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Using Optical Coherence Tomography for the Morphologic Evaluation of the Posterior Vitreous and Retinal Surface

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ORIGINAL ARTICLE

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Key Words

optical coherence tomography, posterior vitreous, retinal surface, preretinal membrane, macular hole, vitreomacular traction syndrome, pseudo macular hole

Abstract

Optical coherence tomography (OCT) is a technique that obtains cross-sectional images of tissue via a near-infrared, low-coherence light beam.[1-2] The OCT constructs images by measuring the intensity and temporal delay of light reflected from the individual retinal layers and allows noninvasive evaluation of diseases affecting the posterior vitreous and retinal surface. The purpose of the current study was to investigate the usefulness of OCT in the morphologic assessment of such diseases. Using OCT, even a slight change in the refractive index can be visualized as a structural change. In addition, OCT can provide images of transparent structures such as the posterior vitreous body. In diseases affecting the posterior vitreous and retinal surface such as preretinal membranes, macular holes, and vitreomacular traction, the anatomic positional relationship between the posterior vitreous membrane and the macula is relevant.

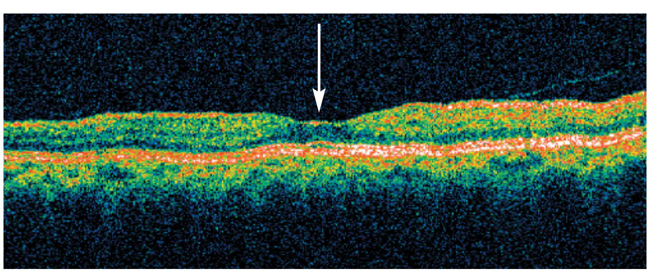

Figure 1: OCT image of a normal human macula. There is a central depression at the foveola, the centermost, thinnest zone of the fovea which contains a high concentration of cones and no retinal blood vessels.

Introduction

An OCT image of low signal intensity may obscure deeper layer information. Because image construction is affected by signal noise and artifacts, the findings should be interpreted cautiously. In conditions affecting the posterior vitreous and retinal surface such as

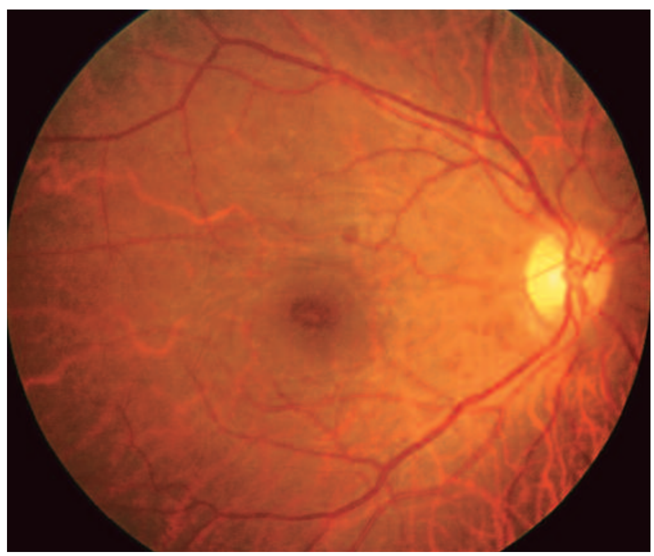

Figure 2: A PRM. Membranous tissue and tortuous vessels.

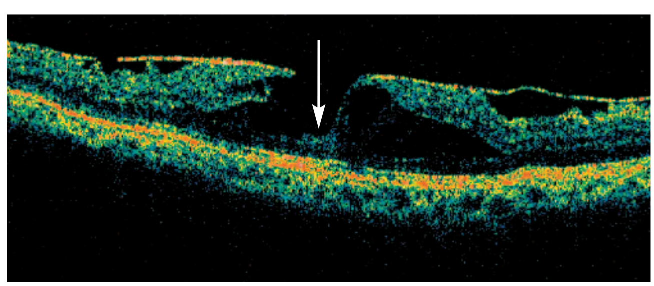

Figure 3: OCT image of a PRM. A pseudo-MH is seen in the central fovea (arrow).

