

Original Article

Comparison of retinal nerve fiber layer thickness between normal and patients with high myopia after phacoemulsification surgery

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Abstract: Objective: To compare the change of retinal nerve fiber layer thickness between normal and patients with high myopia in the short term after phacoemulsification combined with intraocular lens implantation. Methods: An analysis of phacoemulsification and intraocular lens implantation in 52 eyes of 46 patients from September 2013 to December 2013 in Tongji Hospital, measured the retinal nerve fiber layer thickness with optical coherence tomography, and compared the changes of RNFL thickness at different time after surgery with before operation in two groups. Results: Before surgery, the mean retinal nerve fiber layer thickness value was $94.43 \pm 9.35 \mu\text{m}$ in simple age-related cataract group, compared with high myopia group of $90.68 \pm 10.15 \mu\text{m}$, there was statistical difference ($t = -3.653$, $P < 0.001$). The first postoperative day, there was no change of the retinal nerve fiber layer thickness in both groups ($94.42 \pm 9.15 \mu\text{m}$ and $91.32 \pm 10.06 \mu\text{m}$). From the first postoperative week, the retinal nerve fiber layer thickness began to thickening, the values upped to maximum of $100.09 \pm 7.57 \mu\text{m}$ and $100.25 \pm 10.25 \mu\text{m}$ in two groups, and compared with preoperation, there was significant statistical differences in both groups ($t = -5.384$, $t = -4.844$, $P < 0.001$). To the sixth postoperative month, the optic disc edema reduced gradually, the retinal nerve fiber layer thickness became thinning. Conclusion: Phacoemulsification surgery perhaps damages the retinal nerve fiber layer, especially for high myopia patients.

Keywords: Retinal nerve fiber layer, high myopia, phacoemulsification, optical coherence tomography

Introduction

High myopia is defined as the diopter greater than or equal to -6. As the growth of the age, the eye axis length is gradually stretching. There are multiple retrogressive changes in fundus: posterior scleral staphyloma, leopard fundus, lacquer cracks, Fuchs' spots and neovascularization, etc. Because of the special structure of high myopia, it often accompanies complications such as macular hole, retinal detachment, glaucoma and cataract. The retinal nerve fiber layer (RNFL) is mainly composed of the axons of retinal ganglion cells, it also includes Müller cell, neurogliocytoma, retinal vessels, etc. Retinal nerve fiber layer is an important part of retina; at the same time, it is significant criterion of glaucoma diagnosis. The influence factors include physiological and

pathological factors. Study [1] have found that myopia eye, especially high myopia, accompanies the change of retinal nerve fiber layer.

With the development in cataract surgery, more and more patients get rid of blindness or low vision. Even in certain metropolises in China, as the strong demands from broad high myopia patients with cataract, phacoemulsification (PHACO) has been transform to refractive surgery from rehabilitation surgery. In past, the researches [2, 3] focused on the change of corneal endothelial cell and macula after cataract surgery, while lack of study of RNFL, especially to high myopia or diabetic retinopathy (DR) patients. In this study, we chosen high myopia patients performed PHACO surgery, measured the RNFL thickness by optical coherence tomography (OCT) technology and observed the quantity change in the short term.

Comparison of RNFL thickness

Materials and methods

Patients

Totally 52 eyes of 46 cataract patients from Shanghai between 65 and 76 years old (average 69.13 ± 8.70) were enrolled in this study. All cases were divided into two groups, in which group A (23 patients, 29 eyes) was age-related cataract without any complications and group B (23 patients, 23 eyes) with high myopia, performed PHACO and intraocular lens implantation (IOL) from September 2013 to December 2013 in Department of Ophthalmology. All patients got routine ophthalmic examination: uncorrected vision acuity, best corrected visual acuity (BCVA), photofixation, astigmatism, slit lamp, ophthalmoscope, corneal endothelium, specular microscope, keratometry, A/B ultrasonic, lacrimal passage irrigation, etc. Fasting blood-glucose below 8 mmol/L before operation. Exclude ocular infection diseases, such as acute conjunctivitis and chronic dacryocystitis, etc. These participants did not have optic nerve diseases and ocular funds diseases, had not underwent intraocular operation, and had no systemic diseases with possible ocular involvement, such as diabetes mellitus. All study procedure followed tenets of the Declaration of Helsinki and the study protocol had been approved by the Institutional Review Board of Tongji Hospital affiliated to Tongji University. Written informed consents were obtained from all the participants.

