWI with b = 800 sec/mm² (see Figure 1). Two oral and maxillofacial radiologists used ROI to compute the ADC values of ADC maps. Furthermore, 3 ROIs by similar size from the spinal cord and cerebrospinal fluid in the upper neck area to obtain a mean ADC value were measured.

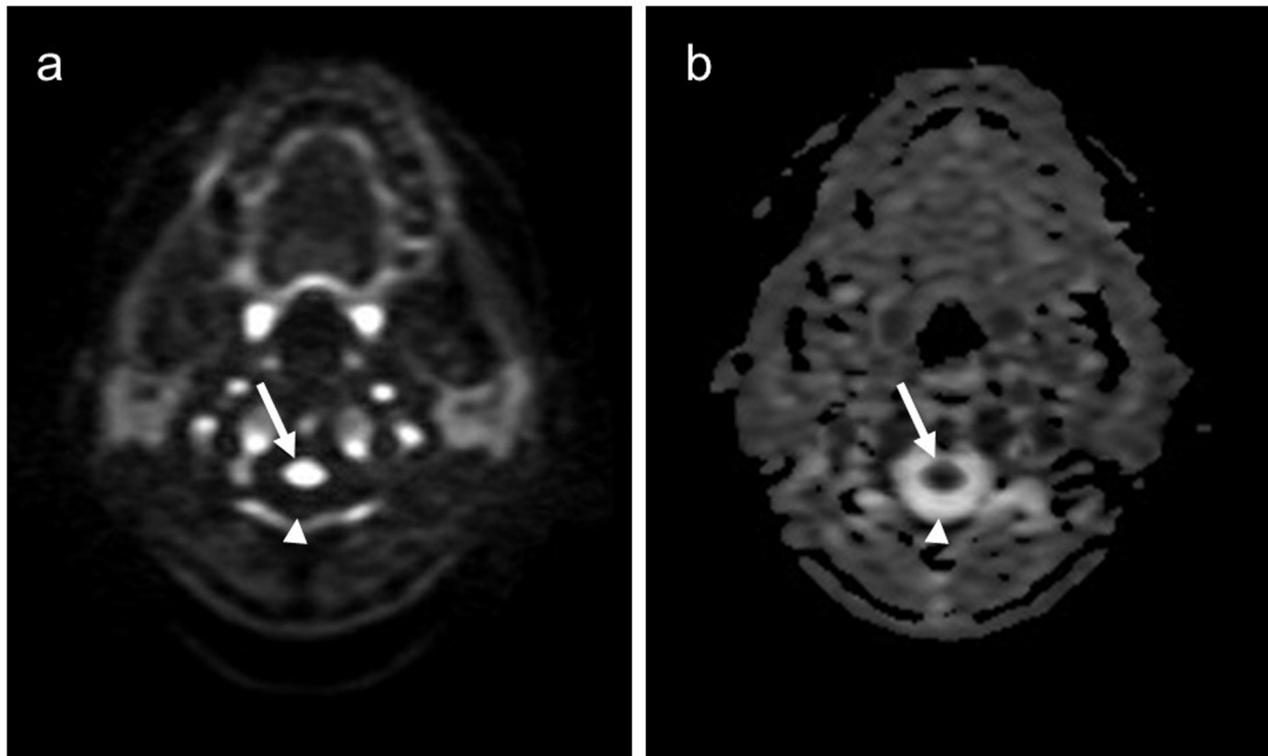


Figure 1. Normal structures in a 25-year-old female. (a) Diffusion-weighted image shows the spinal cord (arrow) and cerebrospinal fluid (arrowhead). (b) Apparent diffusion coefficient (ADC) map shows the spinal cord (arrow) and cerebrospinal fluid (arrowhead).

The relationship between age, ADC value of spinal cord, cerebrospinal fluid and gender was compared by Mann-Whitney U test. Furthermore, the relationship between ADC value in spinal cord, cerebrospinal fluid and age was assessed by Pearson's rank correlation test. A *p* value < .05 was considered significant.

3. RESULTS

The ADC values of spinal cord and cerebrospinal fluid are shown in Table 1. Regarding gender, the mean ADC value of the spinal cord was not statistically significant difference between male ($0.73 \pm 0.19 \times 10^{-3}$ mm²/sec) and female ($0.75 \pm 0.19 \times 10^{-3}$ mm²/sec). Furthermore, the mean

ADC value of the cerebrospinal fluid was not statistically significant difference between male ($3.66 \pm 0.54 \times 10^{-3}$ mm²/sec) and female ($3.62 \pm 0.56 \times 10^{-3}$ mm²/sec).

ADC value of spinal cord had no relation to age ($R^2 = 0.015$, $p = .125$, see Figure 2). ADC value of cerebrospinal fluid had significantly relation to age ($R^2 = 0.026$, $p = .042$, see Figure 3). Furthermore, ADC value of cerebrospinal fluid was significantly correlated to ADC value of spinal cord ($R^2 = 0.141$, $p = .000$, see Figure 4).