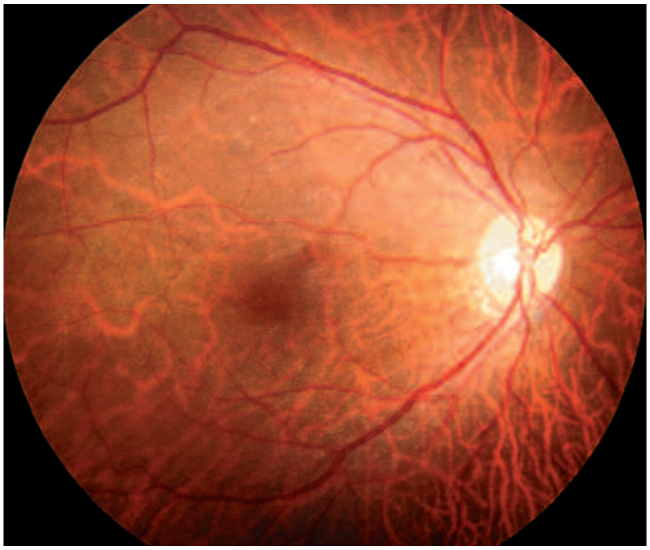

Figure 4: A PRM after vitreous surgery. The tortuosity of the vessels has decreased.

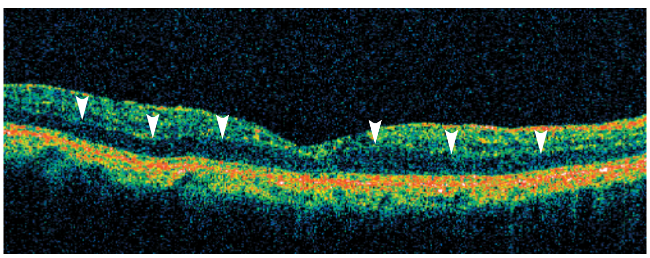

Figure 5: OCT image of a PRM after vitreous surgery. The central foveal depression and a dark layer (arrowhead) with homogenous low reflectivity are seen, with improvement of the array of the visual cell layer.

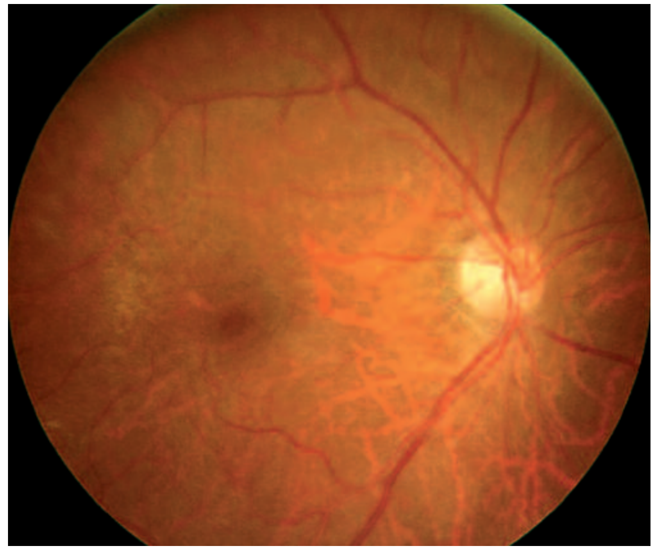

Figure 6: VTS. Membranous tissue is observed at the macula.

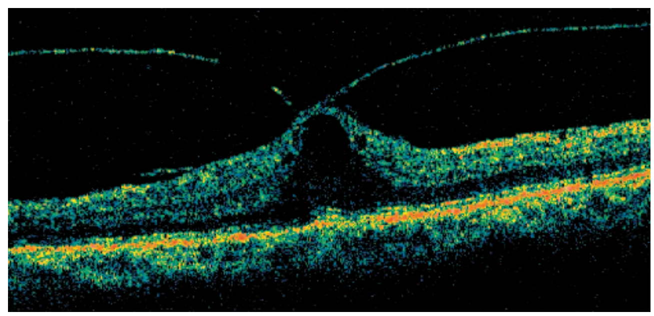

Figure 7: An OCT image of VTS shows that the retina at the central fovea is pulled.

preretinal membranes (PRMs),[3,4] macular holes (MHs),[5-16] and vitreomacular traction (VT),[17-20] the anatomic positional relationship between the position of the posterior vitreous membrane and the macula is a relevant factor. Diagnoses of diseases affecting the posterior vitreous and retinal surface conventionally have been made based on observations using slit-lamp biomicroscopy and a preset lens (such as three-mirror lens), fundus photography and fundus fluorescein angiography. Previously, visual acuity and visual sensitivity have been used, to determine the indications and outcomes of vitreous surgery. While it is important to make diagnostic and therapeutic evaluations in terms of morphologic and functional changes, prior to OCT, it was difficult to clearly show an association between these changes. In the current study, we report the usefulness of OCT to evaluate conditions affecting the posterior vitreous body and retinal surface, with a discussion relating findings with visual function.

