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Evaluation of the optic nerve with MRI histogram analysis in Behçet's disease

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Abstract

Aim: The objective of the present study is to analyze whether the optic nerve is affected using histogram analysis on conventional MRI images in patients with Behçet's disease.

Materials and Methods: Gender and age matched patients between the ages of 21 and 75 and a healthy control group were included in the study. Right and left optic nerves of all patients were evaluated by a neuroradiologist using T2-weighted MR images. The optic nerve examination data of the patients were evaluated by histogram analysis. The workstation was a 27 inch iMac computer manufactured by Apple Inc. Cupertino, 88 California, USA.

Results: There was no statistically significant difference between the two groups in terms of age and gender (p:0.927, p:0.753, respectively). Histogram analysis mean and median values in Behçet's patients were statistically significantly higher than in the healthy control group (p : 0.015, p : 0.006, respectively). The histogram analysis values above the 90th percentile were found to be significantly lower in Behçet's patients with visual symptoms compared to those without visual symptoms.

Conclusion: As a result, this study shows that non-macroscopic optic nerve changes can be detected with histogram data analysis of MRI in diseases that can affect the optic nerve such as Behçet's disease. Therefore, we recommend evaluating conventional MR images together with histogram analysis in diseases where optic nerve damage is expected.

Introduction

Behçet's disease is a chronic, autoimmune and recurrent multisystemic vasculitis which affects blood vessels. Clinically recurring mouth ulcers, genital ulcer , skin lesions, renal, vascular and ocular and neurological findings are among various symptoms of the disease. The prevalence of Behçet's disease is high in Mediterranean, Middle East and Far East countries [1-3]. The most common ocular involvement of Behçet's disease is uveitis. In addition, patients may suffer from other ocular involvements such as recurring panuveitis, retinal vasculitis, retinitis, retinal hemorrhage, macular edema, retinal vascular occlusion, and necrosis [3-5]. Some microvascular involvements in the optic nerve or inflammatory changes in uveal tract may affect the optic nerve [5-7]. Today, shear strain elastography and conventional and advanced MRI techniques are used to radiologically diagnose whether the optical nerve is affected [2,8].

In addition, H istogram analysis, which has become increasingly popular in clinical practice in recent years, is one of the new tissue analysis methods [9]. This method aims to mathematically evaluate the signals from objects that form the basic structure of the texture in an image using pixel distribution. In addition , it provides information about tissue heterogeneity by evaluating the gray tones in the tissue [9,10].

The objective of the present study is to analyze whether the optic nerve is affected using histogram analysis on conventional MRI images in patients with Behçet's disease.

Materials and Methods

Prior to the initiation of this retrospectively designed study, ethical approval was obtained from the local ethics committee in session 2019/21 with decision number 03. This study was conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from the patients' families before participation in the study.

The Behçet's disease group, consisting of 8 women and 13 men aged 21-75 years, and a healthy control group,

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consisting of 9 women and 12 men aged 20-75 years, were included in the study. The right and left optic nerves of all patients were examined, and histogram analysis was performed on a total of 84 optic nerves (42 in the patient group, 42 in the control group).

Inclusion criteria for the control group: Healthy patients of similar sex and age without known chronic diseases that could affect the optic nerve such as multiple sclerosis, diabetes mellitus, glaucoma, orbital mass, optic neuritis were included in the control group.

A radiologist performed the examination using ROI from coronal T2-weighted sequences on the optic nerve in the MRI images. The workstation was a 27-inch iMac computer from Apple Inc. Cupertino, California, USA. Exclusion criteria: Patients with multiple sclerosis, diabetes mellitus, glaucoma, orbital masses, optic neuritis and ocular surgery were excluded.

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MRI examination

MRI examinations were performed using a 1.5T MRI with a cranial coil (Philips Ingenia 1.5T, Eindhoven 2015, The Netherlands); T2-weighted images in the coronal plane (repetition time [milliseconds]/time echo [milliseconds]: 4833/100, field of view: 220×183 mm and matrix 356×209 mm) were obtained with a slice thickness of 5 mm and a section gap of 1 mm, and finally 24 coronal sections were obtained.

