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Brief report

Morphological changes after trabeculectomy in highly myopic eyes with high intraocular pressure by using swept-source optical coherence tomography



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ABSTRACT

Purpose: To investigate the effects of intraocular pressure (IOP) reduction on the eyeball shape in highly myopic eyes with high IOP.**Methods:** This study included patients with an axial length ≥ 26.5 mm and high IOP ≥ 22 mmHg after receiving maximum medication, with successful trabeculectomy by a single surgeon, and who underwent swept-source optical coherence tomography (SS-OCT) examinations on preoperative and postoperative ≥ 3 months periods. Eight eyes of 7 patients were included in the analysis. The morphological changes in the eyeball that occurred pre- and post-operation were analyzed from the SS-OCT images.**Results:** In 6 out of 8 examined eyes, the following apparent morphological changes in the posterior pole and/or peripapillary sclera were postoperatively detected on SS-OCT images: peripapillary scleral shrinkage, decrease in the lamina cribrosa depth, flattening of the peripapillary scleral insertion into the optic disc, decrease in the angle of the scleral protrusion temporal to the optic disc, and inhomogeneous change in scleral curvature of the posterior pole.**Conclusions and importance:** We found that the shape of some eyes with high myopia and high IOP changed owing to the decrease in IOP. Eyeball deformities may be affected by high IOP, and IOP reduction might reduce scleral deformation in highly myopic eyes with high IOP.© 2016 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

In highly myopic eyes, the optic disc and eyeball shape are often deformed [1,2]. In pathologic myopia, defects in the visual field that are not associated with chorioretinal lesions or no detectable cause are frequently observed [3]. We reported that a subset of high myopic eyes may be affected by direct scleral compression or stretching at the peripapillary scleral protrusion [2]. Although it is sometimes difficult to determine whether the visual field defects are caused by glaucoma or pathologic myopia, it is generally accepted that controlling intraocular pressure (IOP) is important in eyes with visual field defects and high IOP. IOP reduction could have

various effects on papillary and/or peripapillary structures. In young patients, it has been reported that IOP reduction could induce an increase in the neuroretinal rim area, decrease or increase parapapillary atrophy, and/or cause disc shape changes [4,5]. In adults, IOP reduction leads to a decrease in the size and depth of the disc cup, peripapillary retinal nerve fiber layer (RNFL) thickness, lamina cribrosa (LC) depth, axial length reduction, and increase in choroidal thickness [6–11]. However, it has not been well elucidated how IOP reduction affects the structure of the highly myopic eyes.

In the present study, we investigated the morphology of the posterior pole and peripapillary sclera before and after IOP reduction by trabeculectomy in highly myopic eyes with high IOP. The morphology was examined using swept-source optical coherence tomography (SS-OCT), and some cases showed drastic

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Table 1
Details of each eye included in the study.

Case no./ sex/age (y)	Side	Operation date	Preoperative examination						Postoperative examination					Changes in the eyeball shape after surgery	
			IOP (mmHg)	BCVA	Medication score	Axial length (mm)	Refractive error (D)	CCT (μ m)	Time-period after surgery (months)	IOP (mmHg)	BCVA	Medication score	Axial length (mm)		Refractive error (D)
1/F/71	R	Sep 2011	28	20/ 40	3	29.07	−3.25 (IOL)	508	29	14	20/ 50	1	28.59	−3.5	Slight
2/F/41	R	Sep 2011	32	20/ 32	4	26.54	−6.0	n/a	9	17	20/ 50	1	26.47	−6.0	Not obvious
3/F/90	R	Feb 2012	40	20/ 200	5	26.51	−2.75 (IOL)	512	7	11	20/ 200	0	26.29	−2.75	Slight
4/M/65	R	Jun 2014	23	20/ 25	4	28.45	−6.75	565	14	16	20/ 25	3	28.27	−6.75	Not obvious
5/M/73	R	Dec 2014	30	20/ 16	4	33.41	−6.0 (IOL)	510	10	7	20/ 16	0	33.29	−5.0	Obvious
	L	Dec 2014	23	20/ 16	5	33.51	−5.75 (IOL)	514	10	5	20/ 20	0	33.29	−4.5	Obvious
6/M/30	L	Jan 2015	40	20/ 320	4	33.60	−23.0	597	10	9	20/ 250	0	29.47	−15.5	Obvious
7/M/46	R	Mar 2015	24	20/ 63	4	28.26	−8.0	488	8	9	20/ 50	0	27.98	−8.75	Slight

