

Retinal vessels caliber changes after strabismus surgery: results of 6mo follow-up

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Abstract

• **AIM:** To evaluate the effect of strabismus surgery on retinal vessels calibers with digital color fundus photographs.

• **METHODS:** Two hundred consecutive strabismus patients underwent surgery, and 118 patients (female/male, 55/63) who finished 6-month follow-up were finally included in this study. Optic disc-centered digital color fundus photographs of both eyes of all patients were taken prior to surgery and 6mo post surgery. The retinal vascular caliber of 116 operated eyes were measured using the computer program IVAN. The operated eyes were divided into 3 groups according to the surgical methods, recession of one muscle, one muscle recession and one muscle folding, one muscle resection and one muscle recession. The effect of number of altered muscles on retinal vessels was analyzed using statistic software SPSS 16.0.

• **RESULTS:** The mean age was 12.4 ± 8.6 y. Averaged central retinal artery equivalent (CRAE) of all patients was 120.31 ± 23.02 μ m preoperatively, and 122.87 ± 15.93 μ m six months after surgery. Averaged central retinal vein equivalent (CRVE) was 171.11 ± 31.73 μ m preoperatively and 175.02 ± 21.00 μ m postoperatively. There was no significant difference of averaged CRAE ($P=0.22$) or CRVE ($P=0.19$) before and after operation. Averaged arteriole to venule ratio (AVR) was 0.71 ± 0.07 before surgery and 0.70 ± 0.07 after surgery. Comparison of preoperative and postoperative retinal vessels calibers among different surgical groups did not show significant differences. Also, there was no advantage of rectus muscle folding to muscle resection.

• **CONCLUSION:** Up to 6mo after strabismus surgery, the retinal vascular calibers were not altered. No more than two muscles in one surgery are safe for retinal perfusion.

• **KEYWORDS:** strabismus; retinal vascular caliber; image processing; computer-assisted

INTRODUCTION

The retinal artery, long posterior and anterior ciliary arteries originate from the ophthalmic artery. The anterior ciliary arteries provide nearly 70% of the blood supply to the anterior segment of the eye, and the long posterior ciliary arteries, which have an intrascleral course beneath the horizontal rectus muscles, provide the other 30%^[1]. Manipulation of the rectus muscles during strabismus surgery may injure the anterior ciliary arteries and cause ischemic injury to the anterior segment of the eye. The consequence of reduced anterior segment perfusion on blood flow in the posterior ciliary, retinal arteries and ophthalmic artery is not known. Moreover, an increase of blood flow to compensate for anterior ciliary arteries may affect patients with ischaemic retinal diseases. As such, the safety of rectus muscle surgery on retinal blood vessels need to be evaluated. There have been several studies using color Doppler ultrasonography to assess orbital blood flow change after strabismus surgery^[1-5]. These studies showed that the blood flow of ophthalmic artery might increase for a short period of time. However, these studies had two shortcomings. First, they had quite small numbers of patients. Second, the follow-up time after surgery was short.

Retinal vessel caliber measurement based on fundus photography is a relatively new method which has been used in ocular blood flow studies in diabetic macular edema and age related macular degeneration. Several studies^[6-7] reveal that the severity of diabetic retinopathy is associated with widening of the retinal venular caliber. Intravitreal injection of triamcinolone acetate and bevacizumab narrows both retinal arteriolar and venular calibres^[8-9]. A wider baseline retinal caliber may be a predictor of better visual outcome in diabetic macular edema treated with ranibizumab^[10]. In the treatment of neovascular age-related macular degeneration (AMD), intravitreal injection of ranibizumab and bevacizumab have caused decreased retinal arteriolar diameter^[11], and dilated retinal venules^[12]. This technique is non-invasive, convenient and can provide direct and

repeatable measurement of retinal vessels. Similarly, using retinal vessel analyzer (RVA) found intravitreal ranibizumab significantly dilated retinal venules after a 1-year period^[13].

The purpose of this study was to evaluate the effect of strabismus surgery on retinal vessels calibers with this fundus photography based retinal vessel caliber measurement technique.

SUBJECTS AND METHODS

Two hundred consecutive patients underwent strabismus surgery, and 118 cases (female/male, 55/63) finished 6-month follow-up (concomitant exotropia, 84; concomitant esotropia 30; vertical strabismus, 2; paralytic strabismus, 2). Four patients were excluded because oblique muscles were manipulated in surgeries, 3 patients were excluded because of blurry fundus photographs which can not be measured either before or after surgery. Finally, 111 cases were included in this study. Patients with other systematic disease such as diabetes mellitus, systemic hypertension, and any other known vascular diseases were excluded. All patients underwent anterior and posterior segment evaluation preoperatively and postoperative at 6mo.