Normal Fundus

A cross-sectional OCT image of a normal fundus is shown in Figure 1. The nerve fiber layer and the retinal pigment epithelium (RPE) layer are seen as a layer with a brighter reflection than the retina. The inner plexiform layer and the outer plexiform layer are displayed in warm colors. The inner nuclear layer and the outer nuclear layer, which are comprised of cell bodies with fewer reflections, are displayed in cool colors. The layer of low reflectivity immediately above the RPE represents the outer segment of the visual cells. The concave portion of the central fovea contains visual cells only, and the foveola is displayed as a layer of low reflectivity thicker than the central fovea. Below the RPE layer, the lamina choriocapillaris is displayed as a mixture of red layers with strong reflectivity. More posteriorly, the RPE absorbs light and the choroid layer is only partially visible.

Pre Retinal Membranes

On examination, this 73-year-old man was seen to have a reflectile membrane and tortuous vessels (Figure 2). The best-corrected visual acuity (BCVA) was 20/30. With OCT, the epimacular membrane was detected as a highly reflective membrane and the gap between the retinal surface and the PRM was clearly shown. An area of retinal thickening contained an area of low reflectivity, and a pseudo-macula hole was observed at the central fovea (Figure 3). After vitreous surgery, the tortuosity of the vessels decreased (Figure 4). The postoperative

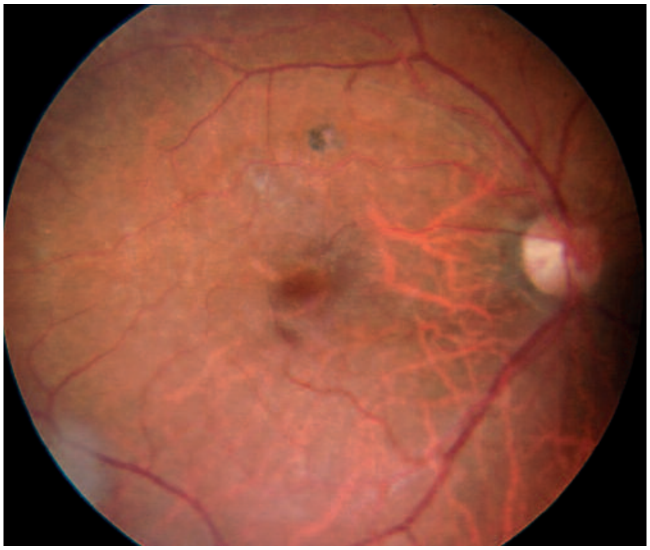

Figure 8: VTS after vitreous surgery. The irregular retinal reflections have disappeared.

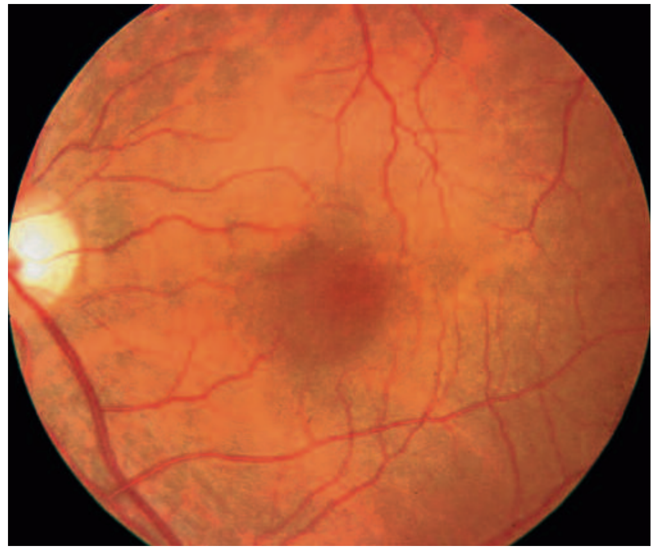

Figure 10: A stage 1A MH. Differentiation from a normal fundus is difficult.

