SCIENTIFIC REPORT

Choroidal blood flow in the foveal region in eyes with rhegmatogenous retinal detachment and scleral buckling procedures

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Aims: To investigate changes in choroidal blood flow (ChBF) in the foveal region of the human eye with rhegmatogenous retinal detachment induced by scleral buckling.

Methods: ChBF was measured in the foveal region using laser Doppler flowmetry in patients with a rhegmatogenous retinal detachment and no macular involvement before and after scleral buckling. The ChBF ratio was evaluated (ChBF of the affected eye to ChBF of the fellow control eye) to minimise individual variations.

Results: Retinal reattachment was confirmed by 2 weeks after scleral buckling in all patients. The ChBF in the foveal region of the affected eyes did not differ from the fellow eyes before scleral buckling. The ChBF ratio significantly ($p < 0.05$) decreased 2 and 4 weeks after scleral buckling compared with that before scleral buckling and returned to baseline 12 weeks after scleral buckling.

Conclusions: The results suggest that ChBF in the foveal region transiently decreases after scleral buckling and recovers to the baseline level within 12 weeks in patients with a retinal detachment and no macular involvement.

Scleral buckling is a well-established surgical treatment for rhegmatogenous retinal detachment. However, postoperative complications such as anterior^{1–4} or posterior segment ischaemia^{5,6} or choroidal detachment,^{7,8} although rare, do occur. Previous studies have suggested that the complications are probably related to ocular circulatory abnormalities.^{9–13} In addition, decreased ocular blood flow was recently reported with transient visual loss after a scleral buckling procedure.⁹

Using laser Doppler velocimetry, we reported previously that reduced retinal blood flow is common after scleral buckling procedures and is one cause of postoperative complications.^{10,11} We also reported that scleral buckling decreases the pulsatile ocular blood flow (POBF) and that the greater the extent of the scleral buckling treatment, the greater the possibility of decreased ocular blood flow.¹² Furthermore, the POBF returns to normal after 6 months. Taken together, it is reasonable to consider that scleral buckling can impair ocular circulation. However, few studies have examined the changes in ocular circulation in the foveal region after scleral buckling. Nagahara *et al.*¹³, using laser speckle flowgraphy, reported no marked change in the normalised blur value, which is an index of tissue blood velocity, in the choroid and retina of the foveal region in patients with retinal detachment without macular involvement. In contrast, Eshita *et al.*¹⁴ using scanning laser Doppler flowmetry, reported that the retinal circulation in the

macular region was disrupted in these patients. Although the POBF is thought to reflect the total pulsatile choroidal blood flow (ChBF),¹⁵ laser Doppler flowmetry can evaluate choroidal circulation in the foveal region.^{16,17} We previously reported impaired ChBF in the foveal region in patients with central serous chorioretinopathy¹⁸ and diabetes retinopathy, and macular oedema,¹⁹ associated with severe visual impairment. However, to the best of our knowledge, no report has been published on the changes in ChBF in the foveal region of eyes with rhegmatogenous retinal detachment. In this study, we investigated changes in ChBF in the foveal region in patients with retinal detachment without macular involvement after scleral buckling surgery.

PATIENTS AND METHODS

Patients

Eleven consecutive patients (age range 17–76 years) who had undergone uncomplicated unilateral scleral buckling procedures for rhegmatogenous retinal detachment at Asahikawa Medical College Hospital, Asahikawa, Japan, were included in the current study (table 1). Informed consent was obtained from each patient before surgery. The extent of the retinal detachment and the absence of macular involvement were determined by indirect ophthalmoscopy, slit-lamp biomicroscopy using a +90-diopter (D) lens and optical coherence tomography. Patients with a retinal detachment with macular involvement, which was confirmed by an experienced ophthalmologist (TN) using optical coherence tomography and biomicroscopy, were not included in our study because the detached retina might have affected the reliability of the blood flow measurements. In addition, patients with glaucoma, uveitis, high myopia, other ocular disorders, a history of ophthalmic surgery and systemic disorders, such as hypertension, hyperlipidaemia, diabetes and other systemic diseases, were also excluded.

All surgeries were performed using general anaesthesia, the same material (no 276 solid silicone tyre and no 40 encircling silicon band, Mira, Waltham, Massachusetts, USA) and the same technique (Schepens implant). No vortex veins were damaged, and no rectus muscles were removed. No complications occurred during surgery. The retinas were reattached completely after one operation. The fellow eye was not treated. The postoperative refractive difference between the treated eye and the healthy fellow eye was within 3.0 D in all patients.

Methods

The ChBF in the foveal region was assessed with laser Doppler flowmetry, according to the method of Riva *et al.*^{16,17}

Abbreviations: ChBF, choroidal blood flow; POBF, pulsatile ocular blood flow; RBC, red blood cell

Table 1 Patient characteristics

Patient	Age (years)	Sex	Eye (treated)	RD extent (degree)	SB extent (degree)	Encircling band	VA before SB
1	69	F	L	180	300	Yes	20/20
2	63	F	R	60	90	Yes	20/30
3	29	M	L	90	150	Yes	20/20
4	24	M	L	90	180	Yes	20/16
5	76	M	R	90	90	No	20/12
6	17	F	R	120	90	Yes	20/16
7	51	F	L	120	180	Yes	20/16
8	26	F	R	60	120	No	20/12
9	53	F	L	90	180	Yes	20/16
10	63	M	L	135	90	Yes	20/12
11	72	F	L	90	90	No	20/16

F, female; L, left; R, right; RD, retinal detachment; SB, scleral buckling; VA, visual acuity.