4. DISCUSSION

Paucity of changes of spinal cord and cerebrospinal fluid with age using DWI warranted this study.

Table 1. ADC values of spinal cord and cerebrospinal fluid in the upper neck area

	Male	Female	p value
Number	80	80	
Age (years)			
Mean ± SD	64.1 ± 14.7	63.2 ± 18.8	.663
Range	25-87	8-90	
ADC value of spinal cord ($\times 10^{-3} \text{mm}^2 \text{s}^{-1}$)			
Mean ± SD	0.73 ± 0.19	0.75 ± 0.19	.481
Range	0.31-1.29	0.30-1.10	
ADC value of cerebrospinal fluid ($\times 10^{-3} \text{mm}^2 \text{s}^{-1}$)			
Mean ± SD	3.66 ± 0.54	3.62 ± 0.56	.611
Range	2.69-4.67	2.49-4.82	

Note. ADC, apparent diffusion coefficient; SD, standard deviation.

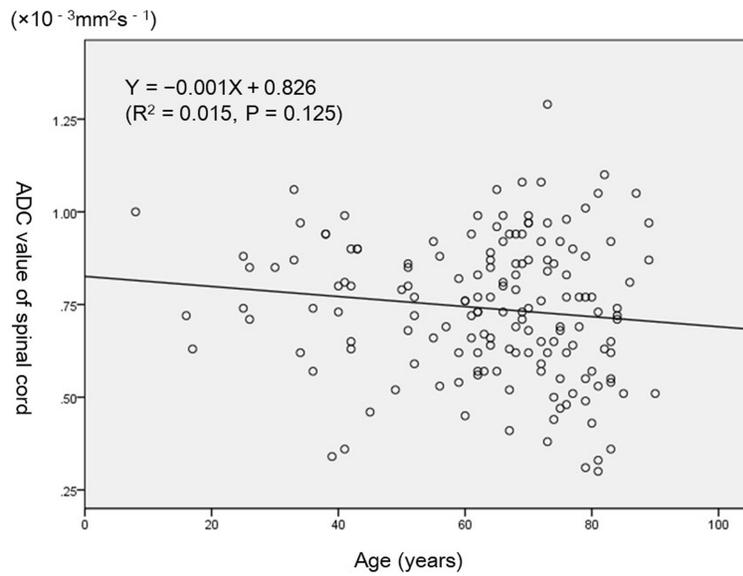


Figure 2. Scatter diagram shows the relationship between age and ADC value of spinal cord

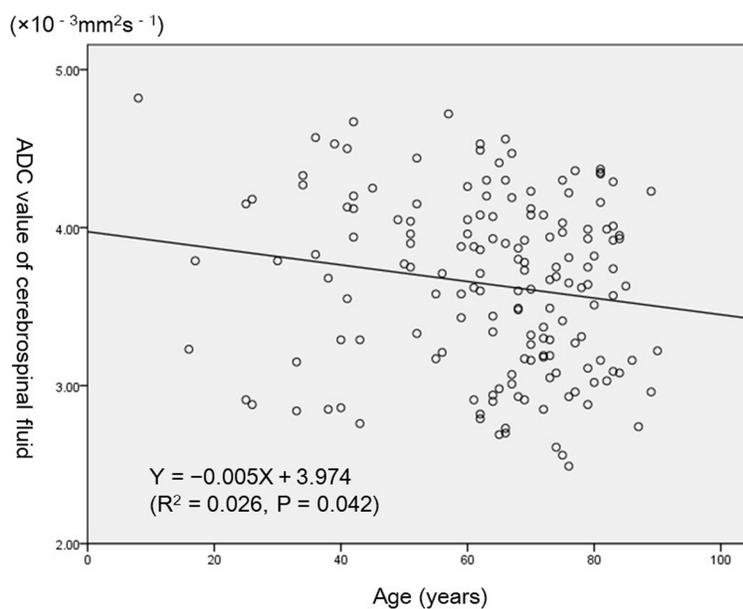


Figure 3. Scatter diagram shows the relationship between age and ADC value of cerebrospinal fluid

