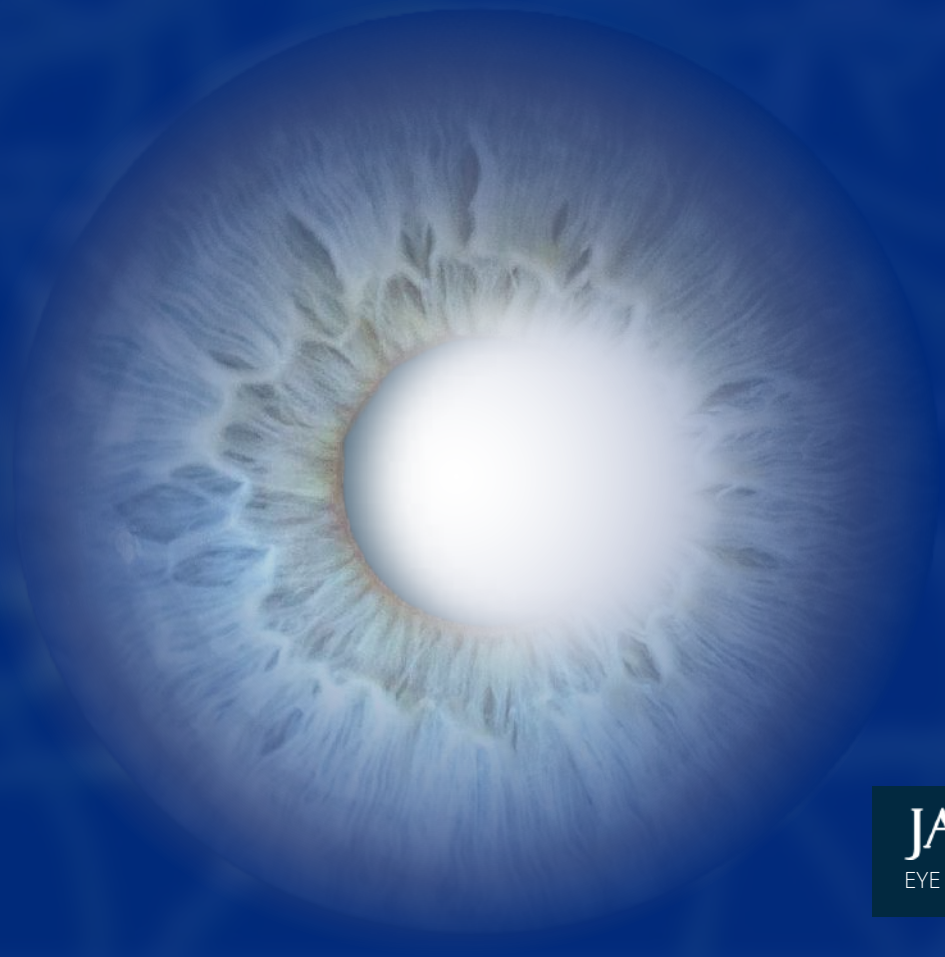
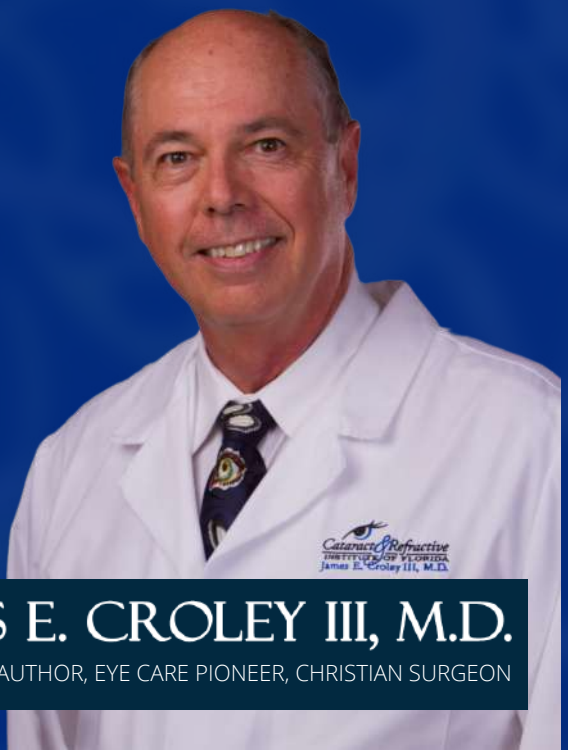
Glaucoma Guidebook







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Glaucoma Guidebook

by **James E. Croley III, M.D.**
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What Kind of Eye Disease is Glaucoma?

