Optical coherence tomography in neuro-ophthalmology: bridging the gap between scientific discovery and clinical practice

Over the past two decades, optical coherence tomography (OCT) has transitioned from being an ocular imaging technology used predominantly in the management of patients with glaucoma and retinal diseases, to an invaluable tool in neuro-ophthalmic practice. As a surrogate marker of neuroaxonal integrity, OCT and recent advancements in OCT-angiography (OCT-A), are now used to diagnose many optic neuropathies, and prognosticate visual recovery over time. OCT provides highly reliable and reproducible measures of retinal integrity that enable structure-function correlations, which can in turn be used to explore mechanisms of injury and repair affecting the afferent visual pathway; a region of the central nervous system (CNS) that is both functionally eloquent and topographically elegant (1). Moreover, OCT measures of peripapillary retinal nerve fiber layer (RNFL) and macular ganglion cell layer structure inform our understanding regarding the pathogenesis and disease progression for many CNS disorders that impact visual function.

The authors contributing to this Focused Issue in the *Annals of Eye Science* represent a group of international thought leaders in the field of neuro-ophthalmology, with specific expertise in the realm of OCT research. Through their contributions, they highlight how scientific discoveries have ultimately changed clinical practice. In the initial installment in the series, Carvalho and Maloca provide a sweeping, state of-the-art perspective regarding established and emerging OCT techniques that complement the arsenal of tests neuro-ophthalmologists use to localize optic nerve injuries. OCT measures that are particularly germane in this setting are highlighted, including assessments of the optic nerve head, macula, peripapillary RNFL, and macular ganglion cell layer-inner plexiform (GCIP) layer. In this paper, the limitations and interpretative pitfalls inherent to OCT and OCT-A are insightfully described. The applications of OCT-A in assessing retinal and choroidal vascular networks are reviewed. The authors also introduce the potential role of adaptive optics in capturing high resolution, three-dimensional images of retinal microscopic structure. This overview provides a solid conceptual "bedrock" of OCT techniques that will aid readers, as they delve into the sections that follow.

The path OCT has taken from scientific discovery, to clinical utility in neuro-ophthalmic practice is perhaps best exemplified by its adoption as a structural marker in the field of multiple sclerosis (MS) (2). The strength of OCT as a surrogate marker in this context is rooted in the fact that pathobiological mechanisms linking measures of retinal structure with global CNS effects of inflammation, axonal loss, and neurodegeneration in MS are plausible (2). OCT measures are also reliable and highly consistent across a variety of available machines (2). When OCT parameters are paired with standardized visual outcome measures, the specificity of the technology is relatively robust in tracking the temporal effects of CNS inflammatory lesions over time, in a well-characterized patient population (2). These features have enabled ongoing, large-scale, multicenter collaborations among MS research sites (2). Beyza Ciftci-Kavaklioglu and Yeh extend the observations gleaned from the adult MS field to the pediatric realm, with a focus on structural and functional outcomes in children with inflammatory optic neuropathies.

The next two papers in the series focus on the value of OCT in distinguishing cases of papilledema from pseudo-papilledema. Fraser and Bursztyn describe how advances in enhanced depth and swept source OCT imaging have allowed better definition of the hyperreflective posterior borders of optic disc drusen, as a cause of pseudopapilledema. The enhanced penetrance provided by these OCT imaging modalities has proved to be particularly helpful in detecting buried drusen. This review also highlights the recent recommendations put forth by the Optic Disc Drusen Studies (ODDS) Consortium (3) regarding the diagnostic value of OCT in cases of optic disc drusen. Malhotra and colleagues tackle the other side of this "pseudo versus real" diagnostic dilemma, by discussing how OCT can be used to characterize changes in the optic nerve head, RNFL, and retinal pigment epithelium—Bruchs membrane complex, associated with true papilledema. These authors also aptly address challenges with image quality and segmentation analyses that currently limit our ability to rely on OCT in the clinical management of conditions presenting with papilledema, including idiopathic intracranial hypertension.

Kaushik and Fraser summarize the role of OCT in the diagnosis and management of compressive lesions affecting the afferent visual pathway, with specific emphasis on chiasmal tumors. In this clinical scenario, OCT provides invaluable diagnostic information, as hemi-nasal thinning in the GCIP layer can be detected prior to visual field loss; thus, facilitating

timely diagnosis. Furthermore, in compressive models of optic nerve injury, OCT has shown robust structure-functional correlations than can help predict the potential for visual recovery in patients with pituitary tumors who require surgical decompression.

Fard and colleagues provide a cutting-edge review of the role of OCT and OCT-A in the diagnosis of ischemic optic neuropathies. These authors highlight how analysis of early and late structural changes of the optic nerve head and retina may ultimately enhance our ability to predict visual outcomes and explore the pathogenic underpinnings of this enigmatic syndrome. Enright and Van Stavern offer a highly contemplative summary regarding the role of OCT in capturing manifestations of mitochondrial dysfunction in toxic, metabolic, and genetic optic neuropathies. In these conditions, OCT typically shows RNFL thinning that is most pronounced temporally; but, can be delayed in appearance. Contemporaneous macular ganglion layer analysis can be particularly useful in these cases, GCIPL layer thinning evident prior to RNFL loss. Finally, Airen and colleagues take a panoramic view, and discuss how focal thickness alterations in different regions of the intraretinal layers can be used to distinguish normal aging from neurodegenerative diseases, with emphasis on glaucoma, MS, Alzheimer's disease, Parkinson's disease, and genetic optic neuropathies. The clinical implications of ongoing research in this field are showcased, and the role of OCT in differentiating various ocular and cerebral neurodegenerative diseases, tracking disease progression, and evaluating the outcome of clinical trials is discussed.

In the current era, OCT has an increasingly useful role to play in neuro-ophthalmology, because the technology allows us to quantify the acute and chronic effects of CNS lesions that impact vision. Scientific discoveries in OCT research have informed our understanding about factors that govern injury and repair in a myriad of optic neuropathies and improved the clinical care we provide for our patients.

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References

1. Costello F. The afferent visual pathway: designing a structural-functional paradigm of multiple sclerosis. ISRN Neurol 2013;2013:134858.

2. Costello F, Burton JM. Retinal imaging with optical coherence tomography: a biomarker in multiple sclerosis? Eye Brain 2018;10:47-63.
3. Malmqvist L, Bursztyn L, Costello F, et al. The optic disc drusen studies consortium recommendations for diagnosis of optic disc drusen using optical coherence tomography. J Neuroophthalmol 2018;38:299-307.

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