All surgeries were performed by the same surgeon to minimize the bias in technique, from December 2013 to August 2014. Rectus muscle folding, the surgical technique adopted in muscle shortening, theoretically preserves the ciliary vessels as this method circumvents the need to dissect the recti from their insertions. Instead, the muscles were shortened by suturing the folded muscle to the desired length. Recession and resection were performed with traditional surgical method and involved transecting the anterior ciliary arteries.

Optic disc-centered digital color fundus photographs of both eyes (fundus camera Type CR6-45NM, Canon Inc. USA) of all patients were taken prior to surgery and 6mo post surgery. The retinal vascular caliber was measured using the computer program IVAN (University of Wisconsin, Madison, WI, USA)^[6,14]. All vessels coursing through an area one-half to one-disc diameter from the optic disc margin were measured. The mean vessel caliber of the largest six arterioles was termed central retinal artery equivalent (CRAE), while that of the largest six venules was termed as central retinal vein equivalent (CRVE). The third index was the arteriole to venule ratio (AVR).

One hundred and sixty-six operated eyes were divided into three groups according to the surgical methods, single-muscle recession, one-muscle recession and one-muscle folding, one-muscle resection and one-muscle recession. The effect of number of operated muscles on retinal blood vessels was analyzed using SPSS 16.0.

This study was approved by the ethics committee of the hospital, and written informed consent was obtained from all the patients' family.

RESULTS

Pre-operative examination of the anterior and posterior segments was unremarkable in all study subjects. All surgeries were carried out without complications. Six months after surgery, strabismus was satisfactorily corrected in all cases. No patient was found to have any visual impairment, and none had signs suggestive of anterior segment ischaemia. Mean age of the 118 patients was 12.4±8.6y (range: 3-51y). For the 3 surgical groups, 93 eyes were included in recession group, male/female 49/44, aged at 11.7±8.9 years old; 54 eyes were included in recession plus folding group, male/female 26/28, aged at 13.2±8.2y; 19 eyes were included in recession plus resection group, male/female 14/5, aged at 14.3±11.7y. There was no significant difference of age ($P=0.43$) or gender ratio among these three groups ($P=0.15$).

For all of the operated eyes, averaged CRAE was 120.31±23.02 μm preoperatively, and 122.87±15.93 μm six months after surgery. There was no significant difference ($P=0.22$). CRVE was averaged at 171.11±31.73 μm preoperatively and 175.02±21.00 μm postoperatively, the difference was not significant ($P=0.19$). Averaged AVR was 0.71±0.07 prior to surgery and 0.70±0.07 after surgery. Still there was no significant difference ($P=0.87$).

Table 1 shows comparison of preoperative and postoperative retinal vessels calibers in different surgical groups. There was no significant difference in different groups preoperatively, and no significant difference was detected in different surgical methods preoperatively and postoperatively.

Table 2 shows the comparison between different surgical methods 6mo after surgery. Still, no significant difference was found between groups. There was no significant difference between one and two muscles resection surgery. In addition, there was no advantage of rectus muscle folding to resection.

In brief, our study showed that up to six months after surgery, strabismus surgery did not alter retinal perfusion.

DISCUSSION

Ophthalmologists have been interested in the pathophysiology of the anterior segment ischemia and the retinal vessels calibers changes that occur in anterior segment circulation after strabismus surgery for many years. Iris fluorescein angiography, indocyanine green angiography, and laser Doppler velocitometry have been used previously. The main risk factors for anterior segment ischemia of the eye are advanced age, vertical rectus muscle surgery, atherosclerosis, blood dyscrasias, and circulatory disorders including carotid artery disease.

Posterior segment ischemia may also occur in some situations. Studies have showed that retinal vascular caliber is an indirect indicator of ocular blood flow and can be measured from photographs. Retinal vascular caliber can be altered by systemic and ocular diseases and may reflect

Table 1 Comparison of retinal vessels caliber preoperative and postoperative by different surgical methods

Surgical method	Time	CRAE (μm)	CRVE (μm)	AVR
Recession, n=93	Preop.	119.13±19.11	168.54±29.6	0.69±0.07
	Postop.	123.83±17.41	174.81±23.03	0.71±0.08
	<i>P</i>	0.49	0.11	0.94
Recession+folding, n=54	Preop.	123.16±28.32	176.70±33.65	0.70±0.07
	Postop.	122.01±14.54	176.15±19.44	0.69±0.07
	<i>P</i>	0.77	0.92	0.94
Recession+resection, n=19	Preop.	118.38±26.00	169.38±37.77	0.70±0.05
	Postop.	120.55±12.69	174.00±16.33	0.70±0.08
	¹ <i>P</i>	0.74	0.62	0.83
	² <i>P</i>	0.56	0.32	0.36

CRAE: Central retinal artery equivalent; CRVE: Central retinal vein equivalent; AVR: Arteriole to venule ratio.
¹Comparison of retinal vessels caliber preoperative and postoperative; ²Comparison of retinal vessels caliber preoperative in different surgical methods.