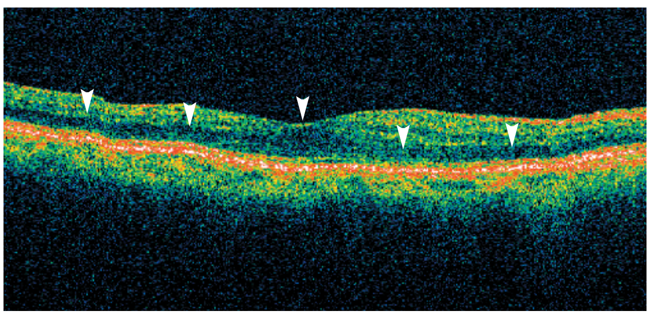

Figure 9: OCT image of VTS after vitreous surgery. The depression of the central fovea and a dark layer (arrowhead) with homogenous low reflectivity, with improvement of the array of the visual cell layer.

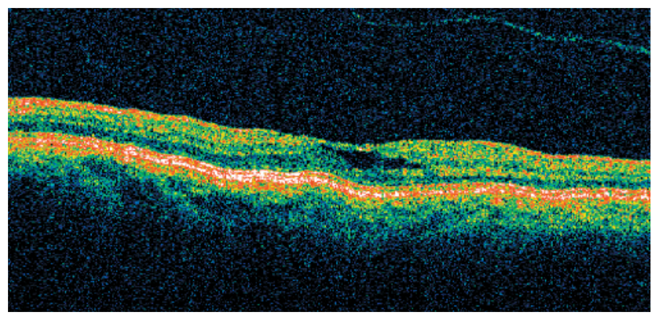

Figure 11: An OCT image of a stage 1A MH. A lamellar retinal detachment is seen.

BCVA was 20/25. OCT showed depression of the central fovea and a dark layer with homogenous low reflectivity, with an improved array of the visual cell layer (Figure 5).

Vitreomacular Traction

Membranous tissue with an irregular reflection was observed at the macular area in an 81-year-old woman, (Figure 6). The BCVA was 20/60. OCT showed that the retina at the central fovea were pulled anteriorly (Figure 7). After vitreous surgery, the irregular retinal reflectivity disappeared, and the BCVA was 20/50 (Figure 8). The OCT post vitreous surgery showed flattening of the retina and depression of the central fovea, with a dark layer (indicated by the arrow head) suggesting improvement of the visual cell outer segment (Figure 9).

Macular Hole (MH)

A MH forms as the result of detachment at the central fovea due to shrinkage of the posterior vitreous cortex with tangential tractional force. In a 65-year-old man, differentiating the MH from the normal fundus was difficult (Figure 10). An OCT revealed a lamellar detachment of the retinal neuroepithelium (Figure 11) and the condition was diagnosed as a stage 1A MH.

In a 72-year-old woman, cystic changes were observed (Figure 12). An OCT showed an elevated retina at the central fovea due to traction by the posterior vitreous body along with a lamellar retinal detachment (Figure 13). The condition was diagnosed as a stage 1B MH.

In a 79-year-old woman, a MH one-half the diameter of the papilla was observed with a retinal detachment around the rim of the hole, which is commonly termed a "fluid cuff" (Figure 14). The BCVA was 20/600. OCT showed the posterior vitreous cortex pulling the retina at the central fovea (Figure 15). The condition was assessed as a stage 2 MH. After vitreous surgery, the fluid cuff resolved and the MH closed (Figure 16). An OCT showed a flattened retina after the vitreo-retinal surgery with a central foveal depression. However, at the depressed area of the retina, no dark layer was present, and absence of the visual cell layer was confirmed (Figure 17). The postoperative BCVA was 20/250.