Glaucoma is not a simple eye disease where the eye pressure is elevated and therefore you have glaucoma. Glaucoma is caused by a variety of etiologies and presents clinically in a variety of forms. In simple terms, glaucoma is a disease process involving the optic nerve inside the back portion of the eye. The optic nerve is the size of a thin pencil and contains nearly 1.5 million nerve fibers. The optic nerve transfers the visual information that the retina has collected to the vision center in the occipital lobe in the back portion of the brain. Glaucoma develops secondary to eye pressure or intraocular pressure inside the eye being higher than what the optic nerve can tolerate. This eye pressure leads to a slow death or damage to the optic nerve fibers, which results in a slow, progressive loss of vision.

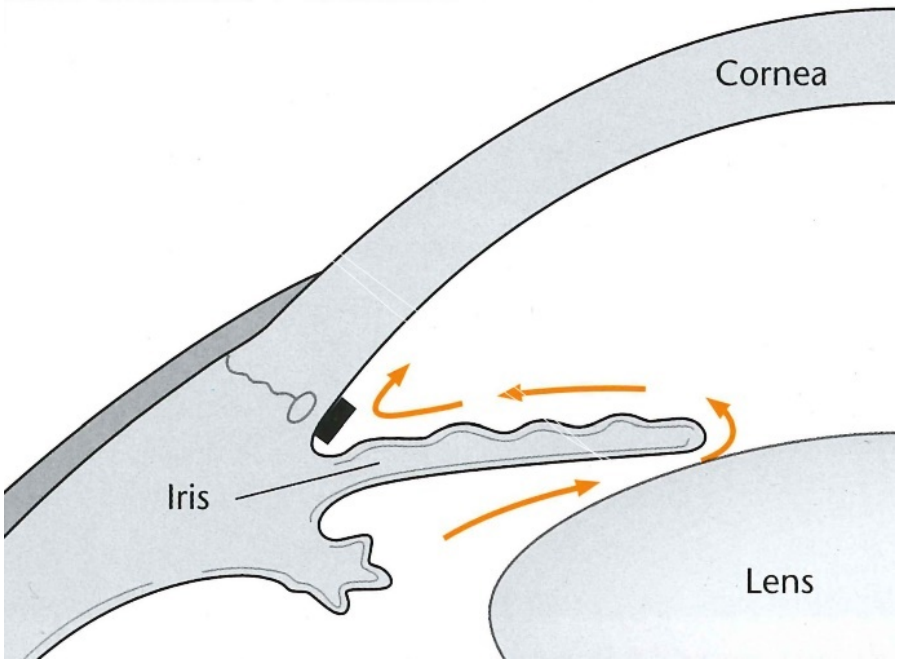
As the nerve fibers die, a person slowly loses vision, with only side vision in the beginning but can lead to blindness that may not be perceived by a person until significant damage has occurred. There are approximately 3.5 million people in the United States with glaucoma. Almost half of the people with glaucoma do not know they have it. Glaucoma is the second leading cause of permanent blindness in people over age 65. Macular degeneration is the leading cause of permanent blindness in people over 65 in the United States. Worldwide, only cataracts cause more blindness than glaucoma.

Why Do People Get Glaucoma?

The eye normally slowly produces a fluid inside the eye called the **aqueous humor**. This fluid contains nutritional substances needed by different tissues inside the eye and helps maintain the normal shape and structure of the eye. The aqueous humor is produced by a structure called the ciliary body which is located behind the colored portion of the eye called the iris. The aqueous humor flows from behind the iris and through the pupil into the anterior chamber (the anterior chamber is the fluid space between the iris and the cornea which is the clear portion of the front of the eye).

The **trabecular meshwork** is a very important structure inside the eye, as the aqueous humor filters through this meshwork to get out of the eye. The trabecular meshwork is located inside the anterior chamber at the place where the iris, cornea, and sclera (white portion of the eye) merge. When you look at the outside of the eye, the trabecular meshwork is located underneath the portion of the eye where the iris, cornea, and sclera meet.

The trabecular meshwork has the appearance of a cheesecloth. The aqueous humor has to filter its way through this cheesecloth membrane into a drainage channel called **Schlemm's canal** which circles all the way around the eye. The fluid flows from Schlemm's canal into venous canals which are located on the surface of the eye. The aqueous humor enters the veins and does not exit onto the surface of the eye. There is a steady state of fluid production inside the eye and flow from inside the eye, maintaining normal eye pressure.



Trabecular meshwork | *Google Images*

The most common type of glaucoma occurs secondary to the trabecular meshwork gradually becoming obstructed with debris. This material makes it more difficult for the fluid to flow out of the anterior chamber. This obstruction raises intraocular pressure. This increased eye pressure over time causes damage to the optic nerve, resulting in blindness. The theory of glaucoma damage is that the intraocular pressure limits or diminishes the blood flow in the optic nerve. This blood flow reduction and therefore diminished oxygen supply causes damage to the nerve.

It is similar to blowing up a balloon. As more air goes into the balloon, it becomes tighter and there is an increased resistance to force more air into the balloon. Elevated eye pressure reduces the flow of blood into the eye and diminishes oxygen to the nerve. There are many other factors and risks related to the development of glaucoma. Increased eye pressure is the major factor in glaucoma, but there are many others as well.