Surgical technique

All surgeries were operated by the same experienced ophthalmologist (Dr. Rong). Before operation, 0.5% Tropicamide eyedrops (SANTEN OY, Japan) was used to each operative eye and made pupil dilated to 6 mm at least. PHACO surgery was performed under ocular surface anesthesia by using 0.5% Alcaine eyedrops (ALCON, Inc). A sclerocorneal incision (3.5 mm from the 12:00 position of corneal limbal) and a side incision (3.5 mm from the 2:00 position of corneal limbal) were made, and anterior curvilinear continuous capsulorrhexis, using Healon (BAUSCH+LOMB, USA) as viscoelastic substance and hydrodissection was performed. The lens nuclei were divided by the chop method, then phacoemulsification and aspiration were performed. After cortical aspiration, an acryl-foldable posterior chamber intraocular

lens was inserted. There was no significant difference between two groups in phacoemulsification time and intraocular infusion volume.

OCT examination

All retinal nerve fiber layer thickness (RNFLT) was measured using Cirrus HD-OCT (software version 3.0.0.64). Every participant sat with mandible on the jaw-frame on the equipment. The technician adjusted the jaw-frame to correct eye position and to compensate for refractive error. Images were obtained with internal fixation. The Optic Disk Cube 200×200 axial protocol was used for scanning: the optic disc was divided into four quadrants including superior, inferior, nasal and temporal by two vertical lines through the center of optic disc with 45°. After high-quality images were obtained, the mean retinal nerve fiber layer thickness was calculated automatically using the existing algorithms. On the analysis page, the RNFL thickness, signal strength and binocular symmetry were displayed. To make sure the accuracy of the results, only the signal strength higher than 6 of image was accepted in our study.

Statistical analysis

Data was analyzed with by SPSS 17.0 (SPSS Inc., Chicago, IL, USA). All data ran the normal distribution and homogeneity of variance tests before analysis and they were expressed as mean \pm standard deviation this article. The mean RNFL thickness in two groups were analyzed using independent sample t-test; while comparison mean RNFL thickness in high myopia group between pre-operation and various postoperative time was analyzed using One-Way ANOVA. The *P* value less than 0.05 was considered statistically different, and less than 0.01 was considered remarkable statistical difference.

Results

Table 1 showed that the retinal nerve fiber layer thickness of operative eye in two groups before PHACO surgery. In normal control group, the retinal nerve fiber layer thicknesses of average, inferior, superior, nasal and temporal were $94.43 \pm 9.35 \mu\text{m}$, $128.10 \pm 25.30 \mu\text{m}$, $100.46 \pm 9.68 \mu\text{m}$, $81.72 \pm 8.79 \mu\text{m}$ and $93.03 \pm 8.68 \mu\text{m}$, respectively. At the same time, in high myopia

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Table 1. The retinal nerve fiber layer thickness of operative eye in two groups before operation ($\bar{x} \pm s$, μm)

	Average	Inferior	Superior	Nasal	Temporal
Normal control	94.43±9.35	128.10±25.30	100.46±9.68	81.72±8.79	93.03±8.68
High myopia	90.68±10.15	114.3±9.80	95.56±10.14	83.65±10.25	95.89±9.98
<i>t</i>	-3.653	-4.371	-5.014	-5.537	0.196
* <i>P</i>	<0.001	<0.001	<0.001	<0.001	0.012

**P*: Independent sample *t* test.

Table 2. Comparison of the mean RNFL thickness in two groups at different time after operation ($\bar{x} \pm s$, μm)

Pre-operation	Post-operation					
	1 d	1 w	1 m	3 m	6 m	
Normal control	94.43±9.35	94.42±9.15	97.46±9.68	98.09±7.57	100.09±7.57	95.63±10.12
High myopia	90.68±10.15	91.32±10.06	95.56±10.14	97.64±9.86	100.65±10.25	91.81±10.03
<i>t</i>	-3.653	-4.668	-5.384	-5.633	-4.844	-4.743
* <i>P</i>	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

RNFL: retinal nerve fiber layer; **P*: Independent sample *t* test.

Table 3. *P* value of comparison in pairs of mean RNFL thickness in high myopia group at different time after operation

	Pre-operation	Post-operation				
		1 st day	1 st week	1 st mon	3 rd mon	6 th mon
Pre-operation	-	0.254	0.021	0.021	0.020	0.981
1 st postoperative day	0.254	-	0.230	0.227	0.197	0.498
1 st postoperative week	0.021	0.230	-	0.697	0.684	0.510
1 st postoperative mon	0.020	0.237	0.697	-	0.877	0.498
3 rd postoperative mon	0.017	0.198	0.663	0.877	-	0.377
6 th postoperative mon	0.116	0.478	0.478	0.456	0.377	-
Total difference				0.124		

95.56±10.14 μm , 97.64±9.86 μm , 100.65±10.25 μm and 91.81±10.03 μm , respectively.

