Report

Report on speckle-noise freed choroidal angiography and virtual tumoropsy using optical coherence tomography

Introduction

Pigmented tumors of the posterior pole may represent a major impact on a patient's life and a diagnostic hurdle for the treating ophthalmologist. In 1997, the Collaborative Ocular Melanoma Study Group published important predictive factors of growth.[1] Shields offered guidelines in the assessment and management of posterior uveal melanoma and evidence grew, that smaller sized tumors may show a potentially better outcome.[2] However, even clinically small tumors may express gene instability as monosomy 3, loss of 6q and 8q and be prone for malignant transformation and hematogenous diseases. Most patients die within one year after metastasis are detected.[3]

Posterior ocular tumors are mostly identified using indirect ophthalmoscopy. Color fundus photography has shown to be of great importance in diagnosis and monitoring of uveal tumors and is used today as a widespread technology. Additional methods as ultrasonography, autofluorescence or fluorescence angiography may help to further clarify the diagnosis.[4]

Fine-needle aspiration would be of priceless value, but is performed only in specific cases, because of the delicate intraocular location. However, despite the great successes in imaging of choroidal tumors, the access has been limited because of technical limits.

In recent years, advances in optical coherence tomography (OCT) have improved imaging of the retina and of the choroidea as well. This progress is of great importance, since about 80 % of ocular melanoma are originated in the choroid. Many difficulties of OCT as motion artifacts, signal loss, and relative long acquisition times, respectively, which were successfully addressed using enhanced-depth imaging OCT, image averaging or the use of a longer wavelength as 1050 nanometer swept source OCT.[5-6]

A major problem that occurs in almost all imaging modalities such as OCT, computer-tomography (CT), magnetic resonance imaging (MRI) or ultrasonography (US), is speckle noise, that may obscure and blur the signal. Many noise filters have been described, but so far have not significantly been introduced in medical imaging. Therefore, in our OCT laboratory of the University of Basel, we have tried a specific approach and focused not on the noise, but on the OCT signal.

Methods

A novel, post-processing, three-dimensional motion vector field algorithm was developed to track an OCT signal pixel per pixel over an acquired OCT volume in all three dimensions. This resulted in a significant noise reduction in all directions and preservation of retinal and choroidal structures. After image normalization and contrast enhancement, subsequent threshold-filtering of choroidal vessels enabled extraction of choroidal vessels and tissue.[7-8]

According to the international nomenclature for optical coherence tomography, hyporeflective choroidal areas were defined as vessels and hyperreflective structures as tissue.[9]

Results and discussion

Ocular tumors may show a significant threat to a patients vision. Therefore, diagnosis at an early stage would be desired. Speckle-noise removal was obtained in choroidal nevi from patients suffering from choroidal tumors. The method allowed a non-invasive, non-contact speckle-noise freed OCT choroidal angiography and choroidal tumoropsy. Results of speckle noise removal are shown in Figures 1-3.