Who is Going to Develop Glaucoma?

The chance of developing glaucoma increases with age. Glaucoma begins to develop in most people after age sixty. There are exceptions to the rule. African-Americans are three times more likely to have glaucoma compared to Caucasians in the United States. Latins, Hispanics, American Indians, and Filipino Americans develop glaucoma at a much higher incidence.

African-Americans may have higher rates of glaucoma because studies have shown they have thinner corneas. In thin corneas, the eye pressure is actually measured lower than what is really inside the eye. A less common form of glaucoma, called **normal pressure** or **low-pressure glaucoma**, occurs more often in Filipino Americans.

There are several genetic factors that have been isolated in causing the development of glaucoma. Recent clinical studies have shown that consistent routine exercise may help reduce the risk of glaucoma.

What are the Risk Factors for Glaucoma?

- Over age 60
- African-American
- Family history of glaucoma
- Latinos and Hispanics
- Filipino-Americans
- American Indians
- Elevated eye pressure
- History of an eye injury

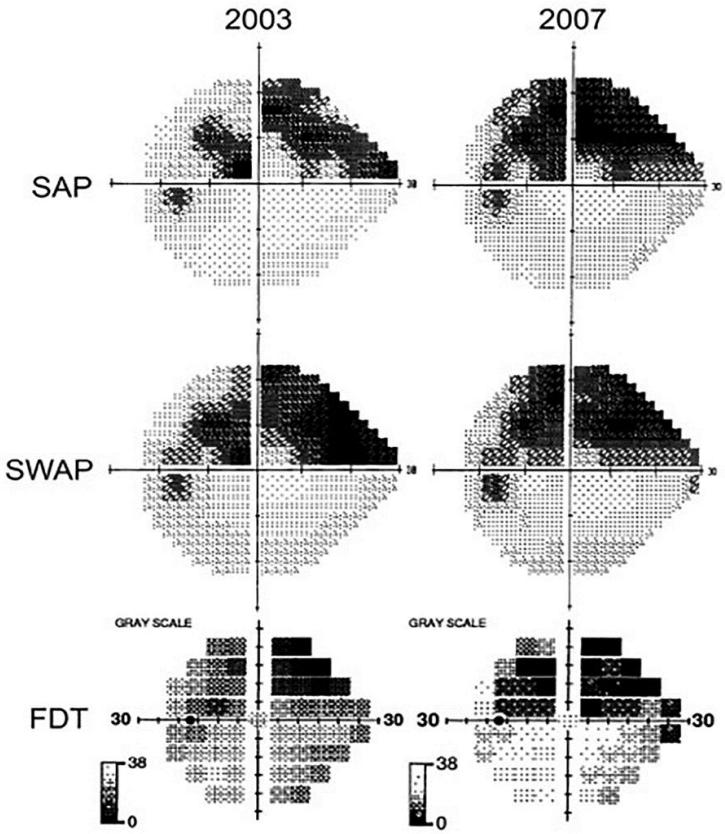
- Reduced or poor circulation and/or cardiovascular disease
- Myopia or nearsightedness
- Thin corneas

Glaucoma Symptoms

The nickname for glaucoma is “thief in the night” or “silent thief of sight." Most types of glaucoma do not cause any symptoms in the beginning. Symptoms do not occur until there has been significant damage to the optic nerve.

In the beginning, there is not any blurred vision, as that usually does not happen until the end stage of the disease. Loss of the central clear vision does not usually occur until the end. Over months and years of time, glaucoma slowly causes loss of side vision. This loss of vision is so insidious that most people are totally unaware of the loss. The brain is very astute and will compensate for the loss of side vision. You will start turning your head more or your brain will have you move your eyes more to compensate for this loss. These are all happening with you completely unaware.

Most of the time, people with more advanced glaucoma with a significant loss of their side vision are not aware of the loss until they are tested and are shown the loss. Unfortunately, there can be significant and irreversible vision loss from glaucoma before it is diagnosed.



Side vision loss from glaucoma | *Google Images*

Types of Glaucoma Diseases

Glaucoma is characterized by two general varieties of glaucoma based on the structure of the eye, which are **open-angle glaucoma** and **angle closure glaucoma** or **narrow-angle glaucoma**. The structure/degree of the angle determines the type of glaucoma present. The term *angle* is in reference to the angle between the cornea and the iris inside the peripheral portion of the eye. If you are looking from outside the eye, the angle is located beneath where the sclera (white portion of the eye) and the cornea meet.