In a 74-year-old woman, a retinal detachment was seen around the hole (fluid cuff) (Figure 18). The BCVA was 20/60. OCT showed a lamellar detachment with

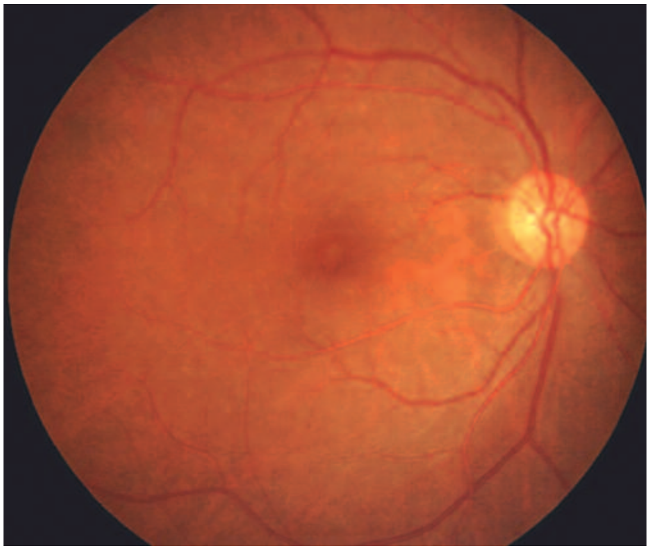

Figure 12: A stage 1B MH. Cystoid changes are observed.

Figure 14: A stage 2 MH. The MH with a retinal detachment (fluid cuff) is seen.

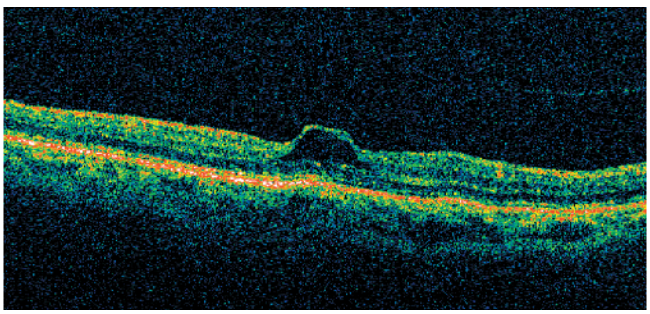

Figure 13: An OCT image of a stage 1B MH shows that the retina is elevated at the central fovea due to traction by the posterior vitreous body.

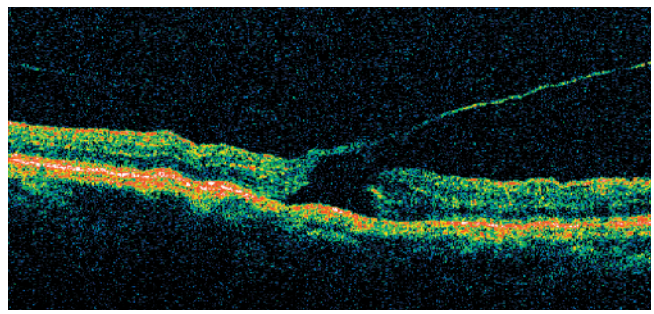

Figure 15: An OCT image of a stage 2 MH shows the posterior vitreous cortex pulling the retina at the central fovea.

retinal thickening around the hole (Figure 19). The condition was assessed as a stage 3 MH. After vitreous surgery, the retinal detachment around the hole (fluid cuff) resolved (Figure 20). OCT showed flattening of the retina and depression of the central fovea, with resolution of the lamellar detachment in the retina, and a dark layer with homogenous low reflectivity was confirmed (Figure 21). The postoperative BCVA was 20/25.

In a 74-year-old woman, with a MH of approximately half of the diameter of the papilla was observed along with a retinal detachment around the hole (fluid cuff) (Figure 22). OCT showed multiple cystoid interlayer detachments at the rim of the hole, (fluid cuff) and enlargement of the base of the hole (Figure 23). The condition was assessed as a stage 4 MH.

Discussion

An OCT of a normal eye uses reflected light to visualize structural changes. The ganglion cells, the inner nuclear layer and the outer nuclear layer are displayed with a low reflectivity. The nerve fiber layer, the inner plexiform layer, and the outer plexiform layer are displayed with high reflectivity. With the low resolving power of the time domain (TD) OCT, there is no clear differentiation between the inner and outer nuclear layers and the inner and outer plexiform layers, but it can depict the retinal thickness and inner structural changes, and detect three-dimensional morphologic changes in the inner retinal layers such as lamellar retinal detachment, retinal detachments, RPE detachments and retinal edema. This provides cross-sectional retinal images and images of the posterior vitreous face and is important for assessing the changes pre and post vitreous surgery.

