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Short Communication

Retinal vascular fractals in Behçet's Disease: A screening method?

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Abstract

Objective: The branching pattern of retinal vessels may be affected in Behçet's Disease (BD). Fractal analysis can be used as a new method to quantify the changes of the vascular branching pattern. In this study, we examined, for the first time, the relationship between retinal fractal dimension (D_f) and retinal vascular changes seen in patients with BD.
Methods: We conducted a retrospective study of 10 new cases of BD with clinically ocular involvement. Color fundus images taken from both eyes of the participants have been analyzed, and D_f of the whole retinal vasculature was quantified using a novel computer-based program. The resultant D_f was compared with that of healthy individuals.
Results: The mean D_f, calculated from 20 fundus images of cases with BD, was 1.59 ± 0.064. It was lower than that of healthy participants (1.65 ± 0.060) significantly ($P = 0.013$).
Conclusion: Retinal fractal analysis of cases with BD has been performed for the first time, and the results showed that early retinal vascular changes seen in new cases of BD are associated with lower retinal D_f. Retinal fractal analysis in BD can be practically utilized as a potential tool for screening of retinal involvement, evaluating the prognosis and the response to treatment.

Keywords: Behcet's disease, Fractal dimension, Retinal vessels

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Introduction

A simple, global tool to measure retinal vascular changes at the early stages of eye diseases would be appreciated. Quantitative analysis of the geometric complexity of retinal vasculature has been performed using computer-based programs.[1] Recent studies supported the value of computer-based analysis of fundus images to study retinal vascular changes seen in diabetes or hypertension.[2] Therefore, it opened a new avenue to globally measure changes of the geometric pattern of retinal vasculature, which can help us with screening and follow-up of the retinal involvement in eye diseases. The retinal vascular tree exhibits a self-similar geometric pattern, which allows it to be quantified in terms of its fractal dimension (D_f).[1] The retinal D_f has been measured in a few studies, and seems to be a sensitive indicator of early vascular changes in eye diseases.[3]

Methods

We hypothesized that the early changes of the geometric complexity of retinal vessels seen in patients with Behçet's Disease (BD) can be quantified using fractal analysis. To examine our hypothesis, we designed a pilot, cross-sectional study and included new cases of BD who were referred to our university hospital with clinically ocular involvement during

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2009–2011. Those who had ocular hazy media, or had any comorbidity (e.g., hypertension), or have been taking any drug (e.g., for treatment of BD) have been excluded from the study.

Color fundus images that have been taken from both eyes of the patients were pre-processed applying Top-hat transformation and then filtering the images to reduce contrast variations and suppress noises. Thereafter, we used a Radon transform-based algorithm to detect and extract retinal blood vessels. The detailed method has been published elsewhere.[4] Binary masks of retinal blood vessels were then used for calculation of D_f. D_f was calculated using the box-counting approach, an established method used to quantify D_f for binary structures that are not perfectly self-similar.[5]

Results

A total of 20 fundus images obtained from 10 cases of BD has been analyzed. The resultant D_f was normally distributed, and the mean D_f was 1.59 ± 0.064. Furthermore, we compared the resultant D_f with that of randomly-selected 20 color fundus images of 10 healthy individuals from our Database. The mean D_f of the healthy individuals was 1.65 ± 0.060 using the same method of image processing and D_f calculation. Our results showed that retinal D_f of patients with BD was lower than that of healthy individuals significantly ($P = 0.013$).

Discussion

Although a limitation of the study was the design of the ''control'' group who were not randomly selected from normal general population, retinal D_f of the control group was lower than that of healthy individuals reported in the literature (i.e., ≈1.70).[6] However, the reported D_f was mostly based on the analysis of red-free fundus images which may show the retinal vascular tree in greater details.

It seems that, at the early stages of BD, fractal analysis of the retinal vascular tree can help us to quantitatively show the changes of the vascular geometric pattern. Therefore, D_f may be used for screening of the retinal vascular involvement in BD, and also for evaluation of the response to treatment in the follow-up period of patients who had retinal vascular involvement. However, it should be noted that the retrospective design of the study did not allow us to ascertain whether lower D_f is antecedent or consequential to clinically ocular involvement in BD. Additional prospective studies are needed to determine the temporal sequence of the observed association. If our findings are confirmed in other samples and in prospective studies, fractal analysis of fundus images using a computer-based program may be applied to clinical studies evaluating risk factors and potential effects of new therapeutic options at the early stages of BD.

Conflict of interest

The authors declared that there is no conflict of interest.

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