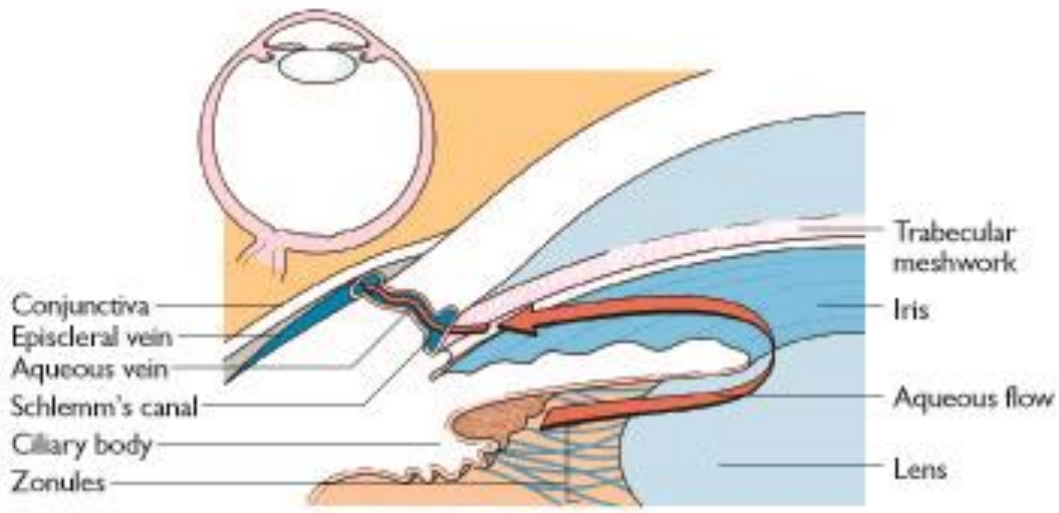
If the angle inside the eye is large enough to allow the flow of the aqueous humor into the trabecular meshwork, then you have open angles. If the angle is very small or the iris is touching the cornea, the angle is narrow or closed. With closed-angle or acute-angle closure glaucoma, the fluid is unable to get to the trabecular meshwork to drain from the eye. This is like putting a stopper in a sink—no fluid passes through to the meshwork and drains from the eye.

In the United States, open-angle glaucoma comprises over 95% of glaucoma, and angle closure glaucoma is 4% or 5%. In other parts of the world, these numbers can be very different.

Open-angle glaucoma is composed of many different types of glaucoma. These include *primary open-angle glaucoma* (POAG), *low-pressure or normal-tension glaucoma*, *pigmentary glaucoma*, *secondary glaucoma* (glaucoma secondary to other eye diseases or medical conditions), *pseudoexfoliation glaucoma*, *congenital glaucoma*, and *neovascular glaucoma*. Before actually developing glaucoma, there are other clinical states before someone has damage from glaucoma. Ocular hypertension and glaucoma suspect are diagnoses used to describe eyes with elevated intraocular pressures, but the eyes have not developed glaucoma damage. These eyes are at risk of developing glaucoma in the future.

The other major type of glaucoma is **acute angle-closure glaucoma**, which includes narrow angles before developing an acute attack of angle-closure glaucoma and chronic angle-closure glaucoma.

Primary Open-Angle Glaucoma (POAG)



Primary open-angle glaucoma | *Google Images*

POAG is the most common type of glaucoma. The access to the angle is open but the trabecular meshwork is partially blocked for a variety of reasons. The aqueous humor is restricted from flowing from the eye. This blockage restricts the drainage of the fluid from the eye, causing the fluid to build up inside the eye which raises the intraocular pressure (IOP). The presence of permanently elevated eye pressure damages the optic nerve. The loss of optic nerve tissue causes the eye to lose vision. The side vision is the first to go and is slowly lost over months and years. When advanced, this can lead to what is called "tunnel vision". If left untreated, this will eventually to irreversible total blindness.

Low-Pressure Glaucoma or Normal-Tension Glaucoma

Low-pressure glaucoma goes by other names as well, which are *normal-tension glaucoma* or *normal-pressure glaucoma*. Low-pressure glaucoma is a variation of primary open-angle glaucoma in that there is damage to the optic nerve with normal eye pressure or low eye pressure. Normal-tension glaucoma in the United States occurs in a small percentage of people, but it occurs more often in people with a history of vascular disease, the elderly, those of Japanese descent, and females. Many scientists believe that the optic nerve is damaged at a lower eye pressure secondary to poor blood flow in the optic nerve. People with low-pressure glaucoma can be difficult to treat as they need to maintain very low eye pressure.

Pigmentary Glaucoma

Pigmentary glaucoma occurs from the pigment coming loose from the pigment layer of the iris. These free pigment cells make their way to the trabecular meshwork, obstructing the flow of the aqueous humor from the eye. Pigmentary glaucoma is different from primary open angle glaucoma as it occurs at a younger age, from the mid-30s to the 40s, and is much more common in males versus females.