In PRM, tissue develops between the internal limiting membrane and the vitreous, which is detected as an irregular reflection on ophthalmoscopy. PRM without a posterior vitreous detachment is histopathologically interpreted as fibrous tissue proliferation containing predominantly glial cells on the retinal surface layer with few cellular components. With OCT, when the membrane adheres to the retina, the nerve fiber layer and the membranous tissue are both displayed with a high reflectivity, and can be interpreted as retinal thickening. In cases with increased traction or increased edema with disappearance of the depression at the central fovea or presentation of a pseudo-MH, fundus photographs show a hole-like finding,

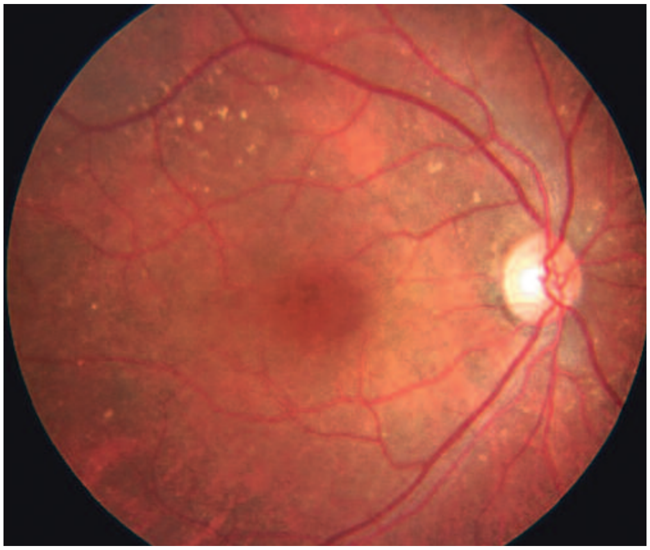

Figure 16: A stage 2 MH after vitreous surgery. The MH is closed.

Figure 18: A stage 3 MH. The MH with a retinal detachment (fluid cuff) is seen.

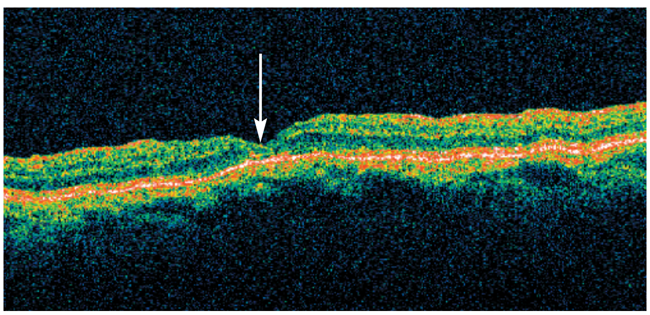

Figure 17: An OCT image of a stage 2 MH after vitreous surgery. There is no visual cellular layer (arrow).

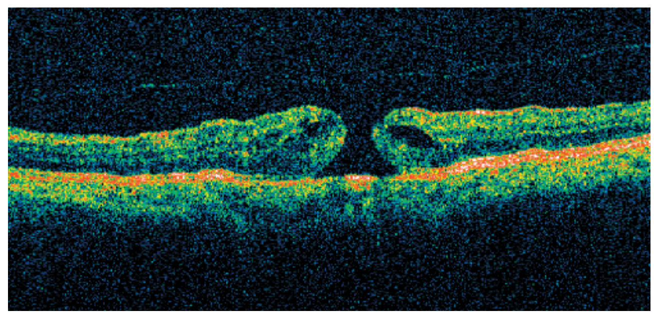

Figure 19: An OCT image of a stage 3 MH. A lamellar detachment with retinal thickening around the hole is seen.

while OCT shows a residual outer retinal layer, and the central fovea is observed as a cylinder-shaped depression, thereby allowing differentiation from a MH.

In cases of advanced VT, cystoid macular edema (CME) develops and patients complain of decreased visual acuity and metamorphopsia. In the natural course, complete posterior vitreous detachment at the macula is followed by improvement of the condition, but persistent traction is followed by the onset of irreversible retinal damage. To prevent this, vitreous surgery is performed to release the macular traction. OCT is useful to visualize the positional relationship of the posterior vitreous body and retinal surface, which is difficult to detect by ophthalmoscopy.