R, right; L, left; BCVA, best-corrected visual acuity; CCT, central corneal thickness; IOP, intraocular pressure; IOL, intraocular lens; n/a, not applicable.

morphological changes in eyeball shape as a response to IOP reduction.

2. Materials and methods

2.1. Patients

This retrospective observational case series study adhered to the tenets of the Declaration of Helsinki. A review of the medical records was approved by the Institutional Review Board and Ethics Committee of the Kyoto University Graduate School of Medicine. The medical records of patients who had undergone trabeculectomy at the Kyoto University Hospital between January 1, 2011, and March 31, 2015 by one surgeon (TA) were reviewed. Trabeculectomy with mitomycin-C was performed by making a fornix-based conjunctival incision and a 3.0 × 3.0-mm quadrangular scleral flap. The inclusion criteria were: normal anterior segment, normal and open angle by gonioscopy, axial length ≥ 26.5 mm, preoperative IOP ≥ 22 mmHg with maximum tolerable medication, and preoperative and ≥ 3 months postoperative SS-OCT examinations. The exclusion criteria were hazy media, systemic disease, and IOP ≥ 22 mmHg on postoperative SS-OCT examination. Patients with evidence of vitreoretinal disease associated with high myopia (e.g., posterior staphyloma, chorioretinal atrophy, and myopic choroidal neovascularization) were not excluded.

2.2. Swept-source optical coherence tomography examination

SS-OCT examination using DRI OCT-1 (Topcon, Tokyo, Japan) [2,12], IOP measurement by Goldmann applanation tonometry, axial length measurement (IOLMaster 500, Carl Zeiss Meditec, Dublin, CA), and fundus photography were performed on the same day pre and postoperatively. Postoperative SS-OCT images with a 12-mm line were repeatedly obtained to gain the images scanned at the same location as the preoperative images. We carefully identified whether the locations of the pre and postoperative scan images were the same with reference to scanning laser ophthalmoscopy images acquired simultaneously, and the images at almost the same location were used for the analysis.

3. Results

3.1. Patients

This study initially involved 12 eyes of 10 participants. Finally, 8 eyes of 7 participants were evaluated before and after trabeculectomy. Eyes with secondary glaucoma, such as pseudo-exfoliation, uveitis, or neovascular glaucoma, were not included in this study. No additional operation was performed and no major complication was found during the follow-up period in all cases. The pre and postoperative details of the eyes are shown in Table 1.

3.2. Swept-source optical coherence tomography imaging evaluation

Only 1 eye showed apparent morphological change on fundus photography (case 6). Obvious or slight morphological changes in the posterior and/or peripapillary sclera were postoperatively detected on SS-OCT images in 6 eyes (obvious changes, cases 5R, 5L, and 6, Figs. 1–3; slight change, cases 1, 3, and 7, Fig. 4). The morphological changes in the shape of the eyeball included several types of changes. The peripapillary sclera had shrunk and shortened postoperatively, and the LC depth was eventually reduced (cases 5R, 5L, and 7). The angle between the sclera inserting into the optic disc and that at the opposite side became more flattened in the vertical OCT B-scan (cases 1 and 5L). The angle of the scleral protrusion temporal to the optic disc decreased in size postoperatively (cases 5L and 7). The scleral curvatures of the posterior pole were apparently changed after the operation (cases 3, 5L, and 6). In case 6, the shape of the posterior staphyloma heterogeneously changed after the operation. The inferior area, where the posterior staphyloma was apparent before the operation, had moved ahead after the operation (Fig. 3). It should be noted that the postoperative IOP was 9 mmHg, which did not indicate hypotony. No apparent morphological change in the posterior or peripapillary sclera was detected between pre and postoperative periods in 2 eyes (cases 2 and 4).