Table 2 P value of comparison between different surgical method 6mo after surgery

Surgical methods	CRAE (μm)	CRVE (μm)	AVR
Recession+folding vs recession	0.49	0.71	0.15
Recession+resection vs recession	0.33	0.53	0.45
Recession+folding vs recession+resection	0.70	0.64	0.70

CRAE: Central retinal artery equivalent; CRVE: Central retinal vein equivalent; AVR: Arteriole to venule ratio.

changes in blood flow, inflammations, and endothelial function [15-17]. Regillo *et al* [18] found that blood flow decreased in the central retinal artery after scleral buckling and Santos *et al* [19] reported the diminution of blood flow in the ophthalmic artery with intraocular pressure elevation after scleral buckling. Additionally, Tribble *et al* [20] observed decreased mean and end diastolic blood flow in the central retinal artery and short posterior ciliary arteries with the diminution of intraocular pressure after trabeculectomy.

It is well known that anterior segment ischemia may occur after strabismus surgery, but the effect on posterior segment perfusion after surgery in the long term is not known. There have been several studies using Color Doppler Ultrasonography to check orbital blood dynamic change after strabismus surgery in the intermediate postoperative period. Twenty eyes of 19 patients who underwent recession or resection surgery on two horizontal rectus muscles, and ophthalmic artery showed a light increase in systolic maximum velocity 1mo postoperatively [1]. Twenty-six eyes underwent surgery on a single or both horizontal rectus muscles, and found surgery on both horizontal rectus muscles in an eye causes hemodynamic changes in

ophthalmic artery on day 1 postoperatively, in which peak systolic (Vmax), end diastolic (Vmin) and mean (Vmean) blood flow velocities were higher in both eye group. However, the difference was not observed on day 7 [2]. Twenty eyes of 18 patients with surgery on one or two horizontal rectus muscles one day and one month postoperatively showed no measurable effect on retrobulbar blood flow [3]. Fifty-six eyes of 28 patients showed similar results one week post surgery [4]. Eighteen patients underwent surgery on two muscles, showed OA blood flow increased on day 1, but not on day 7 and day 30 [5]. These results indicated increased blood flow and decreased vascular resistance in the very early post operative period. The blood flow increase may help to reduce risk of anterior segment ischemia after strabismus surgery.

All these findings were reported at 1mo, and thus, the long-term safety of strabismus surgery on retinal vessel is yet to be assessed. This issue is particularly important for young children, as they are still in the growth period and any alteration to the retinal perfusion might alter the health of their eyes. Also, for patients who have preexisting ischaemic retinal diseases, posterior segment vessel dynamic change after surgery might be riskier. Our study measured retinal blood flow 6mo post operation, which was much longer than these studies ever before. Moreover, our study had much larger population (118 patients) which can provide much stronger proof for this question. Each group had more patients to compare difference between different surgical procedures.

Besides the small number of patients enrolled in these studies, these authors also mentioned that Doppler ultrasonography is a user-dependent and time-consuming imaging method, which might influence the results. In

contrast, digital color fundus photographs is a fast, convenient method, and much easy for young patients to cooperate. Computer program IVAN for retinal vascular caliber measurement is a mature technique widely used in ophthalmic studies. It can measure retinal vessels directly and compare any change by repeatable fundus photography.

In this study, considering all the operated eyes as one group, all the retinal vascular caliber data (CRAE, CRVE and AVR) did not show significant change post surgery. Then, these patients were divided into three surgical groups according to the amount of rectus muscles transected. One muscle recession means transecting of one muscle. One muscle resection plus one muscle recession means transecting of two muscles. In rectus muscle folding method, the muscles were not transected but folded, the vessels in the muscles were preserved and the blood flow might be altered less. Thus, one muscle recession plus one muscle folding can be regarded as transecting of more than one but less than two muscles. Again, each group did not show significant change after surgery. Furthermore, comparison of any two groups did not reach significant difference. Although folding of rectus muscle did not have significant advantage in protection of retinal irrigation, it might be useful for those patients who have preexisting ischaemic disease prior to surgery.

This study showed that up to 6mo after surgery, the retinal vascular calibers were not altered. That was to say, no more than two muscles in one surgery was safe for retinal perfusion in a long term. However, short-term fluctuation of retinal vessel caliber could have been missed out in the long-term-run observation.

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