The principles of laser Doppler flowmetry have been described in detail by Bonner and Nossal.²⁰ Briefly, the vascularised tissue is illuminated by coherent laser light. Scattering of light on moving red blood cells (RBCs) leads to frequency shifts in the scattered light. By contrast, static scattering in tissue does not change the light frequency, but leads to randomisation of light-scattering directions impinging on the RBCs. This light diffusion in the vascularised tissue leads to a broadening of the spectrum of scattered light (Doppler shift power spectrum). From this, the mean RBC velocity, the blood volume and the blood flow can be calculated in relative units. In this study, the laser beam was directed at the fovea to assess blood flow in the subfoveal choroid.

The ChBF in the foveal region was measured in both eyes of all patients with a retinal detachment, 2, 4 and 12 weeks after surgery. To minimise individual variations, the fellow eyes served as controls. The ChBF ratio was calculated as follows:

ChBF ratio = ChBF of the affected eye/ChBF of the fellow control eye

All data were expressed as the standard error of the mean. Data were analysed using standard statistical methods. Student's *t* test was used to compare the affected eyes and the fellow eyes. For statistical analysis, we used repeated measures analysis of variance followed by a retrospective comparison with the Dunnett procedure. Differences were considered significant when the probability value indicated a chance of random occurrence of <5%.

RESULTS

We observed no statistically significant changes in the systemic blood pressure or intraocular pressure during the follow-up period. We did not observe a decrease in the visual acuity in any patient during the follow-up period. The ChBF in the foveal region of the affected eyes (mean 13.2 (SE 2.6) arbitrary units (au)) did not differ from that of the fellow eyes (mean 14.0 (SE 2.1) au) before scleral buckling. The ChBF ratio was significantly lower 2 and 4 weeks after scleral buckling than before scleral buckling ($p < 0.05$; table 2).

Table 2 Changes in choroidal blood flow in the foveal region

	Before surgery	2 weeks	4 weeks	12 weeks
ChBF ratio (mean (SEM))	1.00 (0.20)	0.50 (0.11)*	0.67 (0.12)*	0.90 (0.14)

ChBF, choroidal blood flow.

* $p < 0.05$ compared with preoperatively.

Twelve weeks after scleral buckling, the ChBF ratio was not significantly different from the baseline value.

DISCUSSION

In this study, we examined the relationship between ChBF in the foveal region and scleral buckling procedures in patients with a retinal detachment without macular involvement. Using laser speckle flowgraphy, Nagahara *et al*¹³ reported that there was no significant difference in the tissue blood velocity in the choroids and retina in the foveal region between the operated eyes and untreated contralateral eyes before surgery. Our results showing that the ChBF in the foveal region of the affected eye did not differ from that of the fellow eye before treatment seem to be similar to those in Nagahara *et al*'s previous study. Taken together, the ocular blood flow in the foveal region might be maintained in patients with a retinal detachment without macular involvement before surgery.

We also observed a transient decrease in the ChBF ratio in the foveal region after scleral buckling that returned to near the baseline value within 12 weeks after surgery in patients with a retinal detachment without macular involvement (table 2). We previously reported that the POBF, which roughly reflects total ChBF, was lower in the eye that underwent surgery than in the untreated fellow eyes 6 months after a scleral buckling procedure.¹² By contrast, in this study the foveal ChBF had recovered to the level of the fellow eye 3 months after scleral buckling. Although the reason why the foveal ChBF makes a relatively rapid recovery is unclear, this recovery might be associated with good visual acuity in our patients during the follow-up period.

In addition, another explanation for the discrepancy in the change in ChBF after surgery between the POBF results and our results may be considered. As the only pulsatile component is measured with POBF, the difference between POBF and foveal ChBF could be in the behaviour of the non-pulsatile component. Further study is needed to clarify this methodological issue.

Our results showed that the segmental scleral buckling procedure with encircling elements decreased ChBF in the foveal region in patients without macular involvement (table 2). On the other hand, using the laser speckle method, Nagahara *et al*¹³ reported that the segmental scleral buckling procedure with encircling elements decreased tissue blood velocity in the choroid and retina on the buckled side, but caused no marked change in tissue circulation in other areas of the fundus region or optic nerve head. However, those investigators also reported that tissue blood velocity in the foveal region did not decrease markedly. If it is true that a scleral buckling procedure decreases ocular blood flow because of the increased choroidal vascular resistance, it is plausible that the ChBF in the foveal region might be affected

similarly. As the effect of scleral buckling on the foveal region is smaller than that on the buckled side, ChBF in the foveal region might recover more quickly. Takahashi and Kishi²¹ reported the remodelling of choroidal venous drainage after vortex vein occlusion after scleral buckling for retinal detachment, and that new venous drainage routes formed ≥ 3 months after scleral buckling surgery. Although we did not study vortex vein occlusion or remodelling of the venous drainage, new venous drainage might lead to recovery of the blood flow in the foveal region.

Conclusions

In conclusion, we showed for the first time that the ChBF in the foveal region might decrease as a result of retinal detachment and scleral buckling procedures and return to the baseline value 12 months after surgery in patients with a retinal detachment and no macular involvement, suggesting that these circulatory changes are reversible. Further clinical studies are needed to determine if measuring the ChBF can be useful to predict the visual outcomes in patients with a retinal detachment.

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