Early Detection & Diagnosis for Glaucoma

Nerve Fiber Layer Analysis

Glaucoma is a disease in which there is irreversible damage to the **optic nerve**, resulting in loss of peripheral vision that eventually progresses to involve central vision if left untreated. This disease is often associated with increased pressure inside the eye. The eye doctor can look inside the eye to see the damage to the optic nerve, and can perform visual field testing to assess the extent of visual loss. However, a significant amount of damage must occur to the optic nerve before visible changes occur, and before loss of vision appears on the visual field test. Fortunately, new methods of diagnosis have evolved that allow earlier detection of optic nerve damage.

The nerve cells that are lost in glaucoma are called ganglion cells. There are over 1 million of these cells in the **retina** of each eye. Each cell has a long fiber that connects it to the brain. The fibers of all the cells travel in the nerve fiber layer of the retina, and exit the eye via the optic nerve. The optic nerve consists of all these fibers, and connects the eye to the brain to allow us to see. As these ganglion cells die, the nerve fibers are lost, the nerve fiber layer becomes thinner, and an empty space in the optic nerve called the "cup" of the optic nerve becomes larger and larger until the nerve is essentially gone. It is this cup in the optic nerve that the doctor uses to gauge the extent of damage from glaucoma.

Ganglion cell loss begins in the peripheral retina, and so loss of vision begins in the peripheral visual field. This is why visual field testing can help evaluate damage before it affects central visual acuity (reading vision). However, over half of the ganglion cells may be lost before any abnormality shows up on visual field testing.

Furthermore, many people many not realize that 30 to 50 percent of eyes with glaucoma may not have pressure that is higher than "normal". In normal pressure glaucoma, and in early glaucoma without visual field abnormalities, it may be difficult for the doctor to make the diagnosis of glaucoma and recommend appropriate treatment.

Fortunately, new technology is evolving that may assist the doctor to diagnose glaucoma. This technology allows the doctor to directly measure the thickness of the layer of nerves that is damaged in glaucoma, thereby determining if the disease is stable, or if progression is occurring. Direct measurement of the nerve fiber layer thickness is a more sensitive indicator of glaucoma damage, and may allow intervention before so much damage has occurred that the optic cup enlarges or loss of visual field occurs.

One new technology utilizes the principle of polarimetry, which measures the change in direction of alignment of light (polarization) after it passes through tissue, in this case the retinal nerve fiber layer of the eye. It has been shown experimentally that the amount of change in polarization correlates to the thickness of the retinal nerve fiber layer. The GDx

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Nerve Fiber Analyzer™ is an instrument that measures the change in polarization of a diode laser light that has been shone through the nerve fiber layer of an eye. This laser is not harmful to human tissue. The instrument then calculates the thickness of the nerve fiber layer, based on the amount of change in polarization of the laser light.

Another technology, called Optical Coherence Tomography, or OCT, measures the delay in reflection of laser light from the retina to determine the thickness of the retinal nerve fiber layer. The retina is transparent to the laser light used by the OCT instrument, so the light passes through the tissue. Reflection of the light is delayed when it passes through thicker tissue.

A third technology, called Heidelberg Retinal Tomography™, or HRT, uses a laser to scan the surface of the retina and optic nerve. The HRT can detect very subtle changes in the surface of the retina and optic nerve, and can alert your doctor if a change consistent with glaucoma occurs. The HRT is especially good for detecting and increase in the size of the optic nerve cup (described above).

The doctor can determine if a person's nerve fiber layer thickness is less than normal, indicating a diagnosis of glaucoma, or if the thickness has decreased since the last time the GDx or OCT examination was performed, indicating progression of glaucoma. Likewise, the doctor can determine if the size of the optic nerve cup has increased since the last time the HRT examination was performed, indicating progression of glaucoma. These examinations are performed in the office, and take about 10 minutes for both eyes. Total laser exposure is about 2 seconds per eye, and is not harmful or painful. Dilation is not required. These are promising instruments because they potentially may allow us to diagnose glaucoma before any significant damage has occurred.

Blue-Yellow Visual Field Testing

Without prompt treatment, glaucoma can cause loss of vision due to damage to the optic nerve. One way to measure the amount of damage to the nerve is to measure the amount of peripheral or side vision that has been lost. Glaucoma does not affect your central reading vision until the late stages of the disease. At this late stage, a glaucoma victim may already be partially blind. Therefore, it is important to measure the peripheral vision in the early stages of the disease, so that proper treatment can be given to prevent blindness. This is accomplished with visual field testing, which is an examination that measures the amount of vision lost.

Research has shown us that before damage shows up on standard types of visual field tests, which use white lights of varying intensities, a person may have already lost 50% of nerve tissue inside the eye. Ideally, damage to the nerve should be detected as early as possible, so that maximum visual function is preserved.

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Blue-yellow visual field testing is a recent development that allows us to detect damage to the visual field up to five years earlier than possible with standard white visual field testing. Blue-yellow visual field testing is also called short-wavelength testing, SWAP, or color visual field testing. This type of testing is most helpful in two situations. The first situation when blue-yellow testing is helpful is when the diagnosis of glaucoma is suspected, but not yet proven. Since this test shows damage earlier than other types of visual field testing, it may help make an early diagnosis of glaucoma, so that treatment can be initiated to prevent further loss of vision. The second situation when blue-yellow testing is helpful is when a person has early glaucoma with only minor loss of peripheral vision. Blue-yellow testing may help determine if visual loss is stable or progressive. This will help the doctor decide if more aggressive treatment is necessary.

The examples below show how blue-yellow testing detected more damage to a person's vision than standard white visual field testing.