En Face Images Using Ultra-Widefield Optical Coherence Tomography in 2 Cases of Traumatic Hypotony Maculopathy before and after Surgical Intervention

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Keywords
En face imaging · Hypotomy maculopathy · Ocular trauma · Traumatic cyclodialysis · Ultra-widefield optical coherence tomography

Abstract
The aim was to investigate the structural changes of the retina using en face ultra-widefield optical coherence tomography (OCT) images during the treatment of hypotony maculopathy with traumatic cyclodialysis. Case 1 was a 43-year-old male patient with visual crowding in his left eye (metallic wire injury that occurred 3 weeks previously) who was referred to our department. Although best-corrected visual acuity was 20/20 in his left eye on initial evaluation, intraocular pressure was 6 mm Hg. Case 2 was a 20-year-old male patient with visual crowding in his left eye (baseball ball injury that occurred 4 weeks previously) who was referred to our department. Although best-corrected visual acuity was 16/20 in his left eye on initial examination, intraocular pressure was 5 mm Hg. Surgical interventions were performed in both cases. En face ultra-widefield OCT images were able to be used to trace dynamic changes before the intervention and up to 1 year later. The images obtained in these two cases made it possible to confirm the progress from wrinkles on the surface of the retina to normalization of vascular structure and improvement of ellipsoid zone disruption. En face ultra-widefield OCT is useful for monitoring multilayer structures of the retina in hypotony maculopathy cases.

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Introduction

Cyclodialysis cleft arises from disrupting the ciliary body into the scleral spur after being triggered by blunt trauma [1]. When aqueous humor moves into the suprachoroidal space, this results in chronic ocular hypotony. Since the intraocular pressure is usually low, this can produce ocular complications such as a shallow anterior chamber, choroidal effusion, retinal and choroidal folds, and hypotonic maculopathy. These complications in severe cases can potentially result in permanent visual loss [2]. Hypotonic maculopathy is characterized by the presence of hypotony conditions, papilledema associated with wrinkling, or retinal and choroidal folds that are observed throughout the posterior pole. In the macular area, there are several fine retinal folds that radiate outward from the fovea, with these folds resulting in distortion of the neurosensorial elements of the retina [3].

The implementation of multimodal imaging, which includes optical coherence tomography (OCT) and fundus angiography, has recently helped to obtain clearer diagnoses [3]. However, there have been no reports that have described the use of en face ultra-widefield OCT associated with hypotony maculopathy.

In the two present cases, we investigated the clinical pathology of hypotonic maculopathy that was observed for approximately over 1 year before and after surgical interventions that were performed in conjunction with en face ultra-widefield OCT images. These images were not only of the posterior pole but also included the equator-peripheral retinal structures.

Case Report

Case 1

A 43-year-old male patient with visual crowding in his left eye (metallic wire injury that occurred 3 weeks previously) was referred to our department for a detailed examination. Although best-corrected visual acuity was 20/20 in his left eye at the initial examination, intraocular pressure was 6 mm Hg. Anterior slit-lamp examination revealed that the anterior chamber appeared to be shallow and exhibited mild hyphema. Fundus examination and OCT (HRA/Spectralis; Heidelberg Engineering Heidelberg, Germany) (Fig. 1a, b) revealed retinal vascular meandering with choroidal folds in his left eye. Ultrasound biomicroscopy revealed almost 360-degree ciliary cyclodalysis (Fig. 1c). In addition, en face ultra-widefield OCT (Xephilio OCT-S1, Canon, Japan) images between the internal limiting membrane surface and the choroidal surface demonstrated the presence of bending vascular structures from the posterior pole area to the peripheral area due to hypotonic changes and retinal surface pucker, especially within the posterior pole area. Furthermore, there was disruption of the optic nerve fibers in the ganglion cell complex (Fig. 2a–i).

Case 2

A 20-year-old male patient with visual crowding in his left eye (baseball ball injury that occurred 4 weeks previously) was referred to our department for a detailed examination. Although best-corrected visual acuity was 16/20 in his left eye at the initial examination, intraocular pressure was 5 mm Hg. Anterior slit-lamp examination revealed that the anterior chamber appeared to be slightly shallow in addition to exhibiting mild inflammation. Fundus examination and OCT revealed mild vitreous hemorrhage, commotio retinae, and retinal vascular meandering with the presence of bending vascular structures ranging from the posterior pole area to the peripheral area due to hypotonic changes and retinal surface pucker (Fig. 1d, e). Ultrasound biomicroscopy demonstrated that there was almost 210-degree ciliary cyclodalysis (Fig. 1f). En face ultra-widefield OCT images between the internal limiting
membrane surface and the choroidal surface revealed bending vascular structures that ranged from the posterior pole area to the peripheral area due to hypotonic changes, especially within the posterior pole area. Furthermore, there was disruption of the optic nerve fibers in the ganglion cell complex and ellipsoid zone (EZ) (Fig. 3a–i). In addition, there were images of B-scan of OCT corresponding to Figures 2 and 3 (Fig. 4).

