昭衍
JOINN

In vivo Imaging and Quantification of Retinal and Choroidal Vasculature in Cynomolgus Monkeys using Optical Coherence Tomography Angiography

Jin Cai, Wankun Xie, Sucai Zhang, Ted Zhao
JOINN Laboratories (Suzhou) Co., Ltd. Suzhou, CHINA

Jin Cai, Wankun Xie, Sucai Zhang, Ted Zhao
JOINN Laboratories (Suzhou) Co., Ltd. Suzhou, CHINA

JOINN Laboratories | www.joinnlabs.com
Contact: bd@biomere.com

昭衍
JOINN

In vivo Imaging and Quantification of Retinal and Choroidal Vasculature in Cynomolgus Monkeys using Optical Coherence Tomography Angiography

2146845

Jin Cai, Wankun Xie, Sucai Zhang, Ted Zhao
JOINN Laboratories (Suzhou) Co., Ltd. Suzhou, CHINA

ABSTRACT

Optical coherence tomography angiography (OCTA) is a non-invasive technique that visualizes the retinal and choroidal microvascular system. Non-human primates (NHPs) are commonly utilized in preclinical ocular research due to their anatomical and genetic similarities to humans. This study aimed to characterize OCTA features in NHPs and establish standardized evaluation methods for retinal vascular complexes.

Nine eyes from six healthy adult cynomolgus monkeys were examined using OCTA with Heidelberg Spectralis HRA+OCT, capturing macular and peripapillary regions (20° × 20° , 512 A-scans/B-scan, 512 B-scans/volume). Images were segmented and quantitatively analyzed using Fiji/ImageJ software.

Results demonstrated clear visualization of superficial vascular complex (SVC) and deep vascular complex (DVC). The superficial capillary plexus (SCP) exhibited an intense, fine capillary network, while the deep capillary plexus (DCP) showed a dense capillary network surrounding the perifoveal area. Choriocapillaris displayed numerous hyper- or hypo-intense dots, and larger choroidal vessels appeared as distinct hypo-intense linear structures. Vascular density (VD) at the SVC level was 47.70 ± 2.64% (macular) and 48.18 ± 2.92% (peripapillary). DCP macular VD was 34.14 ± 3.54%. The foveal avascular zone (FAZ) at the DCP level measured an area of 14474.3 ± 3811.67 μm² with specific shape parameters.

In conclusion, OCTA provides high-resolution, non-invasive visualization and quantifiable measurements of retinal and choroidal microvasculature in NHPs, supporting its use in longitudinal studies for evaluating novel ocular therapies in preclinical research.

METHODS

The OCTA images (20° ×20° ,512 A-scans/B-scan and 512 B-scans/volume) were obtained from the macula (fovea-centered) and peripapillary (optic nerve head-centered) region using the OCTA module of Heidelberg Spectralis HRA+OCT. After segmentation into different layers, images were processed using Fiji/ImageJ software, and quantitative parameters of the retinal vasculature were evaluated. Nine eyes from six healthy adult cynomolgus monkeys and one eye from a laser-induced choroidal neo-vascularization (CNV)-cynomolgus monkey were included in this study.

RESULTS

In cynomolgus monkeys, retinal and choroidal microvasculature can be visualized using the OCTA system. The superficial vascular complex (SVC, ILM to IPL [-]) and deep vascular complex (DVC, IPL [-] to OPL) can be clearly distinguished in the retinal layer. The superficial capillary plexus (SCP) appears as a fine capillary network with an intense signal. Deep capillary plexus (DCP) presents a dense capillary network developing all around the perifoveal area and participates in contouring the foveal avascular zone (FAZ). The corresponding B scan image displays hyperreflective dots stratified in two layers. In the choroidal layer, choriocapillaris exhibit numerous tiny hyper- or hypo-intense dots in a homogeneous pattern, while large choroidal vessels exhibit distinct hypo-intense linear structures in OCTA images. A standard method to quantitatively analyze OCTA images of the macular and peripapillary vessels was provided in this study (Fig.1).