Glaucoma Secondary to Other Eye Diseases or Causes

Glaucoma can develop secondarily to other eye diseases. Eye diseases that cause inflammation inside the eye can cause glaucoma. The inflammatory cells inside the eye from the inflammation collect in the trabecular meshwork, and white blood cells block the flow of fluid from the eye. The

inflammation can be secondary to many systemic diseases. If this type of inflammation is present, a thorough medical workup is necessary to find its etiology. The inflammation needs to be treated, and once treated, the glaucoma may resolve.

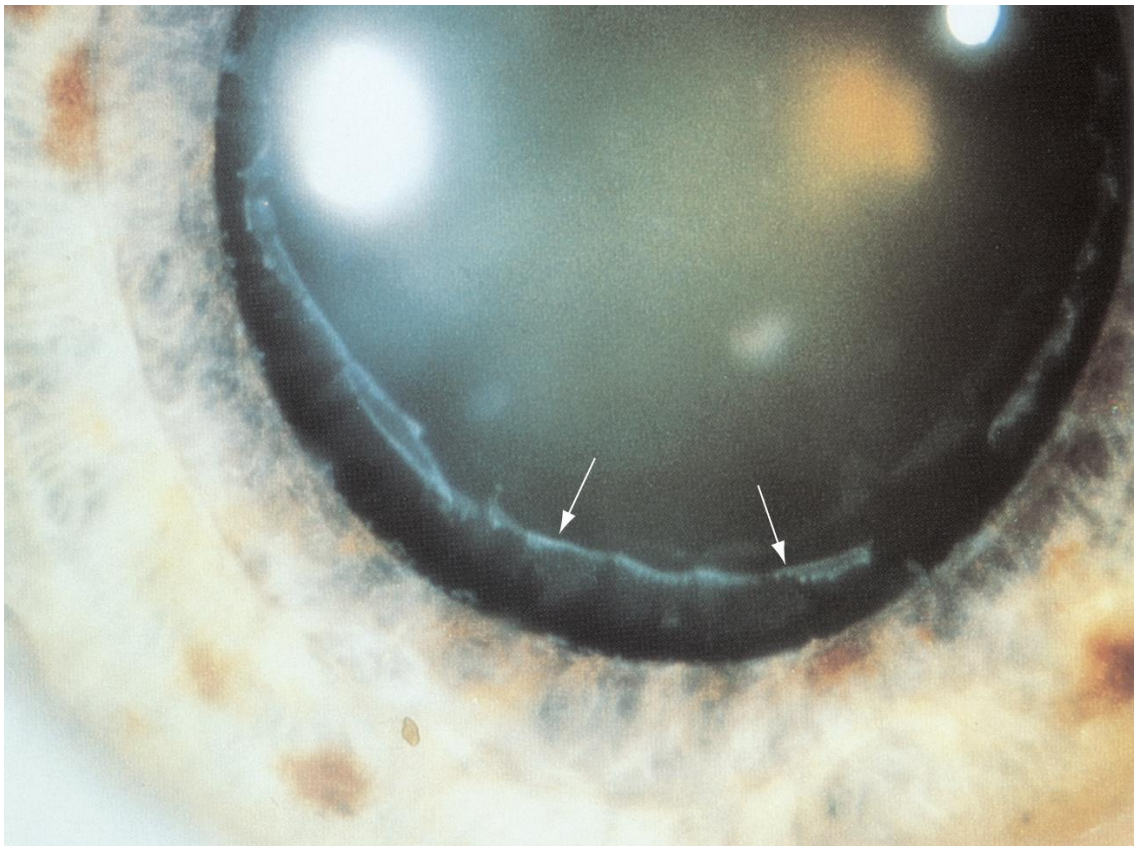
The use of medications such as corticosteroids, prednisone, or cortisone either by eye drops, pills, injections, skin applications, or inhalers can increase eye pressure. Eye tumors, overripe cataracts or hypermature cataracts, and eye injuries or trauma can cause glaucoma.

Pseudoexfoliation Syndrome and Glaucoma (PXF or PEX)

Pseudoexfoliation syndrome is a systemic disease or disorder in which a fibrillar, proteinaceous material is produced in high concentrations in ocular tissues. Pseudoexfoliation is the most common cause of unilateral glaucoma in the United States. It occurs in people over age 65 at a rate of approximately 5 percent. Glaucoma occurs in about 50% of people with pseudoexfoliation syndrome.

Pseudoexfoliation syndrome is primarily characterized by the deposition of flakey, whitish deposits on the lens, corneal endothelium (cells lining the inside of the cornea), iris, and trabecular meshwork. These deposits can obstruct the aqueous humor from filtering through trabecular meshwork, raising the eye pressure and causing glaucoma. This material also keeps the pupil from dilating due to deposits on the iris. The capsule and zonules of the lens can be weakened by this process as well. This poor dilation and weakened capsule and zonules increase the risk of complications during cataract surgery. Pseudoexfoliation glaucoma responds poorly to treatment

with medications. Laser treatment and other surgeries may be necessary to control the glaucoma.



