High resolution retinal imaging

CHAPTER 13

SUMMARY

The ability to look inside the living human eye is central to our understanding of how the normal eye works and the diseased eye fails. This thesis focuses on technological advances in the spatial resolution of retinal imaging during the last decade. These advances have transformed retinal imaging from a macroscopic to a microscopic modality in which individual cells can now be resolved. To better visualize the cellular microstructure and understand the processes in the living retina, high-resolution imaging is the key. In order to study dynamic processes, non-invasive imaging provides an exciting alternative to histology. We discuss two modalities in this thesis, namely adaptive optics to study the neural network of the retina and optical coherence tomography angiography to analyse the vascular plexus of the retina.

As adaptive optics imaging finds more clinical applications, normative databases need to be developed for different populations as a reference for disease states. It may help us understand the pathogenesis of diseases at a subclinical stage, thus paving way for the exciting possibility of early treatment for these diseases.

Imaging and analysis of the retinal vasculature can be a surrogate marker for systemic vascular health. Correlations between vascular abnormalities in the retina and elsewhere in the body have been demonstrated in a diverse array of conditions including diabetes, hypertension and stroke. The earliest change in disease begins at the level of the microvasculature, however, imaging retinal capillaries is difficult because of their small size, low contrast, and arrangement in multiple planes of varying retinal depth. Optical coherence tomography angiography (OCTA) is an exciting and new imaging modality that has revolutionized our understanding of the retinal and choroidal vasculature in a non-invasive manner in normal as well as diseased states.

Chapter 1 is an introduction to the thesis and discusses the anatomy of the eye, histology of the retina and principles of the two high-resolution imaging systems, adaptive optics and optical coherence tomography angiography.

Chapter 2 involves a review of literature on AO. Here, we described the basic principle of AO and some clinical applications of AO in photoreceptor analysis in retinal degenerations and dystrophies and in retinal vascular analysis. AO is an innovative new tool in the extensive armamentarium of ophthalmologists to explore the cellular details of the retina. It is possible that as more detailing of cellular structures becomes possible, we may need to develop better analytical tools.

Chapter 3 describes normative data in cone density in emmetropes. We described the distribution of density, spacing and the hexagonal packing arrangement of the cone photoreceptors at different retinal eccentricities across the parafovea in emmetropic young adults in the Indian population. A statistically significant drop in the cone-packing density was observed from 2° from the fovea to 3°. The spacing correspondingly increased with increase in distance from the fovea. As the axial length increases, the cone density significantly decreases. Interocular variations were noted. It is essential to establish normative data in order to detect early onset of pathology at a cellular level and intervene early.

Chapter 4 looks at the variations in the cone mosaic in a population of young myopic adults in relation to the axial length and extent of the refractive error. In myopic patients with good visual acuity, cone density around the fovea depends on the quadrant, distance from the fovea as well as the AL. The strength of the relation of AL with cone density depends on the quadrant and distance. The mean cone density was significantly lower as the eccentricity increased from 2° to 3° from the fovea. There was also a statistically significant difference between the four quadrants. The correlation of cone density and spacing with AL showed that there was a significant inverse relation of AL with the cone density.

Chapter 5 describes the structure-function correlation by correlating the cone-packing with the retinal sensitivity utilizing microperimetry (MAIA) in emmetropes at different eccentricities. A drop in retinal sensitivity was observed as the eccentricity increased. It was also found that as cone-packing density decreased retinal sensitivity also decreased in all quadrants. This may be useful in establishing the functional correlates of photoreceptor mosaic structure in patients with macular disease who develop central scotomas due to various macular diseases like age-related macular degeneration.

Chapter 6 discusses the case of a patient with history of cutaneous melanoma in the foot, who developed MAR. Combined imaging and functional tools aided in

assessment of early pathological retinal alterations. This chapter describes the role of AO in detection and assessment of the extent of pathology in MAR.

Chapter 7 is a case report describing improvement in perfusion of the superficial capillary plexus immediately after anterior chamber paracentesis in acute central retinal artery occlusion. This shows the immediate recovery in vascular perfusion that occurs with intraocular pressure reduction. OCTA, being a non-invasive vascular imaging modality, helped document it before and after procedure.

Chapter 8 discusses the role of OCTA in detecting increase in macular perfusion and vascularity indices immediately after cataract surgery independent of improvement in signal strength. These increments were slightly lower but still statistically significant in the parafoveal and perifoveal regions. It may be prudent to perform OCTA before cataract surgery, especially in eyes with diabetic retinopathy and other diseases prone to developing macular edema postoperatively.

Chapter 9 demonstrated that the changes in OCTA measurements were reflective of use of 3 consecutive intravitreal anti-VEGF injections (Ranibizumab-Lucentis®) for the functional recovery of DME at the end of 3 months. It suggests that the resolution of microvascular damage noted on OCTA – FAZ, VD, and PD reliably correlates with the functional recovery (improved BCVA), and that reduction in CMT was the most reliable predictor of response.

Chapter 10 showed that manual segmentation of OCTA is required in more than 50% eyes with CNVM and this progressively increases from CNVM in ORCC to below the RPE. There is moderate concordance between OCTA and structural OCT in determining CNVM activity, with OCTA perhaps, being better at detecting disease activity.

Chapter 11 shows the superficial capillary plexus of an isolated racemose angioma in an asymptomatic young girl without any systemic associations.

Chapter 12 is the discussion of important findings, issues, and implications for future studies based on the above chapters.