Overview of the GDx Nerve Fibre Analyser

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Introduction

Glaucoma is a multifactorial optic neuropathy in which there is a characteristic acquired loss of optic nerve fibres; this loss of fibres typically eventuates in visual field loss.[1] However, glaucoma is now known to 'cause the loss of a substantial number of optic nerve fibres and ganglion cells without detectable anomaly in standard perimetry'.[2] Several clinical trials have demonstrated that thinning of the retinal nerve fibre layer (RNFL) precedes visual field defect.[3]

The Nerve Fibre Analyser instrument referred to in this paper is the updated 'GDx Glaucoma Scanning System.' The GDx is a scanning laser polarimeter. It is a diagnostic instrument which provides sensitive testing for the early detection of glaucoma.[4] Around the region of the optic nerve head, the RNFL is known to be the most vulnerable to damage in the glaucoma process.[5] Therefore, by analysis of the thickness of the RNFL around this region, and by comparing the thickness with an age/race matched normative data base, glaucomatous damage can be identified.

The GDx gives precise, reproducible, quantitative, objective measurements of the RNFL. It is important to understand that the GDx measures the thickness of the RNFL rather than the surface topography of the retina. The birefringent nerve fibres cause a low power infra-red polarised light directed towards the eye to split into two parallel rays that travel at different velocities. The light undergoes a wavelength shift proportional to the thickness of the RNFL. The retardation between the rays emerging from the RNFL directly correlates to the nerve fibre layer thickness. Since the cornea also has birefringent properties, the GDx incorporates a "corneal compensator" to correct for the effect this may have on the retardation measurements.[4]

Image Acquisition

The GDx has a liquid crystal display (LCD) monitor as part of the scanhead, which allows for continuous visual contact of the fundus during the acquisition of the retinal image. (See Figure 1.) The patient is set up in front of the scanhead and asked to fixate a green target light. Acquisition of the retinal image involves aligning the optic disc with the centre of the LCD monitor and adjusting both the intensity and focus controls. The GDx is linked to a Microsoft Windows programme which records and analyses the data. The total time of the procedure, including alignment of the optic nerve can vary from one minute to several minutes. This time is dependent upon the patient's ability to fixate the target light in a steady manner. Once a focused image of the optic nerve is visualised by the examiner, the scan is then recorded in 0.7 sec. Approximately sixty-five thousand measurement points (known as pixels) are taken in a 15x15 degree field. These pixels are not affected by magnification error or media opacities. Pupil dilation is not required provided the pupil diameter is greater than 2mm. There is no discomfort experienced by the patient during acquisition of the RNFL image. The data is then processed. The scanning procedure is repeated so that images are obtained for each eye enabling the best to be selected for analysis.[4,6]

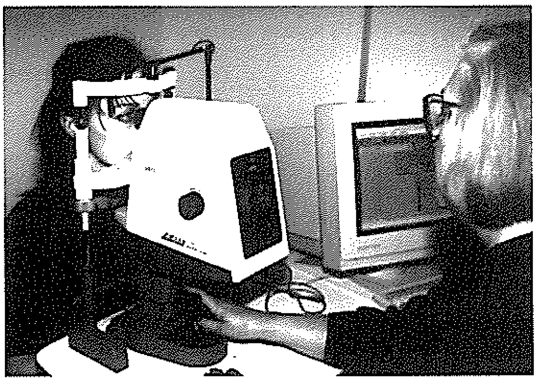

Figure 1. *The GDx Glaucoma Scanning System - Nerve Fibre Analyser.*

Data Analysis

The GDx normative data base was developed by Laser Diagnostic Technologies Inc by collecting data from normal eyes of volunteers between the ages 18 and 80 years of various races. The GDx software automatically compares images to the database and presents the scan results for each eye. Normal ranges were established for a variety of parameters, and the most effective parameters at differentiating normals from those with glaucoma are evaluated.[6]

The final result includes the assignment of an overall score for each eye referred to as "the number". "The number" is an experimental value currently under evaluation. It is derived from the assessment of 200 parameters via the computer's neural network. This network assigns to "the number" a value between 0 and 100, where 0-30 represents normal, 30-70 GDx suspects (ie glaucoma suspects), and 70 and above glaucomatous.[6]

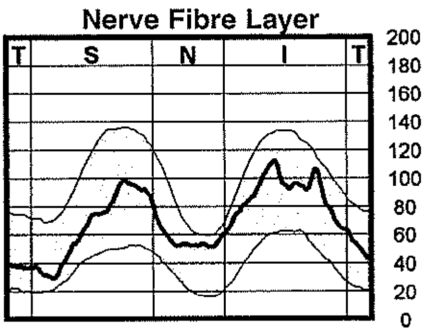

Figure 2. *Double-hump curve of a normal RNFL measured in microns.*

In addition to "the number", the analysis provides a list of values known as "GDx parameters". These parameters include maximum thickness scores, intergrals (ie total area scores) and ratios of the four quadrants examined around the optic nerve head. Parameter results indicate whether the patient is "Within Normal Limits" ($p>10\%$; the chance that the patient has a normal RNFL is more than 10%), "Outside Normal Limits" ($p<5\%$), or "Borderline" ($5\%<p<10\%$).

Patients in the GDx suspect category may prove to be "Borderline" or "Outside Normal Limits" on some GDx parameters, but not exhibit any visual field loss or other indications of glaucoma.[6]

The crucial step in establishing reliable GDx parameters is the placement of the 'illuminated alignment ring' referred to as the ellipse. The ellipse allows for measurement of the RNFL thickness at a set radial distance from the disc. Physiological cup size is genetically determined and dependant on the size of the disc.[7] This variation in the size of the optic nerve head means the operator must adjust the ellipse using the computer mouse, until best possible placement around the disc is achieved. Once the elipse is in place the operator can obtain statistical analysis by selecting the 'Calculate Analysis Data Button' on the menu bar.[6]

The monitor displays a reflectance/ fundal image and a colour coded thickness map. The dark colours (black and blue) represent thinner areas of RNFL and light colours (red and yellow) represent thicker areas. The reflectance image is like an optic disc photograph. This image is therefore useful in reviewing the cup disc ratio, but more importantly for the purpose of judging the quality of the image displayed. The image shows whether the scan has met the criteria of centration of the optic nerve head, clear focus of the flat peripheral retina and even illumination with correct intensity.

The thickness of the RNFL around the optic nerve head, in the temporal, superior, nasal, and inferior segments is represented by a bi-modal (double hump) curve. (See Figure 2.)
The double hump curve represents an "unrolled view' of the RNFL thickness around the optic nerve head. In the normal subject the superior and inferior RNFL at the retinal rim are thicker than nasal and temporal bundles.[5] Therefore the thicker RNFL in the superior and inferior regions are represented by two peaks on a bi-modal curve. The shaded double hump curve represents age related normal parameters. The line graph which falls within the shaded area is the patient's RNFL thickness in microns.

Summary

In summary, this diagnostic instrument provides a sensitive and quantitative measurement of RNFL thinning prior to visual field loss. The GDx has the advantage of being objective and efficient, with the results being processed and compared to a normative, age related data base.

References

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