

Original Article

Variation in subfoveal choroidal thickness in patients with high myopia complicated by choroidal neovascularization

Junbo Rong^{1*}, Yuan Wang^{1,2}, Lijuan Wei^{1*}, Dongmei Zhu^{2*}, Jinsong Zhang^{1*}

¹Department of Ophthalmology, The First Affiliated Hospital of Zhengzhou University, No. 1, Jianshe East Road, Zhengzhou 450000, Henan, China; ²Department of Ophthalmology, Zhengzhou Central Hospital Affiliated to Zhengzhou University, Zhengzhou, China. *Equal contributors and co-first authors.

Received September 14, 2015; Accepted July 9, 2016; Epub August 15, 2016; Published August 30, 2016

Abstract: The aims of this study was to observe the variation in subfoveal choroidal thickness (SFCT) in patients with highly myopic macular complicated by choroidal neovascularization (CNV) and to compare choroidal thickness in these eyes with highly myopic eyes without CNV, matched with the others group by ages, genders, eye axial length and diopter. 72 cases with 72 eyes, confirmed with high myopia in the ophthalmology clinic outpatient of The First Affiliated Hospital of Zhengzhou University from September 2013 to August 2014, were collected in this study. 36 cases with 36 eyes in the group without CNV and similarly, 36 cases with 36 eyes in the group with CNV. Eye axial length, diopter, eye ground and spectral-domain optical coherence tomography examinations were performed on the two groups. Subfoveal choroidal thickness observed in high myopia without CNV group was $(102.38 \pm 39.05) \mu\text{m}$, while that in high myopia with CNV group was $(61.72 \pm 22.28) \mu\text{m}$. The difference of choroidal thickness (CT) between the each two groups was statistically significant ($t=5.16$, $P<0.05$). A statistically significant negative correlation was found between CT and eye axial length. In high myopia group, $r=-4.13$ and $P=0.012$, while in high myopia with CNV group, $r=-5.52$ and $P=0.000$. The development of high myopia may be associated with the choroid blood perfusion. The thinning of choroidal thickness led by reduced choroid blood perfusion may play a role in the occurrence of choroidal neovascularization.

Keywords: Subfoveal choroidal thickness, choroidal neovascularization, high myopia

Introduction

High myopia is one of the major reasons for the irreversible visual loss in worldwide. It has been the second reason for low vision and blindness among adults in China, next only to cataract [1]. High myopia is mainly expressed as various pathological changes of eye ground, such as macular hole, retinoschisis, retinal detachment, Fuchs spots, lacquer crack and retinal degeneration. Among those, choroidal neovascularization (CNV) is the vital complication seriously harming eyesight, and it can lead to sub-retinal hemorrhage, effusion and the scars formation in macular region [2]. Although it is generally considered at present that vascular endothelial growth factor (VEGF) plays an important role in the CNV occurrence, numerous other factors also participate in the patho-

genetic process of high myopia CNV, including the atrophy degeneration of retina, the occurrence of posterior scleral staphyloma and the appearance of lacquer crack. Especially, in recent years, there are studies showing that the changes in the choroidal regional blood flow and the thinning of the choroidal thickness may have close relationships with the occurrence of high myopia CNV. So far, spectral-domain imaging optical coherence tomography (SD-OCT) can not only intuitively display the retinal tissue structure, which is used in the CNV diagnosis, but also provide the choroid cross-sectional imaging, which helps to measure the choroidal thickness from Bruch's membrane to the internal layer of sclera and acknowledge the abnormality of CNV in the choroid layer. Analyzing the variation in choroid among high myopia patients is conducive to determine the lesion degree of