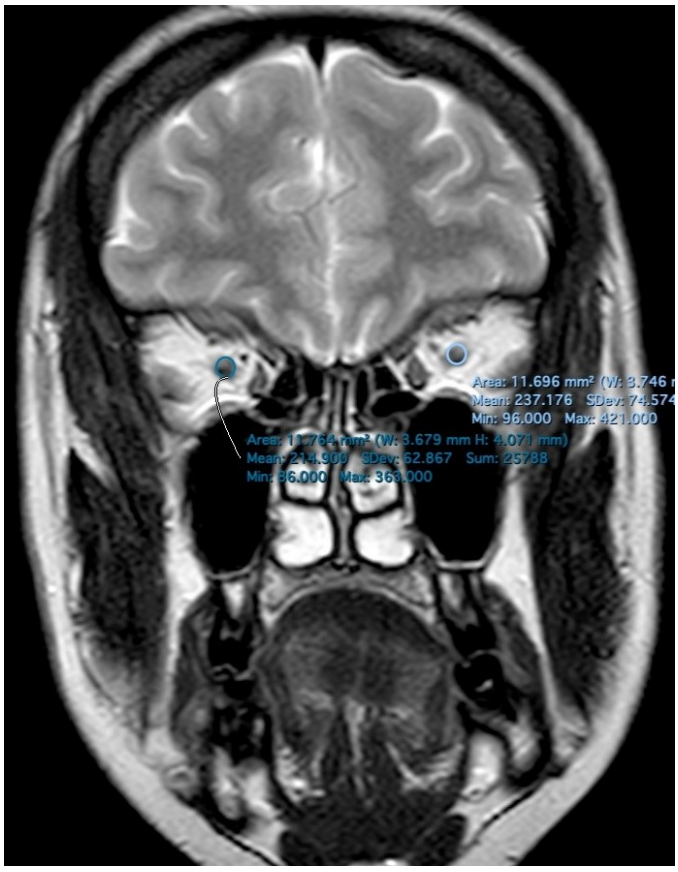

Figure 1. !!!CAPTION!!!!

Image processing

ROI placement on the optic nerve (area 11-13 mm^2) for histogram analysis was given in Figure 1. Images were magnified to some extent and a line drawing tool was used to obtain clearer boundaries. In addition, pixel images in the ROI were transferred to an XML (eXtensible Markum Language) file. MATLAB version 2009b (MATrix LABoratory, Mathworks Inc, Natick, ABD) was used for histogram analysis on XML files.

Statistical analysis

Mean, standard deviation (SD), minimum, maximum, median, variance, entropy (irregularity), uniformity (inhomogeneity), size L%, size M% and size U%, skewness and kurtosis parameters and 01, 03, 05, 10, 25, 75, 90, 95, 97 and 99 per cent were analyzed in the histogram analysis. Chi-square and Student's t-test were also used to compare the patient and control groups.

Results

The mean age was 41.86±13.36 and 42.24±13.39 years in the patient and control groups, respectively, and no statistically significant differences were observed with respect to sex (p=0.927, p=0.753). No correlations were found between the duration of Behçet's disease and the histogram analysis. In addition, when the right and left optic nerves of the patients included in the study were compared, there was no statistically significant difference between the two eyes in terms of histogram analysis (p>0.05).

Table 1. Histogram analysis parameter values of Behçet patients and control group.

	Behçet mean±SD (n=42)	Control mean±SD (n=42)	P value
Mean*	256.74±50.14	231.32±43.33	0.015
Standart Deviation	64.24±15.86	61.10±18.91	0.413
Minimum	115.43±66.27	104.74±45.09	0.390
Maximum	417.71±81.15	402.14±102.06	0.441
Median*	256.35±49.49	228.58±40.89	0.006
Variance	4372.79±1998.86	4083.57±2556.51	0.565
Entropy	6.24±0.13	6.19±0.10	0.120
Size%L	15.23±3.09	14.82±2.81	0.530
Size%U	15.04±3.04	14.32±2.56	0.243
Size%M	69.71±4.72	70.84±4.17	0.248
Kurtosis	3.07±0.78	3.46±1.14	0.068
Skewness	0.06±0.50	0.31±0.63	0.052
Uniformity	0.27±0.07	0.24±0.08	0.070
Percent01	119.44±65.89	109.19±45.18	0.408
Percent 03	132.94±62.30	123.32±42.75	0.412
Percent 05	146.87±62.26	134.44±40.60	0.282
Percent 10	173.40±56.75	153.66±37.18	0.063
Percent 25*	216.04±51.13	192.33±35.10	0.015
Percent 75*	298.26±51.11	266.22±51.77	0.005
Percent 90*	338.26±57.60	309.21±63.59	0.031
Percent 95	365.29±60.77	342.25±78.31	0.136
Percent 97	382.95±68.56	359.89±84.25	0.173
Percent 99	406.20±74.98	389.73±96.30	0.385

*Statistically significant difference p<0.05.

Table 2. Histogram analysis parameters of patients with positive and negative visual symptoms.