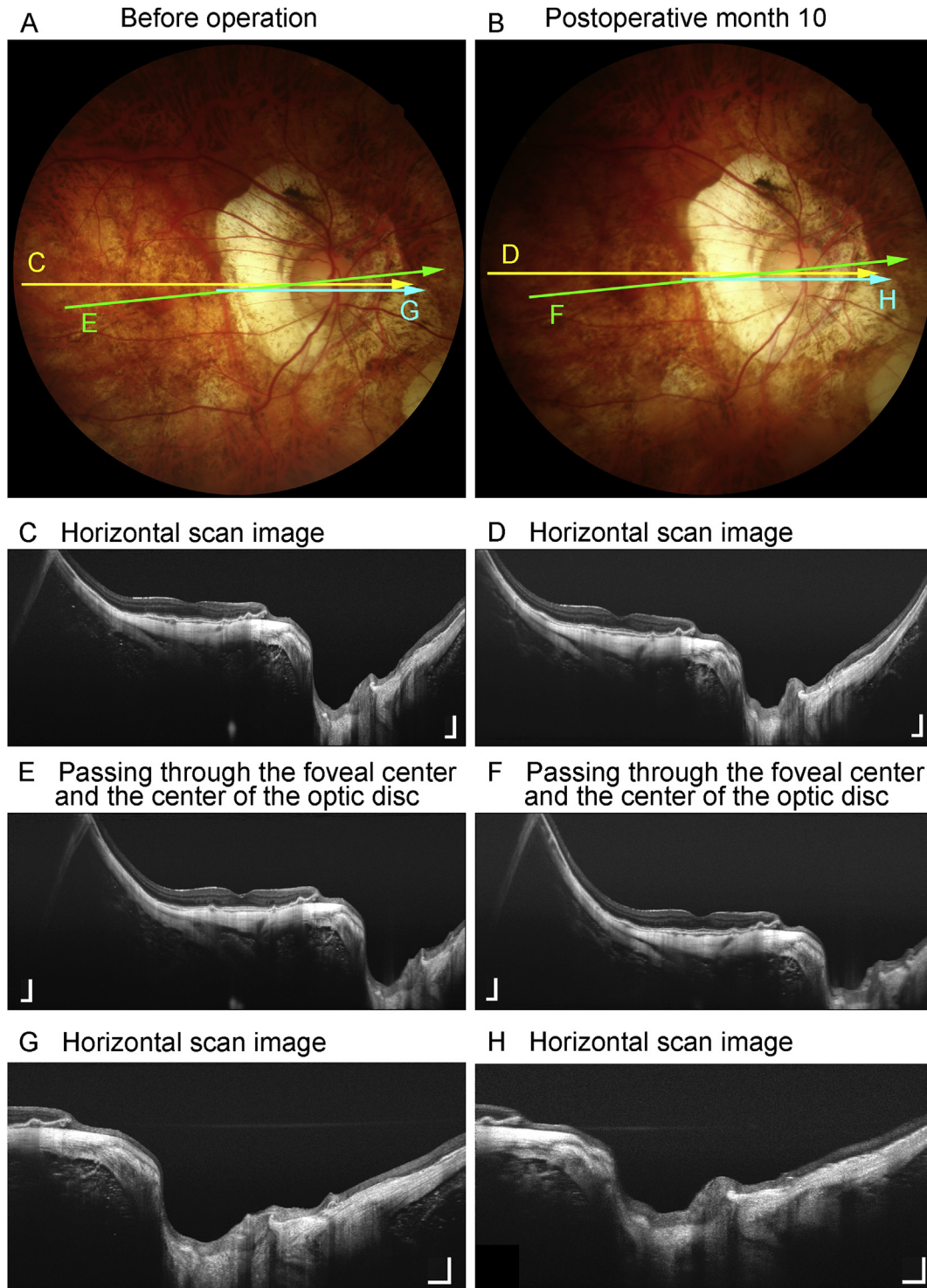


Fig. 1. Obvious change in the peripapillary sclera after trabeculectomy (Case 5R) A, B, Color photographs. C–H, Swept-source optical coherence tomography images. The peripapillary sclera is shrunk and shortened after surgery, and eventually the lamina cribrosa moved forward. Scale bar = 300 μ m. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