Subfoveal choroidal thickness

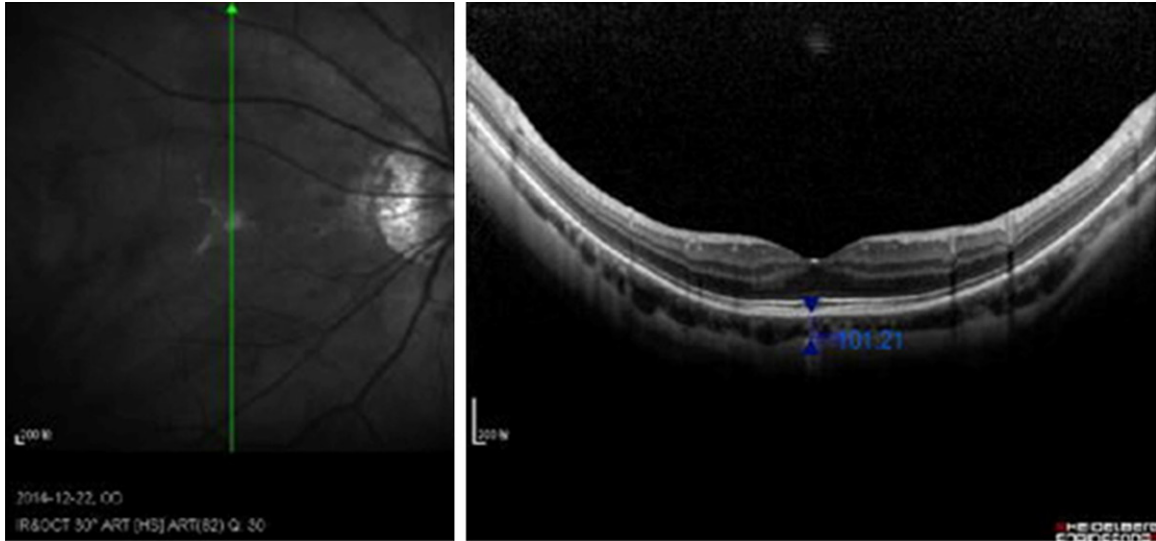


Figure 1. EDI-OCT observed in highly myopic eyes without CNV.

high myopia and that whether there is other complications of eye ground. Therefore, this study, through adopting SD-OCT enhanced depth imaging optical coherence tomography (EDI-OCT) to make subfoveal choroidal thickness (SFCT) measurement on high myopia with CNV eyes and high myopia without CNV eyes, respectively, and making primary analysis on the data between the two groups, provided theoretical basis for the pathogenesis basic researches of high myopia with CNV.

Information and methods

Study subjects

Seventy-two cases with 72 eyes, confirmed with high myopia in the ophthalmology clinic outpatient of The First Affiliated Hospital of Zhengzhou University from September 2013 to August 2014, were collected in this study. There were 40 males (40 eyes) and 32 females (32 eyes) with high myopia, with ages ranging from 18 years to 66 years, an average age of (41.41 ± 4.72) years, eye axial length at 23.91~30.52 mm (average at (27.07 ± 3.89) mm) and myopic diopter at -6.50~-19.25 D (average at (12.75 ± 6.50) D). At the same time, eye ground was expressed with pathologic changes involving in retina peripheral lattice degeneration region or non-compressive white change, peripapillary atrophy, optic disc tilt, posterior scleral staphyloma, lacquer crack at macular area and submacular CNV. In accordance with whether there was CNV below the macular, high myopia patients were divided into with CNV

group of 36 cases with 36 eyes and without CNV group of 36 cases with 36 eyes. Patients in both two groups showed matches among ages, genders, eye axial length and diopter. Apart from high myopia, profiles of ophthalmic diseases, eye surgery history, eye laser history and turbid dioptric media affecting OCT detection were excluded for patients in the two groups.

Methods

The basic information of patients was recorded. The examinations of uncorrected visual acuity (comparing with international visual chart), anterior ocular segment (slit lamp), eye ground (indirect ophthalmoscopy), intraocular pressure (CT-80A type, TOPCON, Japan), eye axial length (IOL-Master), diopter (AOS-1500 type, AUTO OPTOMETRY SYSTEM, Guangzhou Shi Tong Optics Equipment, CO.LTD), fundus camera (FF450 TYPE, ZEISS, Germany) and SD-OCT (SPECTRALIS type, HEIDELBERG, Germany) were conducted. As to the cases similar to CNV, a confirmed diagnosis was made by combing with fundus fluorescein angiography (FFA). Besides, the SFCT of subjects accepted examination was measured by adopting the EDI model of SD-OCT. OCT examination was accomplished by the same inspector who was at skilled operation.