Pseudoexfoliation of the lens capsule can block the trabecular meshwork and block the flow of fluid out of the eye | *Google Images*

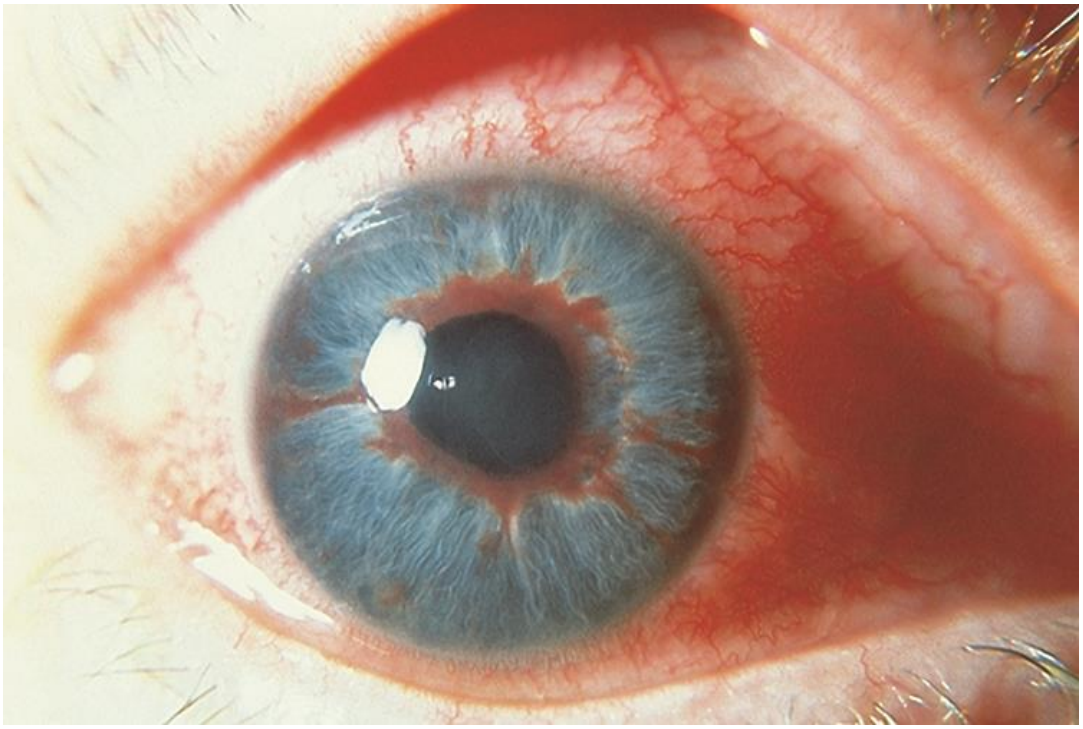
Congenital or Childhood Glaucoma

Congenital glaucoma is an inherited form of glaucoma. This type of glaucoma is diagnosed at birth or a very young age. The incidence of congenital glaucoma in the United States is 1 in 10,000 births. It is bilateral in 65 percent of cases. The cause is not known but is believed to be a developmental defect.

The child usually presents with large protruding eyes, large corneas, cloudy or hazy corneas, painful eyes, and/or watery eyes. There are certain areas around the world where congenital glaucoma is very common. Many children by the age of 6 or 7 are blind from glaucoma.

Some famous people have lost their vision from congenital glaucoma, such as Stevie Wonder, Ray Charles, and Andrea Bocelli. Congenital glaucoma must be diagnosed as soon as possible to prevent blindness.

Neovascular Glaucoma (NVG)



Abnormal blood vessels growing into the iris | *Google Images*

Neovascular glaucoma (NVG) is a type of secondary glaucoma, but this glaucoma needs a separate discussion. This type of glaucoma is the most

severe and/or the most difficult type of glaucoma to treat. It is a potentially devastating consequence of an underlying eye disease or systemic disease. A hypoxic event in the eye is causing the growth of abnormal and fragile new blood vessels inside the eye, including the angle, trabecular meshwork, iris, and retina. This new vessel growth or neovascularization develops from ischemia in the eye secondary to the obstruction or loss of blood flow into the eye. There are a variety of different causes for the diminished blood flow to the eye.

Diabetes

Diabetes is a cause of neovascular glaucoma in 33 percent of cases secondary to ischemia in the retina from diabetic retinopathy.

Central Retinal Vein Occlusion

Blockage of the main central retinal vein that drains the blood from the retina leads to severe alteration of the blood flow through the retina. This can lead to significant ischemia or loss of blood flow, leading to hypoxia of the retina.