Changes at the central fovea during the early stages of a MH, i.e., stages 1A and 1B, are difficult to detect by ophthalmoscopy or slit-lamp biomicroscopy. In the early stages of a MH, posterior vitreous traction may be released spontaneously. In addition, because OCT imaging allows clear observation of the course from a lamellar retinal detachment to a lamellar MH with the surface layer of the retina becoming an operculum, OCT imaging is extremely useful for understanding the mechanism of the onset of a MH, staging, and follow-up.

Conclusion

This study was conducted to investigate the usefulness of OCT to evaluate the posterior vitreous and retinal surface. Intraretinal morphologic tissue changes are minor during the early disease stages. In OCT, even slight changes in the refractive index can be visualized as morphologic changes. In addition, OCT can provide images of optical media such as the posterior vitreous body with the slightest change in the refractive index. With PRM, MH, and VT, the anatomic positional relationship between the posterior vitreous membrane and the macula and shows changes in the inner retinal layer even during early disease stages allowing the evaluation of changes in visual function.

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Figure 20: A stage 3 MH after vitreous surgery. A retinal detachment (fluid cuff) around the hole has disappeared.

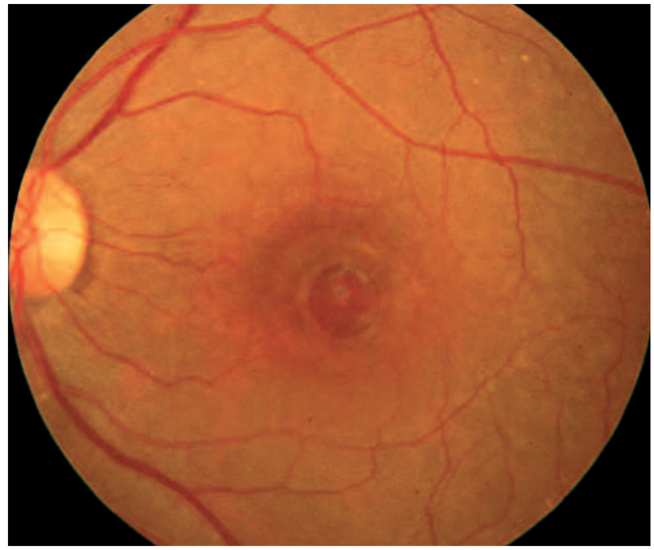

Figure 22: A stage 4 MH that is approximately half the diameter of the papilla.

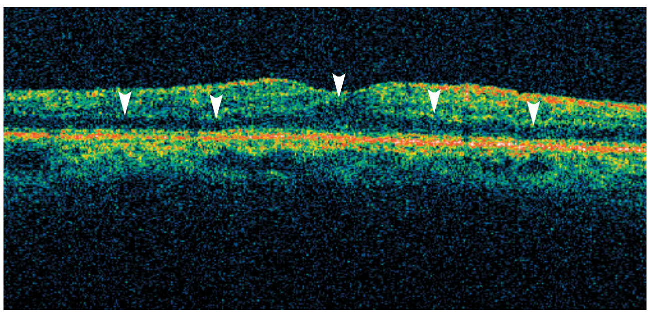

Figure 21: An OCT image of a stage 3 MH after vitreous surgery. Depression of the central fovea and a dark layer (arrowhead) with homogenous low reflectivity, with improvement of the array of the visual cell layer.

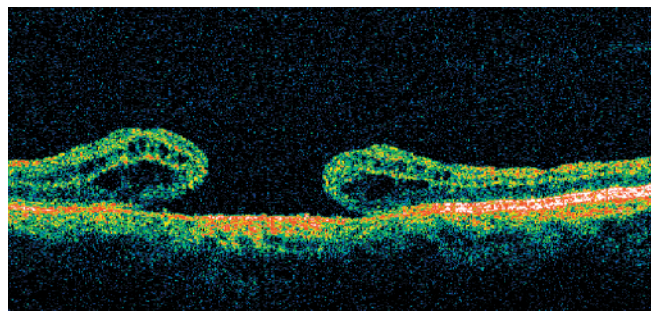

Figure 23: An OCT image of a stage 4 MH shows multiple cystoid interlayer detachments at the rim of the hole of the and enlargement of the base of the hole.

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