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Intact Retinal Tissue and Retinal Pigment Epithelium Identified within a Coloboma Via High-Speed, Ultrahigh Resolution Optical Coherence Tomography

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Abstract

Purpose—To report on a posterior segment coloboma manifesting unusual morphology as determined by high-speed, ultrahigh resolution optical coherence tomography imaging (hsUHR-OCT).

Methods—A 47-year-old patient with bilateral colobomas was evaluated via fundus examination and hsUHR-OCT.

Results—Imaging with hsUHR-OCT showed intact retinal pigment epithelium (RPE) within the posterior segment coloboma. Most of the retinal layers appeared to continue into the coloboma, although they exhibited slight attenuation. The external limiting membrane (ELM) was clearly visible continuing within the coloboma, suggesting that Muller cells and the inner segments of the photoreceptors were still present in this area. The junction between the inner and outer segments of the photoreceptors ended at the margin of the coloboma, which may be due to either photoreceptor disruption or a change in the orientation of the outer segments.

Conclusion—hsUHR-OCT demonstrated the presence of Muller cells and photoreceptor inner segments within a posterior segment coloboma. The retinal pigment epithelium (RPE) was intact within the coloboma, representing an unusual morphology.

Keywords

coloboma; ultrahigh resolution optical coherence tomography

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Introduction

During the sixth week of gestation, the fetal fissure, which contains neuroretinal cells, closes to allow for normal development of the eye.^{1,2} However, unsuccessful closure of the fissure can occur, possibly due to genetic and/or environmental causes.² This can result in a coloboma, or an area deficient in ocular tissue.³ In this condition, surrounding layers of the neuroretinal cells fail to successfully envelop the inner layers, and coloboma of the retinal pigment epithelium (RPE) and retina results.¹ Subsequently, the choroid does not develop without an underlying RPE.¹ Therefore, coloboma of the posterior segment of the eye has historically been called retinochoroidal (or choroidal) coloboma. Reports suggest that histologically, bare sclera is present within a coloboma without the normal retina, RPE, and the choroid.¹⁻⁴ The only retinal layer that is believed to traverse the defect is the inner neuroblastic layer, which contains Muller cells and amacrine cells.⁵ Previous time domain optical coherence tomography (OCT) studies show that the margin of the coloboma either gradually transitions or suddenly changes into an intercalary membrane (ICM).^{3,5} This ICM can include inner retina, glial tissue, and thin connective tissue.⁵ Patients with retinochoroidal coloboma generally manifest diminished vision, where large areas of the retina are involved and retinal detachments are reported to occur in as many as 40% of cases.⁶ Optical coherence tomography (OCT) represents a valuable imaging tool with which to distinguish individual layers of the retina *in vivo*.⁷ To our knowledge, all previously published reports on retinochoroidal colobomas imaged with OCT used StratusOCT, which has an image resolution of ~10-12 microns and an acquisition speed of ~400 A-scans/second.^{8,9} In our case report, a prototype spectral domain, high-speed ultrahigh resolution OCT (hsUHR-OCT) capable of an axial resolution of ~3.5 microns and acquisition speed of ~26,000 A-scans/second, was used to enhance our ability to distinguish intraretinal structures.^{8,9} To our knowledge, there have been no other studies that utilize hsUHR-OCT to image colobomatous tissue. Using this new imaging technology, we provide information on the inner retinal layers at the margin of the coloboma and report an unusual organization to the morphology of the colobomatous tissue.

Case Report

A 47-year-old female presented with decreased vision in her left eye and a history of bilateral colobomas. Examination of her left eye revealed a large, inferior iris coloboma in addition to an inferonasal posterior segment coloboma spanning a significant portion of retina, inferior to the optic disk (Fig. 1). Her medical history was unremarkable except for bilateral cataracts. Visual acuity was 20/200 in the left eye with no pinhole improvement. In the left eye, the pupil was poorly reactive. The visual field of the left eye was limited superotemporally and slit lamp exam showed a dense nuclear sclerotic cataract. Dilated fundus exam revealed a posterior segment coloboma with no evidence of retinal detachment OS (Fig. 1). hsUHR-OCT showed normal maculas OU, but an atypical morphology of the coloboma OS (Fig. 2). This tissue was devoid of normal retina tissue, although attenuated and abnormal retinal layers were present. The RPE and choroid remained present beyond the immediate margins of the coloboma. Visual changes were attributed to a worsening cataract.

Discussion

Retinochoroidal coloboma of the posterior segment of the eye occurs when the fetal fissure fails to close properly.¹ Histological and OCT studies have previously shown most posterior segment colobomas to be devoid of normal retina, RPE, and choroid.^{1,2,3,4,5} In this report, using hsUHR-OCT imaging, we provide data suggesting preservation of RPE and choroid above the sclera in a case of posterior segment coloboma using hsUHR-OCT imaging.

Furthermore, we provide the first hsUHR-OCT data on the presence of inner retinal layers within the coloboma.

Contrary to previous reports, our patient's retinal coloboma shows a layer of RPE and underlying choroid that continues into the coloboma beyond the immediate margin. Although in our patient these layers cannot be histologically confirmed, their reflectance using hsUHR-OCT imaging correspond to the normal reflectance of RPE and choroid.⁸ Additionally, the retinal layers seem to continue into the coloboma and gradually attenuate, rather than abruptly disappearing at the margin between normal retina and coloboma. However, it should be noted that despite several attempts to image the center of the coloboma to test if intact retina or RPE could be determined, media opacity prevented clear imaging with the hsUHR-OCT. Therefore we cannot be certain that RPE can be appreciated throughout the colobomatous tissue. Nonetheless, our image does show the coloboma at and beyond its margin, allowing us to draw conclusions concerning this area.