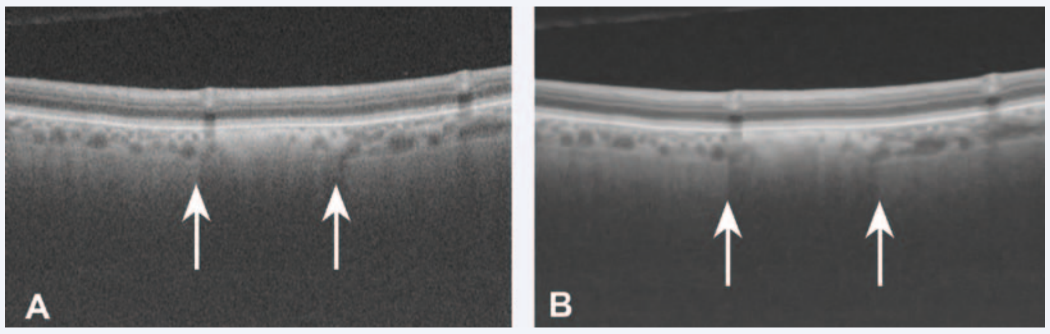

Figure 1: Image enhancement using speckle noise removal from OCT volume scan. Cross sectional Swept Source OCT from a 3D macular cube (SSOCT, Topcon DRI OCT, Topcon Japan) of a relative flat, choroidal nevus. The choroidal nevus shows hyperreflectivity, a moderate posterior OCT signal loss and a reduced density of choroidal vessels. Within the tumor only minor choroidal vessels are depicted because of tumor displacement, signal adsorption and scattering. The retina is normal (A). Same scan after speckle noise removal using a three-dimensional signal-tracker filter with structural preservation shows enhanced visualization of retinal and choroidal structures (B). White arrows indicating nevus.

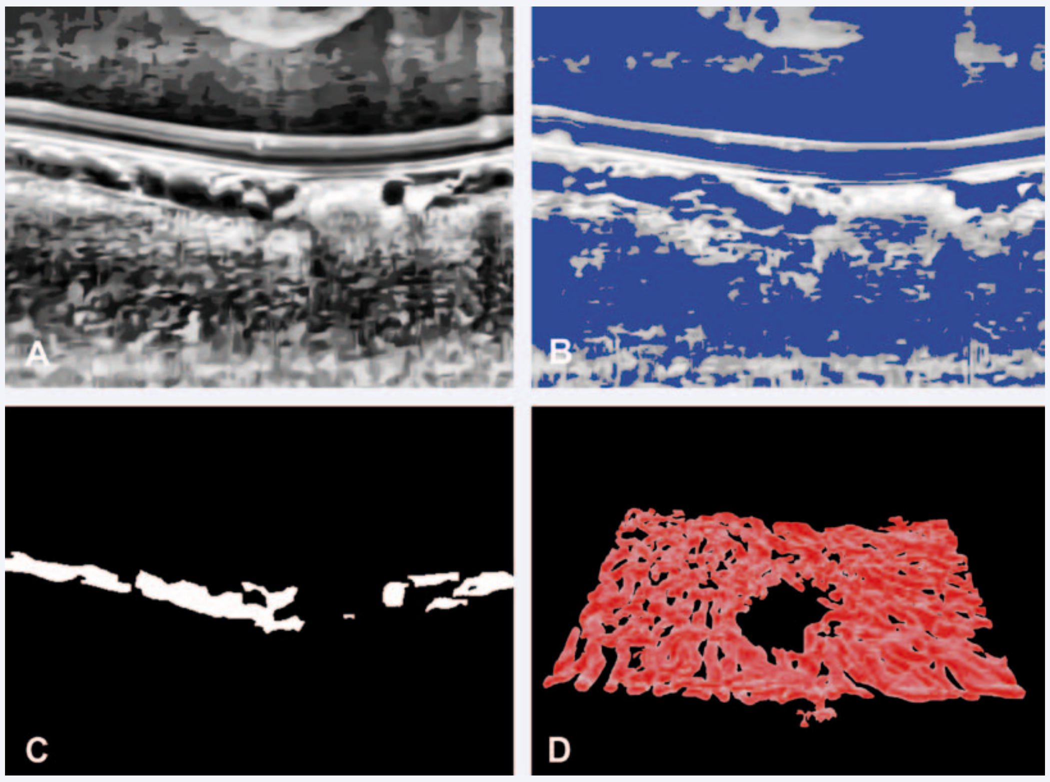

Figure 2: Speckle noise freed choroidal angiography of a choroidal nevus. Cross sectional image of a choroidal nevus after contrast image normalization, contrast enhancement and correction for aspect ratio (A). Threshold filtering of hyporeflective structures (B). Segmentation and extraction of choroidal vessels in a single cross sectional B-scan (C). Three-dimensional model of choroidal vessels calculated from 256 speckle noise freed OCT B-scans of a choroidal nevus (OCT choroidal angiography, D).