Table 3 showed all *P* values are compared in pairs between pre-operation and different time point after operation in high myopia group. Among, compared with pre-operative value, significant thickening in the first week, the first month and the third

month after PHACO surgery. There is no statistical difference about comparison in pairs at the rest of different time

Discussion

As universalness of PHACO surgery in China, it has been the main surgical method and made the majority of patients' visual rehabilitation in metropolises. As all known, there were surprising number of myopia people in China [4], especially high myopia patients who were eager to get rid of subnormal visual acuity through surgery. In the past, the studies [5, 6] about complications after PHACO surgery mainly concentrated on cornea and macular. And as the gradually perfection of preoperative examination and surgical skills, the complication which appeared in cornea and macular region gradu-

group, the retinal nerve fiber thicknesses were 90.68±10.15 μm , 114.30±9.80 μm , 95.56±10.14 μm , 83.65±10.25 μm and 95.89±9.98 μm in corresponding quadrants, respectively. From **Table 1**, except temporal quadrant, there were significant differences in global, nasal, inferior and superior quadrants.

All patients' postoperative visual acuity got improved to varying degrees. As shown in **Table 2**, of 29 eyes in normal control group, the mean retinal nerve fiber layer thickness was 94.42±9.15 μm , 97.46±9.68 μm , 98.09±7.57 μm , 100.09±7.57 μm and 95.63±10.12 μm at the first day, the first week, the first month, the third month and the sixth month after operation, respectively. In the meantime, of 23 eyes in high myopia group, the mean retinal nerve fiber layer thickness was 91.32±10.06 μm ,

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ally decreased with each passing year. The retinal nerve fiber layer is important constituent part of retina, and except observing of macular, optical coherence tomography technology also provides the quantized value of retinal nerve fiber layer [7]. This study selected high myopia patients who performed PHACO surgery, evaluated the change of RNFL thickness after operation by OCT, investigated the effect on high myopia patients from PHACO surgery.

The axons of retinal ganglion cells, Müller cell, neuroglia, retinal vessels constitute retinal nerve fiber layer, its influencing factors include dioptric state, age distribution, race [8-13], and so on. In our study, the mean retinal nerve fiber layer thickness in normal control group was $94.43 \pm 9.35 \mu\text{m}$, this was different from reports [14-16] from other countries and areas: Sani RY and associates [23] measured Northern Nigerian adult's RNFL thickness was $104.17 \pm 10.71 \mu\text{m}$; Toshiyuki and colleagues [24] measured Japanese' RNFL thickness was $103.50 \pm 10.60 \mu\text{m}$; Qu and fellows [25] measured RNFL thickness was $96.04 \pm 7.40 \mu\text{m}$ in healthy Chinese from Putuo District of Shanghai. Meanwhile, the mean RNFL thickness in high myopia group was $90.68 \pm 10.15 \mu\text{m}$. This was also same as other report [20]: there was significant difference between normal people and high myopia patients, and there was closely related to diopter, axial length, etc. Expanding eyeball of high myopia leads to retinal choroidal ischemic and hypoxia, making ganglion cell malnutrition and axon degeneration and depletion in number. Retinal area augmentation due to axial stretching, as a consequence, ganglion cell decreased and retinal nerve fiber layer thinning in unit area.

Half a year after PHACO surgery, the mean retinal nerve fiber layer thickness was changing in different degrees which happened in both normal control group and high myopia group. From the first day to the sixth month after surgery, the difference of mean RNFL thickness in two groups always occurred in every point-in-time. This was same as comparative result of mean value before operation. Compared normal control group, the results shown that there was the difference during various condition. As shown in the table, the overall average RNFL thickness of high myopia patients was $90.68 \pm 10.15 \mu\text{m}$ before cataract surgery, which was no statistical significance compared with the first postop-

erative day of $91.32 \pm 10.06 \mu\text{m}$. From the first postoperative week, RNFL thickness began thicken gradually; until the third postoperative month, the thickness was at its thickest of $100.65 \pm 10.25 \mu\text{m}$; then it emerged trend of thinned gradually, and to the sixth month after operation, there was no an evident statistical significance with preoperation.

The reason why turning up the change of retinal nerve fiber layer thickness after phacoemulsification combined with intraocular lens implantation, we considered that retinal nerve fiber layer degeneration and numeric atrophy because of ganglion cell and axon malnutrition, which due to anoxia and ischemic of retina and choroid in high myopic eyeball. Inflammatory reaction was because by mechanical injury of phacoemulsification surgery [21, 22]; traction reaction of optic nerve head induced by parts of vitreous liquefaction in ultrasonic emulsification process [23]; with the addition of optic neuropathy from ultrasonic energy [24]. For all above, these factors could damage optic nerve in varying degrees. To retinal nerve fiber layer thickening for the moment postoperation, based on others' reports [25], we considered that PHACO surgery may be just made papilloedema, rather than retinal ganglion cell depletion.

To sum up, our conclusion in this study is that compared with the group of same age, retinal nerve fiber layer which in superior, inferior and nasal tend to thin in high myopia people; and after phacoemulsification surgery, it appears quickly edema in short term. We think that not only to cornea and macula, phacoemulsification surgery also may cause retinal nerve fiber layer damage, especially to high myopia patient.

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Disclosure of conflict of interest

None.

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