Statistical treatment

SPSS 19.0 statistical software was applied for analysis. Mean \pm standard deviation ($x \pm s$) was

Subfoveal choroidal thickness

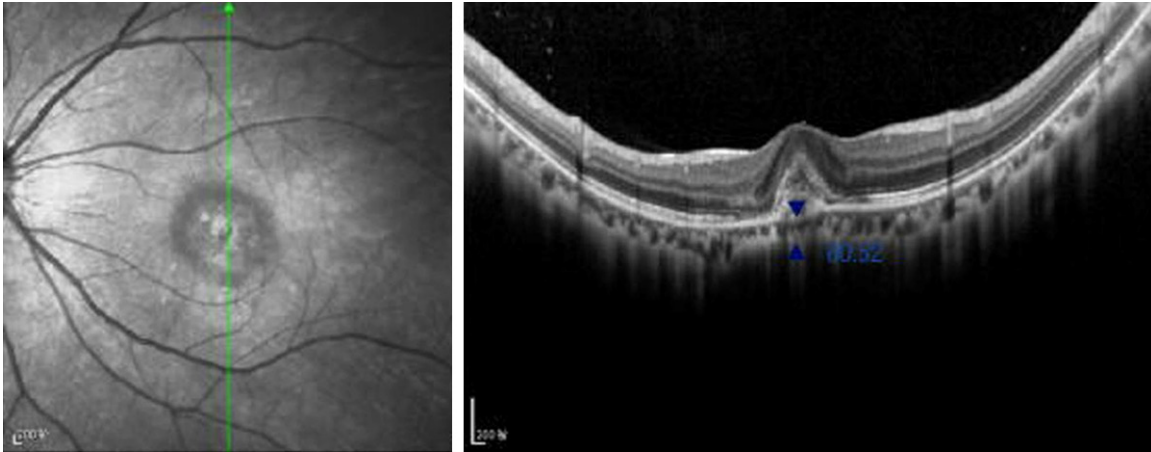


Figure 2. EDI-OCT observed in high myopia with CNV.

represented for measurement data. Homogeneity test of variance was performed on the matched ages, genders, eye axial length and diopter, among which $P > 0.01$ was considered equal variance; the choroidal thickness between two groups were compared by adopting compared matched t test in the two samples, in which $P > 0.01$ was considered statistically significant difference; Choroidal thickness and eye axial length were examined respectively by applying linear correlation analysis, and $P > 0.01$ showed statistically significant difference.

Results

Choroidal thickness below the macular region among patients in the two groups

In the high myopia without CNV group, the ages at (41.50 ± 14.51) years, eye axial length at (28.08 ± 1.09) μm and choroidal thickness at (102.38 ± 39.05) μm ; while in the high myopia with CNV group, the ages at (41.58 ± 13.47) years, eye axial length at (28.69 ± 1.47) μm and choroidal thickness at (61.72 ± 22.28) μm . Difference for the choroidal thickness between two groups by adopting compared matched t test in the two samples was statistically significant ($t=5.16$, $P < 0.05$) (EDI-OCT images for patients in two groups were seen in **Figures 1** and **2**).

Relationships between choroidal thickness and eye axial length for patients in the two groups

A negative correlation was shown between choroidal thickness and eye axial length in the two

groups. A statistically significant difference was found between high myopia group ($r=-0.738$, $P < 0.05$) and high myopia with CNV group ($r=-0.840$, $P < 0.05$). Moreover, the correlation between choroidal thickness and eye axial length in the two groups was stronger and stronger (See **Figure 3**).

Discussion

In the clinical ophthalmic work, the shortsightedness larger than -6.00 D is usually called high myopia. Because the eye ground is always accompanied with pathologic changes such as choroidal atrophy, lacquer crack, Fuchs spots, choroidal neovascularization, macular retinoschisis, peripheral lattice degeneration region, dried ceasma, that is also called pathologic myopia or degenerated myopia [3]. At present, researches have been taken on the high myopia animal model as well as the formation, transmission and visual quality of the visual information on retina, which have been achieved results. But the interrelation between high myopia and choroid is still in the start-up phase. The recent researches has been considered that the regulation of choroid is participating the formation and development of high myopia [4]. Choroid, as the densest section in the whole body blood vessel, plays the role in supplying nutrients for ectoretina, macular area and preoptic nerve of lamina cribrosa as well as carrying away the metabolic waste. Therefore, the variation in choroidal structure and functions is able to induce various ophthalmic diseases, such as central serous chorioretinopathy, age-related macular degeneration, polypo-

