CHAPTER 14

Optic nerve imaging

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Glaucoma is an optic neuropathy with characteristic optic nerve appearance and visual field loss for which elevated intraocular pressure (IOP) is one of the main risk factors.[1] This characteristic optic nerve appearance results from structural glaucomatous changes which usually precede functional deterioration (visual field loss).[2,3] Therefore, improvement of the diagnostic methods of structural abnormality and change can result in earlier diagnosis of the disease.

Structural evaluations of the optic nerve head (ONH) and retina are key to the diagnosis and follow-up of glaucoma patients. Imaging tests complement slit-lamp biomicroscopy exam and stereo photos of ONHs. Ophthalmoscopy and even sequential stereo photos are dependent on the expertise and skills of the observer. High intra-observer and inter-observer variability has been demonstrated in several studies.[4,5] The goal is to diagnose the disease or its progression as early as possible, to increase the probability of preventing visual loss.[6,7]

There are three predominant imaging technologies currently in use for the diagnosis and evaluation of glaucoma in Europe and the U.S.[8] These devices are: confocal scanning laser ophthalmoscopy (CSLO) (the most common commercial application is known as Heidelberg retina tomography (HRT)); optical coherence tomography (OCT); and scanning laser polarimetry (SLP), whose commercial application is known as GDX. Scans of the ONH, retinal nerve fiber layer (RNFL) and of the macula have been studied for their relevance to glaucoma. Not all imaging technologies have the capability of imaging all three intraocular structures. The ONH can be scanned with HRT and OCT. The nerve fiber layer can be scanned with GDX and OCT, and the macula can be scanned with OCT. All these technologies work differently and have their own strengths and limitations as well as different measures of reliability. Full comprehension of all of these points will allow the clinician to accurately interpret the data obtained by each one of the imaging tests, as well as their correlation with one another. The ultimate goal is to improve the early diagnosis of glaucoma and detection of glaucomatous progression.

CONFOCAL SCANNING LASER OPHTHALMOSCOPY (CSLO)

HEIDELBERG RETINA TOMOGRAPHY (HRT)

Confocal scanning laser ophthalmoscopy is the imaging technology and HRT (Heidelberg Engineering, Heidelberg, Germany) is the major commercially available instrument that utilizes this imaging system to study the eye (Fig. 14-1). Heidelberg retina tomography has three generations: HRT, HRT II and HRT 3.

Confocal scanning laser ophthalmoscopy is capable of obtaining three-dimensional images of the optic disc by acquiring high-resolution images, both perpendicular to the optic axis (x- and y-axis) and along the optic axis (z-axis) (Fig. 14-2). It is based on the principle of spot illumination and spot detection. Conjugated pinholes are placed in front of the light source and light detector and allow only light originating from a determined focal plane to reach the detector. Sequential sections are obtained by moving the depth of the focal plane through the whole depth of the tissue being studied; in this case, the optic nerve. The focal plane depth is adjusted by shifting the confocal aperture or pinhole (Fig. 14-3).

Heidelberg retina tomography makes use of a 670 micron diode laser to perform rapid scanning of the fundus. Oscillating mirrors in the HRT device redirect the laser beam to the x- and y-axis, along a plane of focus that is perpendicular to the optic axis (z-axis). A bi-dimensional image (15 × 15 degrees) is obtained at each focal plane. As the device changes the focal plane, other bi-dimensional images of the optic nerve are obtained. Each one represents an optical section of the optic nerve. A total of 64 sections, each done with 1/16 mm of depth interval, are obtained and used to create a three-dimensional image of the optic nerve. These 64 sections are equivalent to a depth of 4 mm.

Each optical section is composed of 384 × 384 points compose each optical section. Each one of these points has an x (horizontal),

Fig. 14-1 Heidelberg retina tomography (HRT) II scanning laser ophthalmoscope.