Both cases underwent surgical interventions (case 1: pars plana vitrectomy with cataract surgery and ciliary body suture [6-0 absorbed thread], case 2: pars plana vitrectomy without cataract surgery and ciliary body suture [6-0 absorbed thread]). After surgery, both the low intraocular pressure and ciliary dissection gradually improved (Fig. 5). Finally, the best-corrected visual acuity improved to 20/20 in both cases.

The present findings showed that en face ultra-widefield OCT images could be used to trace dynamic changes before the intervention and up to 1 year later. Using this technique in these two cases, we were able to confirm the progress from wrinkles on the surface of the retina to normalization of the vascular structure and improvement of EZ disruption (Fig. 2, 3).
Discussion

This brief report provides details on the use of en face ultra-widefield OCT imaging to follow changes and the recovery process observed in multiple retinal layers in hypotony maculopathies over time. In particular, extensive imaging of the recovery process of the retinal folds in the retinal surface and EZ disruption made it possible to evaluate a wide retinal area that corresponded to the observed visual acuity changes.

Previous reports have described using en face OCT imaging in various retinal diseases in order to help better understand the new pathological retinal condition in a noninvasive manner [4, 5]. Even so, it should be noted that it is possible that due to the limited narrow ranges of the OCT scan, these previous reports might have only described finding changes regarding structural limitations of the posterior pole. However, ultra-wide OCT has evolved into a wide-angle technique that can be applied to a diverse range of retinal diseases, with various new reports having been published in the literature [6, 7].

In the present study, our use of ultra-widefield OCT was able to demonstrate that the low intraocular pressure was improved by the surgery, with the folds of the surface layer of the retina drastically fixed along with the restoration of the circumferential structure of the optic disc.
Fig. 3. En face OCT images of case 2 at the preoperative visits (a–c), at 3 months after surgery (d–f), and at 1 year after surgery (g–i). a ILM layer shows a cat whiskers pattern of the macula folds. b Layer from NFL to GCL reveals that folds of the macula and retinal nerve fiber are obscured. c Retinal folds reach to the EZ layer similar to that observed in case 1. d ILM folds have improved at 3 months. e Folds of the macula have completely disappeared. f EZ layer folds have improved. g ILM folds have almost completely disappeared. Postoperative images at 1 year: h Pathways of the retinal nerve fiber layer are clearly drawn. i EZ layer fold have almost completely disappeared.

Fig. 4. B-scan of case 1 and case 2 was shown. A close-up image of the macula was shown above. "Pre" shows tests performed prior to surgery. B-scan at 1 month (1M) and 1 year (1Y) after surgery was shown. Both cases showed improvement in retinal folds after surgery. EZ disruption was observed before surgery (yellow angle). The EZ was improved over time (green arrow head).
nerve fiber layer. In addition, EZ disruption improved over a wide retinal area. These multilayer structural changes were considered to be consistent with the recovery of the visual acuity. However, it should be noted that the effect of the low intraocular pressure could have been related to the pathological conditions of the whole eye, including the peripheral retina, and thus was not localized in the macula.

Clinically, the use of en face ultra-widefield OCT makes it possible to noninvasively and simultaneously view the multilayer structures of the retina in hypotony maculopathy cases. In addition, by increasing the number of cases, this could make it possible to obtain results regarding which layer of the disorder is involved, if it is irreversible, or if it is primarily correlated with the prognosis of visual function.

The present study had some limitations. Only 2 cases were examined, so additional cases need to be accumulated and assessed. In addition, as only 1 year has passed since the start of the study, a long-term follow-up along with comparisons of the visual field have yet to be performed.

In conclusion, en face ultra-widefield OCT could be a useful technique for monitoring multilayer structures of the retina in cases of hypotony maculopathy, especially when there is not only surface retinal folding but also when the optic nerve fiber curved ring and EZ are disrupted. Furthermore, the currently observed results showing the recovery of these patients suggests that this is indeed might be an effective treatment.

**Statement of Ethics**

Ethical approval is not required for this study in accordance with local or national guidelines. Written informed consents were obtained from these patients for publication of the details of their medical cases and any accompanying images.

**Conflict of Interest Statement**

The authors have no financial disclosures or conflicts of interest to report.
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Author Contributions

Yuri Nagatomi, Norihiko Misawa, Yusuke Haruna, Atsushi Sakai, and Mizuki Tagami cared for, worked up, treated, and collected data from the patient. Shigeru Honda analyzed the ophthalmological findings and gave critical suggestions. Mizuki Tagami performed the operation and prepared the manuscript. Yuri Nagatomi, Norihiko Misawa, Yusuke Haruna, Atsushi Sakai, Mizuki Tagami, and Shigeru Honda read and approved the final version of the manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this article. Further inquiries can be directed to the corresponding author.

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