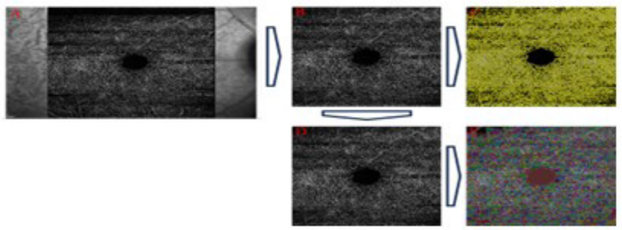

Fig.1 OCTA scan of the macular deep vascular complex (A). Post-process images to quantify vascular density (B and C) and shape parameters of foveal avascular zone (D and E). The original images exported from the Spectralis HRA+OCT (A) was cropped to the size of 800×800 pixels, with the color channel of RGB (B). Adjust the brightness value range in the module of color threshold to select areas with blood flow signals (C). Convert the color channel from RGB to 8-bit (D). Segment foveal avascular zone by the plugin of Morphological Segmentation (E).

At the level of SVC, mean vascular density (VD) of the macular (mSVC) and peripapillary (pSVC) vessels was 47.698 ± 2.636% and 48.176 ± 2.916%, respectively. At the level of DVC, mean VD was 34.14 ± 3.54% in the macular area. At the level of DVC, the mean area, circularity, aspect ratio, roundness, and solidity of the FAZ were (1.447 ± 0.381)^10⁴ μm², 0.67 ± 0.1, 1.16 ± 0.1, 0.868 ± 0.08, 0.895 ± 0.038, respectively (Fig.2).

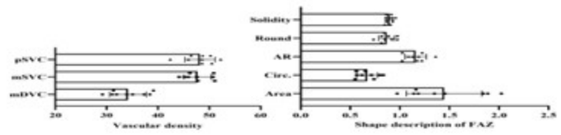

Fig.2 Normal values of vascular density (left) and shape parameters of FAZ (right) using a standard method to quantitatively analyze OCTA images of the macular and peripapillary vessels. Data are presented as mean ± SD. The solid points represent individual values.

Moreover, OCTA images of one eye from a laser-induced CNV-cynomolgus monkey was processed using this method (Fig.3).

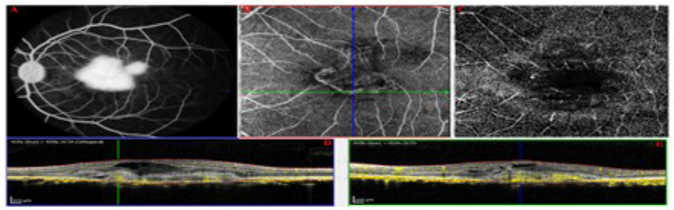

Fig.3 Fundus fluorescein angiography and OCTAblood images of one eye from a laser-induced CNV-cynomolgus monkey. (A) Fluorescence leakage in the late phase indicated the progression of neovascularization. (B) Abnormal flow signals in all complexes of retina (confirmed to be presented in the avascular complex, from ONL to RPE). (C) Severely disrupted capillary network of DVC, with slightly decreased vascular density in DVC and SVC (29.963% and 43.039%, respectively) but severely disrupted capillary network in FAZ (the area, circularity, aspect ratio, roundness, and solidity were 4.702*10⁴ μm², 0.446, 1.375, 0.727, 0.837, respectively), which may be attributed to macular edema caused by neovascularization. (D and E) The b scan image from the correspond position of (B), and the yellow dots represents the blood flow signal.

CONCLUSION

OCTA enables non-invasive visualization of retinal and choroidal microvasculature in NHP with high resolution, providing quantifiable *in vivo* measurements for longitudinal analysis, suggesting that OCTA is useful for investigating novel therapies in animal models of NHP in preclinical ocular research.

CONTACT

Wankun Xie, xiewankun@joinn-lab.com
www.joinnlabs.com