The case of chorioretinal coloboma-induced retinal astigmatism and its implications for future developments in myopia management: A commentary.

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Abstract

A recently reported case of a rare induced retinal astigmatism from a chorioretinal coloboma spurs additional commentary on the implications of future technology that directly measures retinal astigmatism via retinal topography. These implications include the application of such technology to myopia management and the opportunity to more effectively control progressive changes in retinal curvature throughout childhood with the application of custom corneal excimer laser ablations.

Keywords: Chorioretinal coloboma, Corneal refractive surgery, Myopia control, Retinal astigmatism, Retinal topography, Whole eye OCT.

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Description

Recently, I reported a case of presumed retinal astigmatism induced by a chorioretinal coloboma bisecting the so-called macula of a 44 year-old Caucasian male [1]. One critical finding of the case was a large angle kappa denoting the displacement of the visual axis' posterior intercept through the border of the coloboma and the healthy retina. Macular Optical Coherence Tomography (OCT) provided evidence of a possible toric retinal shape; however, it was unable to truly characterize the patient's retinal morphometry and biometry.

Avicenna, the Middle-Ages Persian physician-philosopher, is credited with saying that "the eye is like a mirror, and the visible object is like the thing reflected in the mirror." In one sense, he was correct if you consider the optical properties of a curved surface such as the retina. Retinal astigmatism is somewhat of an enigmatic concept in the sense that it can only be inferred from the total refractive results rather than through direct measurement. Clouding our understanding even further is the fact that the retina is not a refracting element. Interestingly, this rare case seemed to present evidence that retinal astigmatism could not only exist, but could also be clinically significant.

Discussion and Conclusion

Defocused images formed on the surface of a concave mirror can produce observable aberrations, the amount of defocus being dependent upon the spatial relationship of the mirror's surface to the lens' focal length. A real-world example of such a system is the Hubble telescope. Shortly after its deployment in 1990, scientists noted that it was returning images with less clarity than expected. A surfacing error of less than 1/50th of the thickness of a human hair was detected that resulted in an appreciable optical aberration. Instead of attempting to replace the mirror, engineers designed a corrective lens to be installed during a spacewalk. The resulting correction worked to perfection. One could consider Hubble as a paradigm for the contribution of retinal shape to the eye's total refractive error. Visual clarity in humans is dependent upon the precise focus of images upon the sensory retina. When refractive elements create an astigmatic aberration, a cylindrical correction is needed to precisely focus an image on a spherical surface. Likewise, a toric surface will create an astigmatic aberration from a spherical lens. The resulting blurred image is improved by a toric lens that changes the meridional focal points to align with the astigmatic surface. It is also illustrative to note that the concept of peripheral retinal hyperopic defocus is due to a relatively flatter, though not necessarily toric, peripheral retinal curvature which is thought to be produced by axial lengthening.

Retinal astigmatism receives scant attention in the literature. Historically, researchers proposed that a relative thickening of photoreceptors in one meridian versus another could induce astigmatism [2]. In 1995, Flüeler and Guyton simulated a tilted retina and measured a small amount of induced refractive astigmatism [3]. It was proposed that a similar anatomical change could occur in the retina through the unequal lengthening of the sclera in opposite meridians as a result of unequal axial growth [4].

Other scientists discovered that refractive cylinder had an effect on axial length growth during the emmetropization of monkeys, with the stop signal biased toward the least hyperopic plane [5]. Lessening of astigmatism is also common during emmetropization. Though not specified for meridional emmetropization, researchers have determined that corneal and lenticular shape changes do not seem to contribute significantly to a myopic shift [6]. Is it possible that meridional axial lengthening could be responsible for the lessening of astigmatism during emmetropization?

If one could discover the exact peripheral retinal zone that signals axial lengthening in response to a hyperopic focal point, one could envision custom corneal refractive ablations in children to control axial growth and the deleterious effects of associated myopia. This could become a reality if engineers are also able to register corneal topography with retinal topography in order to create an effective amount of myopic peripheral defocus in the appropriate retinal zone and along any toric retinal axis. Such a treatment could be superior to orthokeratology, the gold standard for myopia control, given its potential custom nature and the ability to eliminate the need for persistent long-term myopia control treatment with glasses or contacts and their associated non-compliance.

Fortunately, this instrument appears to be on its way to commercial availability. In 2019, ophthalmologists and engineers from Duke University published a report on a whole eye OCT developed to quantify retinal curvature [7]. It was also able to obtain a volume measurement equivalent to 55° of the retina. Considering that peripheral retinal defocus studies look at the area 20-30° from the fovea, this instrument might actually become useful in myopia management.

Cases such as these awaken the mind to consider the future role of retinal topographical analysis. The OCT was informative enough to recognize a rapidly changing retinal shape at the transition between healthy retina and the coloboma: however, an en face axial topopgraphical image would provide direct evidence of a toric retinal shape. This was a rare and exciting case, but even more exciting was the opportunity to contemplate the future application of retinal morphometry and biometry in managing the scourge of childhood myopia.

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