	Vizual symptom positive mean±SD (n=42)	Vizual symptom negative mean±SD (n=42)	P value
Mean*	250.82±40.52	271.55±68.60	0.231
Standart Deviation	62.00±15.51	69.82±15.97	0.151
Minimum	107.00±63.09	136.50±72.08	0.196
Maximum	399.00±63.08	460.50±103.49	0.016
Median*	253.65±41.01	263.12±68.02	0.582
Variance	4077.92±1835.42	5109.96±2276.52	0.132
Entropy	6.24±0.14	6.22±0.11	0.721
Size%L	15.52±2.94	14.51±3.47	0.348
Size%U	14.61±3.27	16.13±2.14	0.146
Size%M	69.86±4.98	69.34±4.19	0.754
Kurtosis	3.02±0.77	3.17±0.84	0.597
Skewness	-0.06±0.45	0.40±0.51	0.006
Uniformity	0.29±0.06	0.23±0.08	0.028
Percent 01	111.00±62.92	140.57±71.15	0.192
Percent 03	124.64±60.76	153.69±63.83	0.175
Percent 05	138.69±56.62	167.32±73.20	0.181
Percent 10	167.25±51.26	188.80±68.66	0.272
Percent 25*	212.79±44.28	224.16±35.66.88	0.522
Percent 75*	290.94±38.44	316.58±72.99	0.144
Percent 90*	327.15±41.61	366.04±81.40	0.047
Percent 95	351.64±45.59	399.42±80.68	0.019
Percent 97	368.80±56.38	418.32±85.04	0.033
Percent 99	389.26±62.65	448.53±88.72	0.019

*Statistically significant difference p<0.05.

When the results of histogram analysis of the optic nerves of Behçet's patients and control group patients were compared, the mean, median, 25th, 75th, and 90th percentile values were found to be statistically significantly higher in Behçet's patients compared to the control group (p=0.015, p=0.006, p=0.015, p=0.005, p=0.031, respectively) (Table 1).

When the optic nerve histogram analyses of the patients with and without visual symptoms were compared, it was found that the maximum, skewness, uniformity, 90.95.97 and 99 percent values of the patients with visual symptoms were statistically significantly lower than those without visual symptoms (p=0.016, p=0.006, p=0.028, p=0.047, p=0.019, p=0.033, respectively) (Table 2).

Discussion

In the existing literature, the present study is the first to apply histogram analysis, an area of artificial intelligence that is becoming increasingly popular in radiological imaging, to the optic nerve in patients with Behçet's disease. Histogram analysis is particularly important in cases where differences in different radiological images cannot be distinguished. Some anatomical structures may undergo tissue changes in the imaging process that can only be diagnosed by statistical analysis of the pixel distribution in an image rather than by visual analysis of the tissue [11]. Medical images provide a wealth of tissue information relevant to clinical practice. However, MR images do not have the ability to provide microscopic information about tissues that can be visually analysed. In this regard, existing histological tissue changes in a patient can be diagnosed using tissue analysis on MR images. It has been reported in the current literature that pathological tissues in liver, thyroid, breast, kidney, prostate, heart, brain and lung have been successfully classified using the tissue analysis method [11-14]. Histogram analysis has been widely used in diseases involving the central nervous system. It has been used in various practices such as differentiation and classification of benign and malignant brain tumours, differentiation of active and non-active plaques in multiple sclerosis (MS) patients without the use of contrast agent, differences in histological levels of normal-appearing white matter in MS patients, and diagnosis of histological changes in the spinal cord in MS patients without visual pathology. In addition, this method has been successfully used in Alzheimer's disease, acute ischaemic stroke, epilepsy and migraine patients [15-18]. M Rovaris et al. applied MRI histogram analysis to normal-appearing brain parenchyma in patients with Behçet's disease, systemic lupus erythematosus, Wegener's granulomatosis, multiple sclerosis, and antiphospholipid antibody syndrome, and diagnosed microscopic tissue changes [19]. Hongjan Liu et al used MRI histogram analysis of the optic nerve in patients with optic neuritis and diagnosed significant changes in the optic nerve without the use of contrast agents [20]. In the present study, significant optic nerve changes were also diagnosed in patients with Behçet's disease without the use of contrast agents. Optic nerve involvement can lead to permanent vision loss in patients with Behçet's disease, making early diagnosis a priority for these patients. Shear strain elastography and conventional and advanced MRI techniques are used to diagnose

optic nerve involvement. Contrast enhancement of the optic nerve on MRI is an indicator of excessive involvement [2,5]. Accordingly, we have used histogram analysis on conventional MRI images to diagnose nonvisual differences in patients with Behçet's disease without the use of contrast agents. The above-mentioned studies in the existing literature underline the fact that histogram analysis is an effective method to successfully diagnose histological and microscopic changes without any visual pathology and to differentiate pathological from normal tissue. Therefore, in the present study, histogram analysis was also successfully applied to diagnose optic nerve involvement in MRI images without visual pathology, which leads to permanent vision loss due to late diagnosis and reduces quality of life in patients with Behçet's disease. The results showed statistically significant differences between healthy individuals and patients with Behçet's disease. The main limitation of this study is the small number of patients. A larger number of patients would increase the ability of the artificial intelligence to learn and analyse. Despite this limited number, statistical analyses show that early detection of optic nerve damage is possible.