Subfoveal choroidal thickness

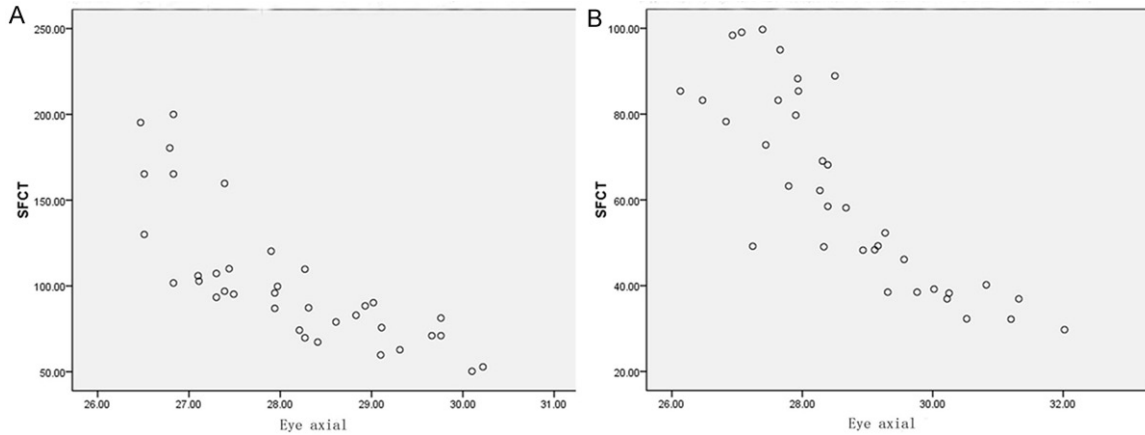


Figure 3. The correlation between CT and AL in two group. A. The correlation between CT and AL in highly myopic eyes without CNV. B. The correlation between CT and AL in high myopia with CNV.

idal choroidal vasculopathy, angioid streaks and high myopia. The occurrence of choroidal neovascularization is a turning point during the natural course of high myopia, because it seriously harms the eyesight, especially when involved the macular central fovea, it will results in losing most patients' sight [5]. For high myopia patients, the avulsion at capillary wall of pigment epithelium layer-Bruch membrane-choroid and the formation of lacquer crack on tissue repair which is leaded by the expansion of eyeball posterior pole provide tissue spaces for new vessels getting into retina from choroid [6]. Moreover, due to the microcirculation disturbance of choroid, hydroxy-ischemia provides an essential condition for the formation of new vessels. Studies have discovered that choroidal thickness in macular area with high myopia becomes thinning [7]. Our study also confirmed that on either the high myopia with CNV or high myopia without CNV, the choroidal thickness in macular area was equally significantly thinning, in which that in the high myopia with CNV became thinner; hence, it was speculated that the thinning of choroid in macular area may lead to the decrease of choroidal blood flow and stimulating the VEGF secretion leaded to the retina hydroxy-ischemia, thus occurring CNV.

Studies have been found that the choroidal thickness in macular area in the high myopia early stage has been changed, earlier than the abnormality of eye ground change and visual function examination, changing with the changes of the lesion degree. So, choroidal thickness in macular area maybe a good observation

index [8]. The changes of choroidal thickness probably is caused by the changes of choroidal liquid osmotic pressure. Histological observation has been indicated that in the recovery phase of form-deprivation myopia, there are numerous liquid getting into choroid from retina, the active transport of liquid in choroidal lymphatic system is enhanced and the thickness also has some increase; and that maybe induced by the choroidal blood vessel density and plentiful status by the active materials in choroidal vessels. Suffered from the innervation of internal ganglion [9] and participation of central nervous system [10], vascular smooth muscle cells are able to result in the changes in the occurrence of choroidal vessels, the decrease of choroidal thickness and the weakness of the ability of blood-supply and oxygen supply to ectoretina, thus making photoreceptor injury and visual dysfunction. Therefore, the accurate observation in the variation of choroidal structure has a critical clinical significance. Before the appearance of EDI-OCT, the measurement of choroidal thickness mainly depends on histological examination method. Due to the influences of ocular perfusion pressure and vaso-active substances in the body, the measurement on the isolated tissues cannot reflect the real thickness of the living organisms. In recent years, the appearance of EDI-OCT has made the full-thickness choroidal imaging of living organisms be possible. With the utilization of this technology, it has discovered that SFCT is relative to the perfusion pressure in eyes, which can indirectly reflect the blood perfusion status beneath the macular [10-12]. There were also studies showing that

Subfoveal choroidal thickness

choroidal thickness had negative correlations with ages and eye axial length [7]. The measured data in this study also had been confirmed that in different groups, choroidal thickness indicated a negative correlation with eye axial.