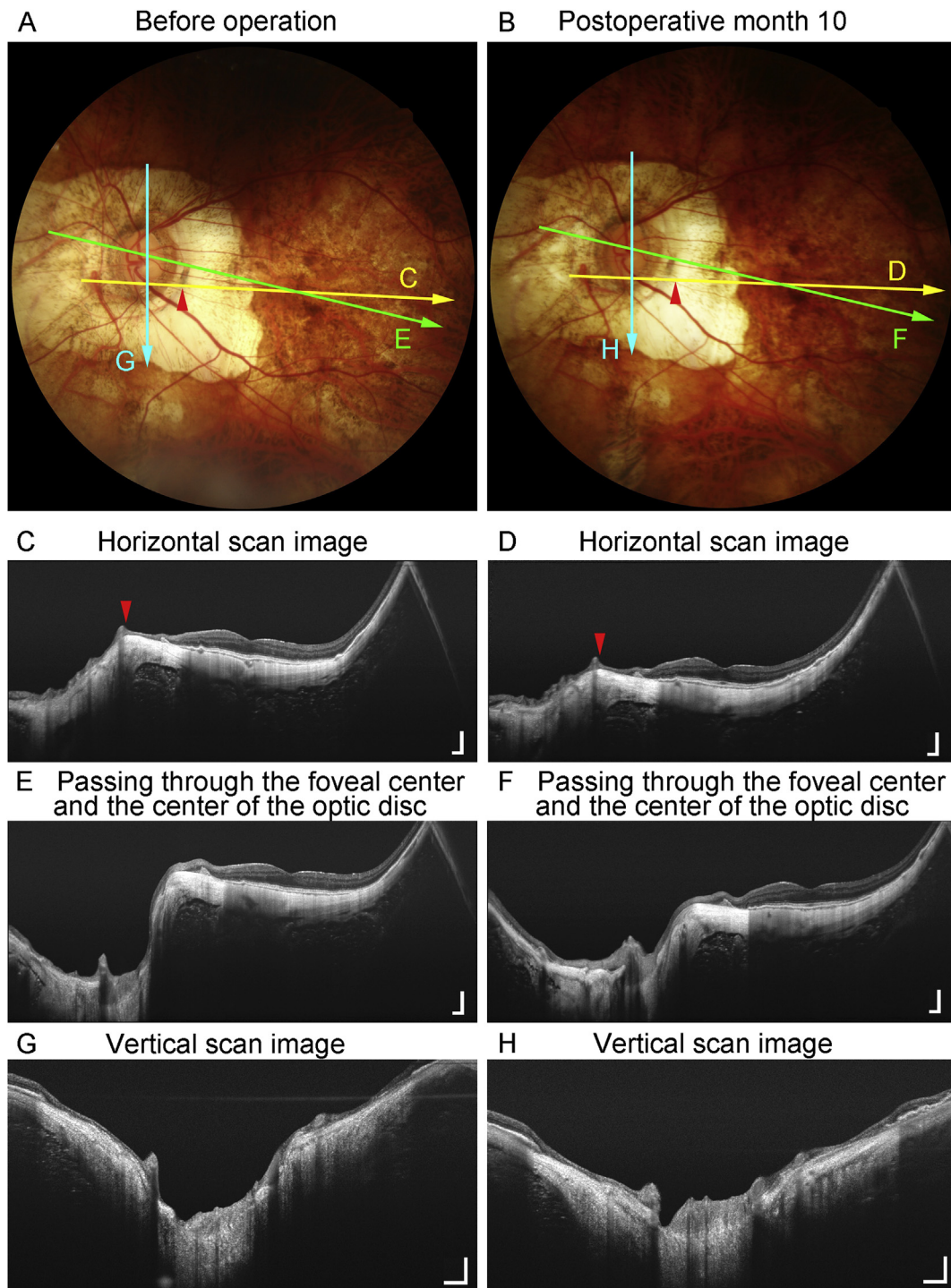


Fig. 2. Obvious changes in the peripapillary and posterior sclera after trabeculectomy (Case 5L) A, B, Color photographs. C–H, Swept-source optical coherence tomography images. The angle of the scleral protrusion temporal to the optic disc decreased postoperatively (red arrowheads in A–D). The peripapillary sclera is shrunk and shortened and the prominence of the posterior sclera becomes less obvious, postoperatively in C–F. The angle between the sclera inserting into the optic disc and that at the opposite side becomes more flattened postoperatively in G and H. Scale bar = 300 μ m. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