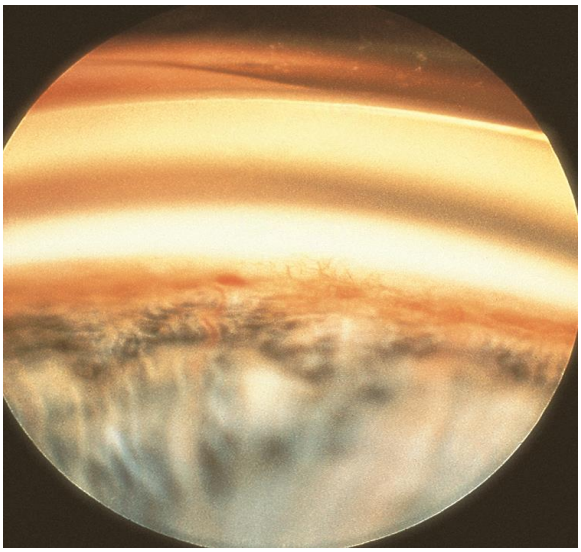
Carotid Artery Obstruction

This is the third most common cause of NVG and is the most difficult to diagnose. The reduction of blood flow to the eye from the obstruction of the carotid artery leads to ischemia and the production of new blood vessels.

All these diseases result in ischemia or reduced blood flow in the retina. A chemical called **vascular endothelial growth factor** is produced in the retina when the retina becomes ischemic or loses its blood flow and oxygen.

This ischemia stimulates the development of new blood vessels or neovascularization in response to the loss of blood flow or oxygen supply to the cells of the retina. At first glance, it may seem that the body is responding in a great manner. These new blood vessels will bring in more blood flow and oxygen to the oxygen-starved cells in the retina. The problem with these new blood vessels is that they are thin and fragile and easily break open and bleed. They grow randomly and in the wrong places.

These neovascular vessels grow into the trabecular meshwork, angle, iris, and retina. They bleed and also block the flow of fluid from the eye. These abnormal vessels can cause tremendous damage to the structures in the eye. The blood vessels can completely obstruct the trabecular meshwork with severe elevations in the intraocular pressure. There can be significant hemorrhaging from these vessels and the blood can nearly fill the eye in some cases. Medications may have limited effects in lowering eye pressure. Glaucoma surgical procedures are difficult as there can be significant bleeding during the surgery. This is the most difficult glaucoma to treat.



Blood vessels growing into the trabecular meshwork blocking fluid from exiting the eye | *Google Images*

Other Glaucoma-Related Conditions

Ocular Hypertension

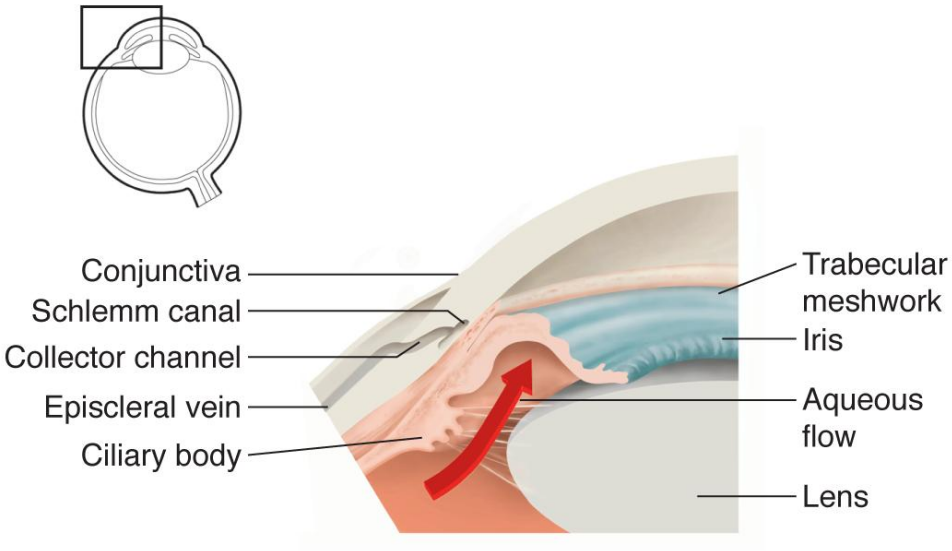
Ocular hypertension is a pre-glaucoma condition. The intraocular pressure is higher than normal but there has been no damage to the optic nerve. All the tests that are performed for diagnosing glaucoma are normal. These people need to be monitored closely depending on other risk factors related to glaucoma. Some people may need to be treated because the intraocular is so elevated that is deemed to be unsafe for the eye.

Glaucoma Suspect

This is another condition or diagnosis related to glaucoma in someone who is at risk of developing glaucoma but has no glaucoma damage to the optic nerve. The intraocular pressure is normal and the glaucoma tests are normal, but there is a family history of glaucoma.

The person needs to be followed closely depending on the number and type of risk factors. Some of the risk factors of concern may be asymmetric cupping of the optic nerve, very large cupping or cup-to-disc ratio of the optic nerves, and/or some of the glaucoma testing done is borderline for glaucoma damage.