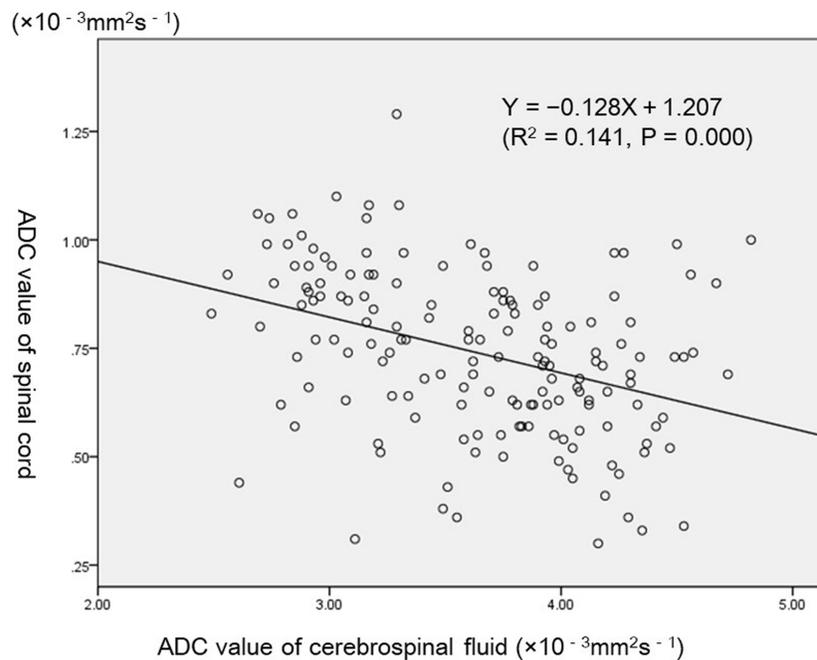


Figure 4. Scatter diagram shows the relationship between ADC value of cerebrospinal fluid and spinal cord

Regarding ADC values of the normal human brain, Helenius et al.^[11] indicated that the cortical gray matter ($0.89 \pm 0.04 \times 10^{-3} \text{mm}^2/\text{sec}$) were highest, the deep gray matter ($0.75 \pm 0.03 \times 10^{-3} \text{mm}^2/\text{sec}$) were lower, and the white matter ($0.70 \pm 0.03 \times 10^{-3} \text{mm}^2/\text{sec}$) were lowest. Furthermore, no difference was observed between female and male. Regarding our study, the mean ADC value in the spinal cord was not statistically significant difference between male ($0.73 \pm 0.19 \times 10^{-3} \text{mm}^2/\text{sec}$) and female ($0.75 \pm 0.19 \times 10^{-3} \text{mm}^2/\text{sec}$). Furthermore, the mean ADC values of the cerebrospinal fluid were not statistically significant difference between male ($3.66 \pm 0.54 \times 10^{-3} \text{mm}^2/\text{sec}$) and female ($3.62 \pm 0.56 \times 10^{-3} \text{mm}^2/\text{sec}$). We consider that no difference was observed between female and male in ADC value of normal human brain, spinal cord and cerebrospinal fluid. Furthermore, this study showed the deep gray matter ($0.75 \pm 0.03 \times 10^{-3} \text{mm}^2/\text{sec}$) and the white matter ($0.70 \pm 0.03 \times 10^{-3} \text{mm}^2/\text{sec}$) were similar to the spinal cord (male: $0.73 \pm 0.19 \times 10^{-3} \text{mm}^2/\text{sec}$, female: $0.75 \pm 0.19 \times 10^{-3} \text{mm}^2/\text{sec}$).

Helenius et al.^[11] showed that ADC values increase with age was found in the lateral ventricles, and the ADC values in the thalami in 65-85 years group were significantly larger than in those of the other age groups. The authors showed that ADC value of spinal cord had no relation to age ($R^2 = 0.015, p = .125$). However, ADC value of cerebrospinal fluid had significantly relation to age ($R^2 = 0.026, p = .042$). Furthermore, ADC value of cerebrospinal fluid was significantly correlated to ADC value of spinal cord ($R^2 = 0.141, p$

$= .000$). The data reported herein are representative, and the ADC values can be used for reference in future studies and in clinical settings.

Fardo et al.^[1] conclude that among subjects with cerebrospinal fluid analyses and genotype data available in the Alzheimer's Disease Neuroimaging Initiative cohort, the hippocampal sclerosis of aging risk gene variants are mostly not found to be associated with cerebrospinal fluid protein changes. Engelborghs^[2] indicated the discriminatory power for the differential diagnosis of dementia should be improved using other cerebrospinal fluid biomarkers, especially those that are reflective of the pathology of the non- Alzheimer's disease dementia etiologies. Geoffroy et al.^[13] showed spinal cord injury is increasingly affecting the middle-aged and aging populations. Regarding the practical implacability of our research, the present study confirmed the changes of cerebrospinal fluid in the upper neck area with age using DWI. The data reported herein are representative, and the ADC values can be used for reference in future studies and in clinical settings. However, the relationship between neurodegenerative diseases, changes with senility and the changes in cerebrospinal fluid using DWI had not been brought out clearly. The author consider that further study is necessary to investigate changes in spinal cord and cerebrospinal fluid with Alzheimer's disease and spinal cord injury using DWI in the upper neck area, furthermore, the research can help predict them.

5. CONCLUSIONS

The authors investigated changes in spinal cord and cerebrospinal fluid with age using DWI in the upper neck area. The present study confirmed the changes in cerebrospinal fluid with age using DWI in the upper neck area. The data

reported herein are representative, and the ADC values can be used for reference in future studies and in clinical settings.

CONFLICTS OF INTEREST DISCLOSURE

There are no conflicts of interest in relation to our article.

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