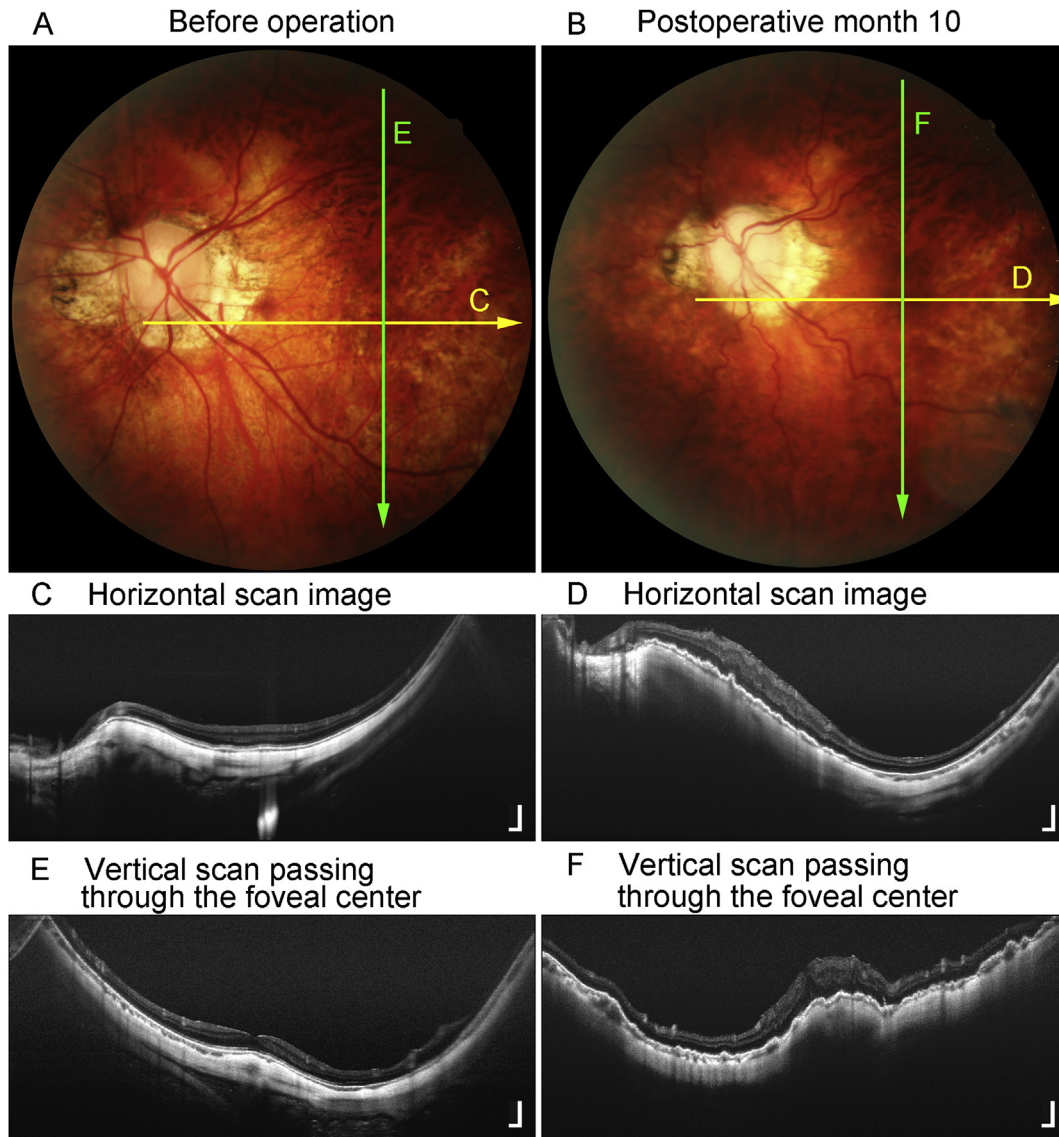


Fig. 3. Obvious change in the eyeball morphology after trabeculectomy (Case 6) A, B, Color photographs. C–F, Swept-source optical coherence tomography images. There appear to be asymmetric changes in the sclera postoperatively. In areas where the sclera had increased the anterior displacement, the overlying choroid and RPE exhibits a ruffled appearance. Scale bar = 300 μ m. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

4. Discussion

In extremely myopic eyes, the curvature of the posterior eye segment was very irregular and aspherical, probably because the globe expansion with deformed sclera is different in each eye [1]. Saka et al. [13] suggested that the IOP could be a mechanical factor that can lead to the stretching of the sclera for the eyes. We observed that the posterior staphyloma could be inhomogeneously reduced in response to IOP reduction in eyes with extreme posterior staphyloma (Fig. 3), which suggests that deformed regions in highly myopic eyes might be more susceptible to IOP stress. The postoperative IOP of this case was 9 mmHg, 8 months after operation, and the choroidal folds and tortuous retinal vessels existed mainly at the inferior posterior pole, where the posterior staphyloma was reduced. An IOP of 9 mmHg did not mathematically indicate hypotony, although the thick cornea may have affected the IOP measurement, and the actual IOP may be < 9 mmHg. A suggested mechanism is that the reduced scleral rigidity may contribute to the collapse of the scleral wall during hypotony,

causing chorioretinal folds [14]. On the other hand, it was reported that chorioretinal folds could emanate from the staphyloma edge in highly myopic eyes with posterior staphyloma, irrespective of the low IOP [15]. In this study, some directional force toward the staphyloma was suggested as the cause for chorioretinal folds. We completely agree with their theory and speculate that inhomogeneous morphological changes in the staphyloma induced localized chorioretinal folds in our case.

While LC deformation is an important factor for glaucoma [9,16], peripapillary scleral protrusion has been proposed as a possible cause of RNFL damage in a subset of highly myopic eyes [2,17]. The greater scleral bending at region with sudden change temporal to the optic disc was reported to be significantly associated with a thinner RNFL and greater visual field defects [2,3]. We found that the angle at the scleral bending could be reduced after trabeculectomy (Figs. 2D, F, and 4A). Further longitudinal studies would be needed to elucidate the effects of these peripapillary scleral morphologic changes on subsequent visual field progression.

