In Vivo AOSLO Imaging of Retinal Detachment Associated Pathology

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Summary

Disruption of the area of contact between the retina and the nourishing retinal pigment epithelium (RPE) threatens the stability of our vision and its recovery following intervention. In vivo interpretation of disruption is dependent on imaging techniques whose resolution is severely restricted by inherent ocular aberrations. Adaptive optics (AO), a newer imaging technique, is capable of optically correcting these aberrations and allows in vivo imaging of the photoreceptor mosaic at a resolution comparable to those available with histology.1

In retinal detachment associated pathology, disruptions of the Eiliasmoid Zone (EZ) and Interdigitation Zone (IZ) bands are visible on Optical Coherence Tomography (OCT) images. As these bands originate from the rod and cone photoreceptors, their disruption has been correlated with severe defects in visual acuity.1 In this study we sought to use AO imaging in combination with standard clinical imaging to assess photoreceptor structure in patients with visual disturbances caused by photoreceptor separation from the RPE.

Results

1. Split-Detector AOSLO Shows Photoreceptor Structure in Dark Areas

Confocal AOSLO has been used to demonstrate residual cone structure within dark areas (as defined on OCT) in patients with Macular Hole (Mac Hole).2 Confocal AOSLO has demonstrated residual photoreceptor structure within dark areas in patients with retinal detachment (RD).3 Similar dark areas are present in en face OCT and confocal images from patients with vitreomacular traction (VMT), retinal detachment (RD), and central serous retinopathy (CSR). Using the split-detector AOSLO imaging, we observed remnant inner segment structure within these lesions. Scale bars = 100 µm.

2. Microfolds Visible in Split-Detector Images

As part of the normal aging process, vitreous shrinks from the retina towards the anterior eye. Anomalous VMT occurs when this retraction adheres to the retina. In the untreated eye, severe disruption is visible on OCT resulting in microfolds that interfere with visualization of cone structure on AOSLO. In the treated eye, despite apparent resolution on OCT, we see residual lesions in the AOSLO image (possibly accounting for their 20/10 vision in that eye). Scale bars = 100 µm.

4. Cone Inner Segments Within Dark Areas in Mac Hole

In previous studies of Mac Hole, dark areas were thought to be areas of complete photoreceptor loss.1 Split-detector images of Mac Hole show a presence of cone inner segments, which may account for patients that have a higher BCVA than projected based on the lesion area. The color merge image demonstrates additional information (blue) from split-detector shows with respect to conical (orange). Scale bars = 50 µm.

3. Waxy Membrane Found in Post-Operative RD

This waxy reflectivity was found on the surface of the Nerve Fiber Layer (NFL) just nasal to the fovea. Other small membranes were found in various peripheral locations. Waxy membranes are thought to contain a connective tissue component and are often visualized on OCT, though this membrane was not visible on en face imaging. These small remnants post-operatively could account for a waxy membrane that predisposed the patient to RD.1 Scale bars = 50 µm.

5. Peripheral Rod Cells Visible in CSR Dark Areas

CSR results from choroidal fluid infiltrating the subretinal space.1 This condition is distinct from vitreomacular traction in that the fluid detachment comes from the outer spaces of the eye rather than the inner. When viewed with confocal imaging, cone signals are irregular and reflectance is distorted suggesting the presence of non-waveguiding photoreceptors. Split-detector images show only the presence of intact cones, but also intact rods within the area of detachment. This suggests some cones have degenerated, allowing the remaining rods to swell. Scale bars = 25 µm.

Methods

Photoreceptor Imaging

EZ and IZ band disruptions in OCT images appear as dark ‘areas’ in confocal AOSLO images. The confocal AOSLO mosaic uses a waveguide light from the photoreceptor that has passed through both the outer and inner segments of the cell; these dark areas could indicate disrupted waveguiding or may be the result of photoreceptor degeneration. A recently developed split-detector AOSLO modality allows visualization of the photoreceptor inner segment in a manner independent of the cell’s waveguiding properties.1 This allows for a potentially more sensitive assessment of photoreceptor structure in and around clinically detectable lesions.

Clinical Imaging Techniques

Fundus images are useful for seeing gross structure, OCT for visualizing the layers of the retina, and AOSLO for evaluating the integrity of the photoreceptor mosaic. As lesions can sometimes be visible in AOSLO images, but not OCT, clinical imaging tools are unable to accurately predict changes in Best-Corrected Visual Acuity (BCVA).

En Face OCT

En face OCT is currently used to visualize and measure lesion size within the band of EZ disruption and for localization of AOSLO images. An en face image is made by plotting a contour along the EZ band in each of 400 B-scans. Scans are then stacked to form a projection of the specified segmentation. The resulting image looks similar to a fundus photo, however, it shows layers deep within the retina.

Conclusions and Future Directions

AOSLO provides valuable information when studying retinal detachment associated pathology not accessible with existing clinical tools. Both confocal and split-detector modalities provide useful information about the etiology and cellular structures associated with disease. Combined imaging of patients with retinal detachment associated pathologies will help to identify unknown structures associated with various disease presentations observed with AOSLO.

The unique presentation and recovery of patients with Mac Hole provides a unique opportunity to study photoreceptor morphology during the healing process. A longitudinal study of residual cone structure present in dark areas with split-detector imaging may be able to detect changes in cone density and morphology. These changes may provide improved sensitivity, compared to OCT, in predicting recovery of visual function following surgical intervention.

References


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