Imaging with hsUHR-OCT allows better definition of the inner retinal layers at the margin of a coloboma (Fig. 2). The external limiting membrane (ELM) is clearly seen continuing into the coloboma. Since the ELM consists of adherens junctions between Muller cells and photoreceptor inner segments, we are assuming that the Muller cells and photoreceptor inner segments are still intact beyond the margin of this coloboma.¹⁰ However, the junction between the inner segments and outer segments of the photoreceptors (IS/OS) ends abruptly at the margin of the coloboma. The disappearance of the IS/OS junction alone may be due to a change in photoreceptor orientation, and does not necessarily indicate photoreceptor impairment. For instance, in acute central serous chorioretinopathy, outer segments point away from the central pupil, causing reduced backreflection from the IS/OS junction.⁹ In our patient this of photoreceptor orientation and structure may account for the observed loss of retinal function in the coloboma despite other persisting retinal tissue. Therefore, while retinal tissue remains present beyond the margin of the coloboma, it appears morphologically different from normal retina.

According to the definitions of ICM provided by Schubert, the persisting retinal tissue in our coloboma fits the description of ICM with the exception of the layers beneath it.⁵ The presence of inner retinal layers and Muller cells within the coloboma remains consistent with ICM as well as embryologic formation of a posterior segment coloboma. However, even if ICM exists in our patient's coloboma, it manifests in an atypical manner; the ICM is present along with underlying photoreceptor inner segments and RPE.

We present the first imaging of a posterior segment coloboma with hsUHR-OCT. This demonstrates that the ELM, consisting of Muller cells and photoreceptor inner segments, continues into the coloboma rather than ending abruptly. Conversely, the IS/OS junction ceases at the margin between normal retina and coloboma. Additionally, hsUHR-OCT imaging reveals a previously unreported morphology to colobomatous tissue. In contrast to other posterior segment colobomas, this coloboma shows a continuation of RPE and choroid within the coloboma. Retinal layers appear to remain in the coloboma, although they are attenuated and possibly abnormal. Future studies with hsUHR-OCT imaging will need to be performed to determine whether other colobomas with traditionally described morphologies show similar inner retinal structure within and at the margin of the coloboma.

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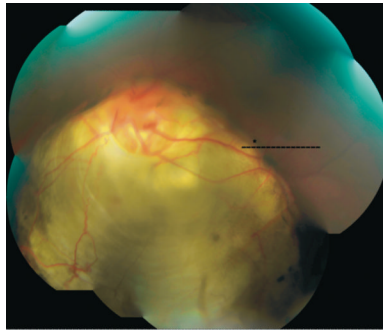


Figure 1. Color fundus photo mosaic shows an inferonasal posterior segment coloboma with no evidence of retinal detachment. The coloboma involves the optic disk. The approximate cross-section taken by the UHR-OCT is superimposed onto the mosaic. The asterisk corresponds to the approximate margin between normal retina and the coloboma.

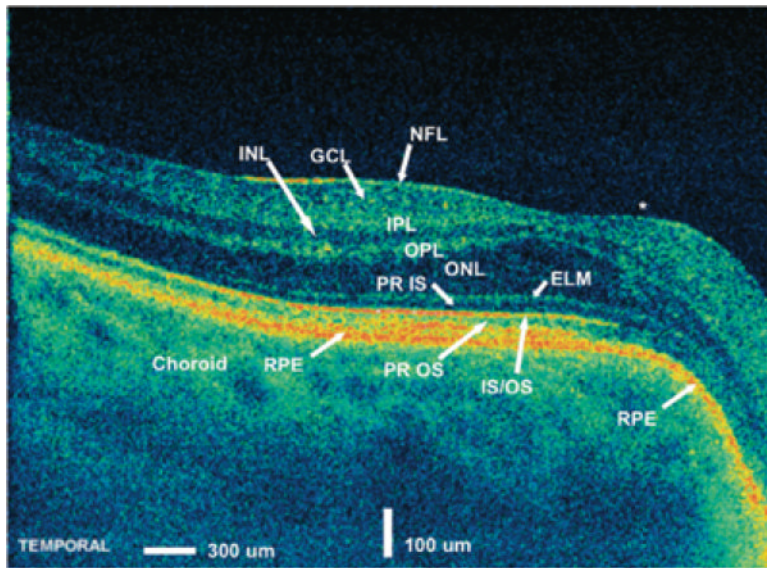


Figure 2.

High-speed, ultrahigh resolution optical coherence tomography scan of the macula. Three high-definition 6-mm OCT images (8192 axial scans per image) are acquired at 0.3 seconds per image. This protocol is especially useful for patients with media opacity that results in a decreased OCT signal. The approximate margin between normal retina and coloboma (asterisk) corresponds to a discontinuation of the junction between inner and outer photoreceptors (IS/OS). The external limiting membrane (ELM) and retinal pigment epithelium (RPE) continue within the colobomatous tissue. The choroid can be seen below the RPE persisting in the coloboma. The thickness of the retina can be observed decreasing beyond the margin of the coloboma. GCL, ganglion cell layer; IPL, inner plexiform layer; INL, inner nuclear layer; NFL, nerve fiber layer; OPL, outer plexiform layer; PR IS, photoreceptor inner segments; PR OS, photoreceptor outer segments.