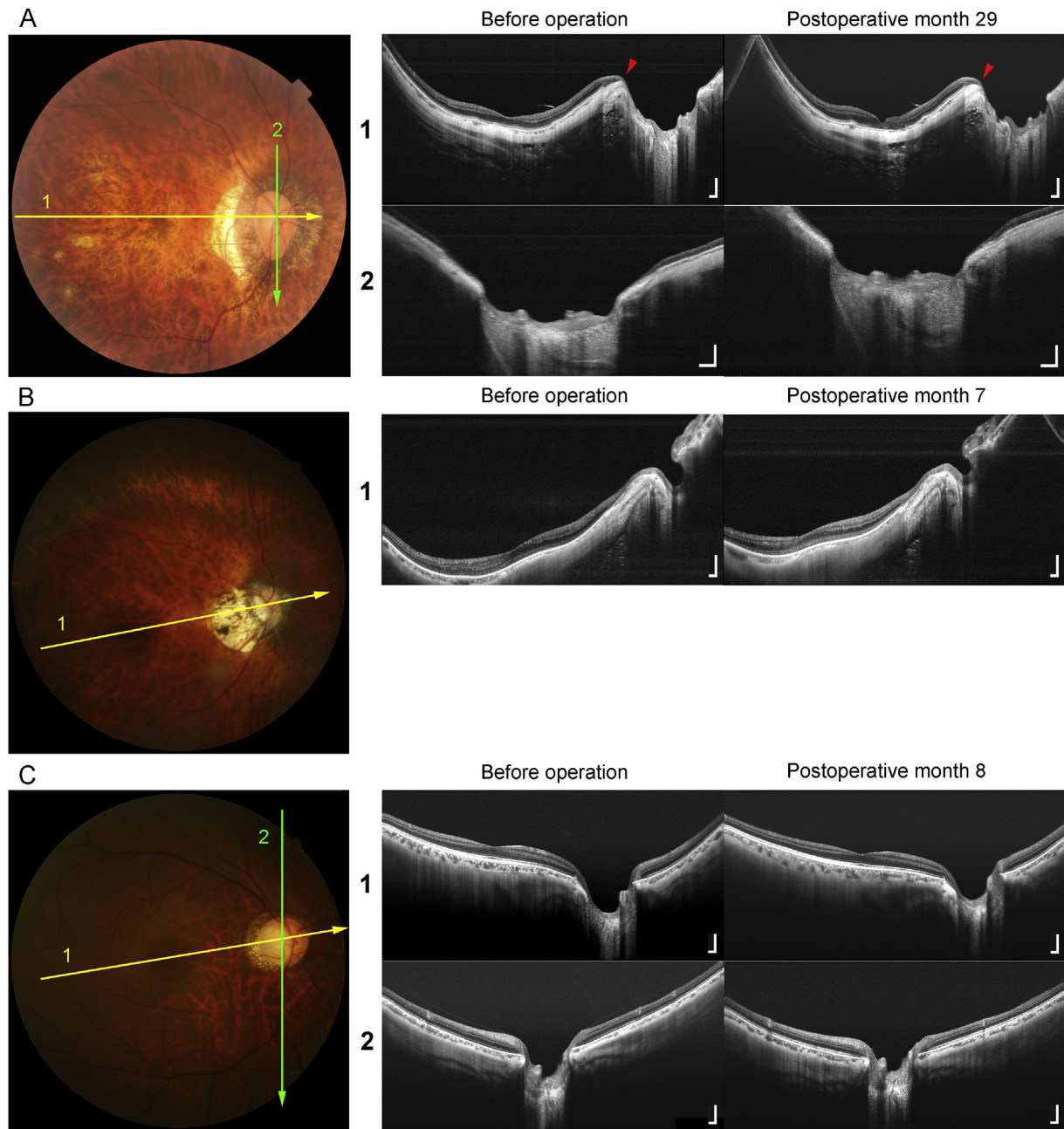


Fig. 4. Slight changes in the peripapillary and/or posterior sclera after trabeculectomy A, Case 1. The protrusion edge is slightly more flattened postoperatively (red arrowheads). B, Case 3. The prominent posterior sclera is more flattened postoperatively. C, Case 7. The peripapillary sclera is shrunk and shortened postoperatively. Scale bar = 300 μm . (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The current study has some limitations. First, it is a retrospective study and contains a small sample size. Second, the eyeball shape qualitatively and not quantitatively analyzed. Further prospective studies using techniques, such as three-dimensional morphological analysis, would be needed to determine the exact morphological changes in the eyeball.

5. Conclusions

In some eyes, high myopia and high IOP can cause changes in the shape of the eyeball in response to IOP reduction. A deformed eyeball shape might be affected by high IOP and IOP reduction,

which may reduce scleral deformation in highly myopic eyes with high IOP.

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