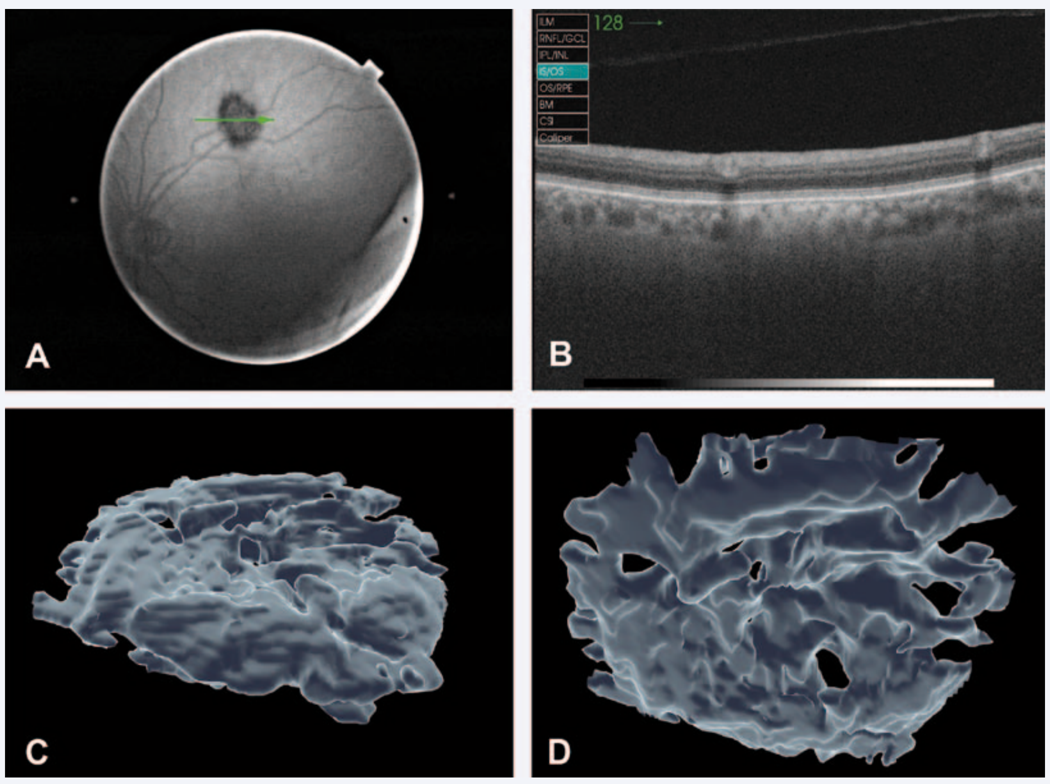

Figure 3: Non-invasive virtual choroidal tumoropsy of a choroidal nevus using speckle-noise freed Swept Source OCT (SSOCT). Fundus imaging of a small, temporal-superior located choroidal nevus. Green arrow indicating area of cross sectional OCT measurement (A). Choridal nevus shows hyperreflectivity, minor thickening of the choroid, reduced amount of choroidal vessels (B). Three-dimensional OCT model (virtual OCT choroidal tumoropsy) of a choroidal nevus calculated from speckle-noise freed, segmented and extracted SSOCT volume (view from top, C; view from below, D).

As a post-processing method, the described algorithm may be used on all standard spectral-domain or advanced 1050 nanometer OCT systems and liberate the OCT signal from noise and provide further enhanced imaging of all ocular tumors. The limitation of speckle-noise removal are the relative long rendering time in all three dimensions, the need for a relative high number of cross sectional images, and the impossibility to use the technology described for the analysis of a single layer image. Furthermore, the new method has to be validated in new studies.

However, the proposed algorithm may allow a novel approach in the qualitative and quantitative assessement of ocular tumors and other ocular pathologies such as diabetic retinopathy, glaucoma or age-related macular degeneration (AMD).

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Disclosure of potential conflicts of interest
Dr. Peter Maloca and Cyrill Gyger are owner of intellectual property on speckle noise analysis discussed in this publication. Dr. Peter Maloca and Dr Hasler are consultant of Mediconsult/Topcon but the organisation had no role in the design or conduct of the presented manuscript.

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