Conclusion

Histogram analysis, an area of artificial intelligence, has shown that visually normal interpreted brain MR images of patients with Behçet's disease may in fact be pathological. This suggests that this finding may help clinicians in the early diagnosis of optic nerve damage, which can cause permanent vision loss in Behçet's patients. However, this idea needs to be supported by more extensive studies.

Ethical approval

Before starting this retrospectively designed study, ethical approval was received from Kahramanmaraş Sütcü İmam University Clinical Research Ethics Committee with decision number 03 in the 2019/21 session.

References

1. Doğan A, Bayar Muluk N, Şahan MH, et al. Olfactory bulbus volume and olfactory sulcus depth in migraine patients: an MRI evaluation. Eur Arch Otorhinolaryngol. 2018;275(8):2005-2011.
2. Inal M, Tan S, Demirkan S, et al. Evaluation of Optic Nerve with Strain and Shear Wave Elastography in Patients with Behçet's Disease and Healthy Subjects. Ultrasound Med Biol. 2017 Jul;43(7):1348-1354.
3. Ksiaa I, Abroug N, Kechida M, et al. Eye and Behçet's disease. J Fr Ophtalmol. 2019 Apr;42(4):e133-e146.
4. Ucar D, Uygunoglu U, Dikkaya F, et al. Retinal nerve fiber layer structure abnormalities in patients with neuro-Behcet's disease. Graefes Arch Clin Exp Ophthalmol 2015;253:1181–1185.
5. Voros GM, Sandhu SS, Pandit R. Acute optic neuropathy in patients with Behc¸et's disease: Report of two cases. Ophthalmologica 2006;220: 400–405.
6. Cetin EN, Yaylali V, Yildirim C. Isolated optic neuropathy in a case of Behc¸et's disease. Int Ophthalmol 2011;31:153–155.
7. Kidd DP. Optic neuropathy in Behcet's syndrome. J Neurol 2013;260: 3065–3070.
8. İnal M, Tan S, Yumusak EM, et al. Evaluation of the optic nerve using strain and shear wave elastography in patients with multiple sclerosis and healthy subjects. Med Ultrason. 2017 Jan 31;19(1):39-44.
9. Baykara M, Koca TT, Demirel A, Berk E. Magnetic resonance imaging evaluation of the median nerve using histogram analysis in carpal tunnel syndrome. NSN 2018; 35(3): 145-150.
10. Park YW, Han K., Ahn SS, et al. Whole-tumor histogram and texture analyses of DTI for evaluation of IDH1-mutation and 1p/19q-codeletion status in world health organization grade II gliomas. AJNR Am J Neuroradiol 2018; 39: 693-698.
11. Castellano G, Bonilha L, Li LM, Cendes F. Texture analysis of medical images. Clin Radiol 2004; 59: 1061-1069).
12. Bernasconi A, Antel SB, Collins DL, et al. Texture analysis and morphological processing of magnetic resonance imaging assist detection of focal cortical dysplasia in extra-temporal partial epilepsy. Ann Neurol. 2001;49(6):770-5.
13. James D, Clymer BD, Schmalbrock P. Texture detection of simulated microcalcification susceptibility effects in magnetic resonance imaging of breasts. J Magn Reson Imaging, 2001;13:876-881.
14. Chabat F, Yang GZ, Hansell DM. Obstructive lung diseases: texture classification for differentiation at CT. Radiology, 2003;228:871-877.
15. Kassner A, Thornhill RE. Texture analysis: a review of neurologic MR imaging applications. Am J Neuroradiol 2010; 31(5):809-16.
16. Kassner A, Liu F, Thornhill RE, et al. Prediction of hemorrhagic transformation in acute ischemic stroke using texture analysis of postcontrast T1- weighted MR images. J Magn Reson Imaging 2009;30:933–41.
17. Freeborough PA, Fox NC. MR image texture analysis applied to the diagnosis and tracking of Alzheimer's disease. IEEE Trans Med Imaging 1998;17:475–79.
18. Chen Z, Chen X, Liu M, et al. Magnetic resonance image texture analysis of the periaqueductal gray matter in episodic migraine patients without T2-visible lesions.Korean J Radiol 2018; 19(1):85.
19. Rovaris M, Viti B, Ciboddo G, et al. Brain involvement in systemic immune mediated diseases: magnetic resonance and magnetisation transfer imaging study. J Neurol Neurosurg Psychiatry 2000;68:170–177.
20. Liu HJ, Zhou HF, Zong LX, et al. MRI Histogram Texture Feature Analysis of the Optic Nerve in the Patients with Optic Neuritis. Chin Med Sci J. 2019;34(1):18-23.