It was concluded that EDI-OCT provided non-intrusive and repeatable detection approach for observing choroid in clinic, which was able to effectively observe the choroidal thickness changes during the occurrence and development process of different diseases. This study, through the measurement on the choroidal thickness of high myopia patients, was to acknowledge the change degrees of choroidal thickness during CNV occurrence period among high myopia patients, which was conducive to provide some new thoughts and supplements for the researches on the changes in the high myopia development. On the whole, this is a new research orientation. However, due to the technological limitation, the information of choroidal internal fine structure was not able to provide. How to evaluate the changes of choroidal thickness on the status and guidance for clinical treatment during the occurrence and development of high myopia CNV was still not clear, which needed further confirmation.

Disclosure of conflict of interest

None.

Address correspondence to: Jinsong Zhang, The First Affiliated Hospital of Zhengzhou University, No. 1, East Jianshe Road, Zhengzhou 450000, Henan, China. E-mail: zhangjs166@163.com

References

- [1] Xu L, Wang Y, Li Y, Wang Y, Cui T, Li J, Jonas JB. Causes of blindness and visual impairment in urban and rural areas in Beijing: the Beijing Eye Study. *Ophthalmology* 2006; 113: 1134, e1-11.
- [2] Zhao PQ, Xu Y. High myopia-related macular lesions: diagnosis and treatment. *Chin J Ocul Fundus Disx* 2006; 25: 327-330.
- [3] Zhu ZC, Zhang JS, He GJ. Curative effects of posterior scleral reinforcement in high myopia patients with macular retinoschisis. *Rec Adv Ophthalmol* 2009; 29: 452-454.
- [4] Flores-Moreno I, Lugo F, Duker JS, Ruiz-Moreno JM. The relationship between axial length and choroidal thickness in eyes with high myopia. *Am J Ophthalmol* 2013; 155: 314-319.
- [5] Avila MP, Weiter JJ, Jalkh AE, Trempe CL, Prurtt RC, Schepens CL. Natural history of choroidal neovascularization in degenerative myopia. *Ophthalmology* 1984; 91: 1573-15781.
- [6] Li SQ, Wen F, Wu WJ, et al. Analysis of classification and fundus fluorescein angiographic characteristics of high myopia maculopathy. *Rec Adv Ophthalmol* 2007; 27: 113-115.
- [7] Flores-Moreno I, Lugo F, Duker JS, Ruiz-Moreno JM. The relationship between axial length and choroidal thickness in eyes with high myopia. *Am J Ophthalmol* 2013; 155: 314-319.
- [8] El Matri L, Bouladi M, Chebil A, Kort F, Bouraoui R, Lagueche L, Mghaieth F. Choroidal thickness measurement in highly myopic eyes using SD-OCT. *Ophthalmic Surg Lasers Imaging* 2012; 43: 38-43.
- [9] Atkinson J, Braddick O, Robier B, Anker S, Ehrlich D, King J, Watson P, Moore A. Two infant vision screening programmes: prediction and prevention of strabismus and amblyopia from photo-and videorefractive screening. *Eye* 1996; 10: 189-198.
- [10] Wildsoet C, Wallman J. Choroidal and scleral mechanisms of compensation for spectacle lenses in chick. *Vision Res* 1995; 35: 1175-1194.
- [11] Kim M, Kim SS, Kwon HJ, Koh HJ, Lee SC. Association between choroidal thickness and ocular perfusion pressure in young, health subjects: enhanced depth imaging optical coherence tomography study. *Invest Ophthalmol Vis Sci* 2012; 53: 7710-7717.
- [12] Li L, Yang ZK, Dong FT. Choroidal thickness in normal subjects measured by enhanced depth imaging optical coherence tomography. *Chin J Ophthalmol* 2012; 48: 819-823.