Acute Angle-Closure Glaucoma



Angle closure glaucoma | *Google Images*

Angle-closure glaucoma is diagnosed solely on the size and shape of the structures of the eye. In general, people with narrow angles have small eyes and are usually farsighted or have hyperopia. In these types of eyes, the iris is very close to the cornea and the anterior chamber is very shallow. If the iris happens to come in contact with the cornea and the trabecular meshwork, none of the aqueous humor fluid can exit from the eye. The intraocular pressure will rapidly shoot upward. The intraocular pressure can increase to a level that the blood flow into the eye is diminished or nearly stopped. This loss of blood flow into the eye can cause severe damage to it, which can cause permanent loss of vision.

This type of glaucoma is different from the more common open-angle glaucoma, as acute-angle closure glaucoma does have symptoms. When the

intraocular becomes extremely elevated, it causes severe pain in and around the eye. This eye pain is so severe that it can cause nausea and vomiting.

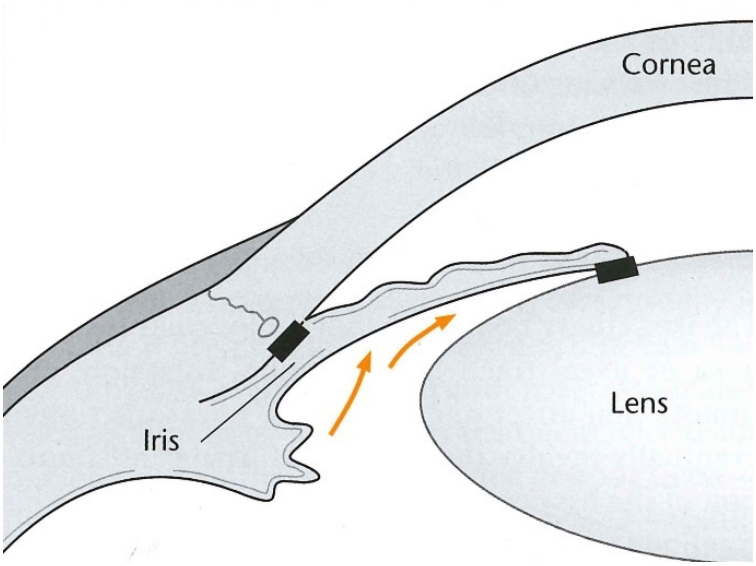
Many years ago, people with this type of severe pain were sometimes taken to surgery because the doctor thought the patient had a brain aneurysm because the pupil is dilated and the pain is so severe. When the intraocular pressure is extremely elevated, the pupil is partially dilated and it does not react to light. Acute angle-closure glaucoma causes other symptoms, such as red eyes, a cloudy or hazy cornea, blurred vision, loss of vision, and halos or rings around lights.

This is an ocular emergency and needs to be treated as soon as possible. A laser is used to make an iridotomy or opening in the peripheral portion of the iris. The iridotomy opening allows the aqueous humor to flow directly into the trabecular meshwork. This is like a safety valve. The aqueous humor does not have to make a complete trip through the pupil and around to get to the trabecular meshwork. The laser opening rapidly lowers the intraocular pressure. The laser treatment needs to be performed as soon as possible.

Chronic Angle-Closure Glaucoma

Chronic angle-closure glaucoma is a less common form of angle-closure glaucoma in the United States but is more prevalent in other areas around the world. Chronic angle-closure glaucoma occurs when there are multiple partial temporary acute angle-closure glaucoma attacks. Over time, the multiple closures create scarring in the angle. The angle and trabecular meshwork gradually close down with these repeated attacks.

Narrow Angles



Narrow angles | *Google Images*

Someone may have narrow angles but has not had an attack of acute angle-closure. During a routine eye exam, the eye doctor will see that the angle is narrow and will evaluate the degree of the narrow angle.

If the angle appears to be so narrow that a possible attack of angle-closure glaucoma could occur, a laser iridotomy can be performed before the attack. This would prevent the attack from occurring.

Heredity plays a role in narrow angles as well. The goal with acute angle glaucoma is to discover the narrow angles before an attack of angle closure-glaucoma occurs so that a preventative laser iridotomy can be performed.

Glaucoma Diagnosis

Routine Comprehensive Eye Exam

The primary step in diagnosing glaucoma or any other eye disease is a complete thorough dilated eye examination. A complete eye exam includes a thorough ocular history, past medical history, medications list and review, social history, and review of body systems.

The eye exam consists of testing your vision, pupil evaluation, extraocular muscle movements, confrontation visual fields, external examination of the eyelids and surrounding ocular structures, slit-lamp exam of the eye, intraocular pressure check, and dilated examination of the retina. There are many other tests used for determining the presence of glaucoma.

Testing the Intraocular Pressure(IOP) or Eye Pressure

There are different instruments designed to measure intraocular pressure.

Non-contact or Air Puff Instrument

Canon Air Puff Tonometer | *Google Images*

Tonopen | *Google Images*

Diaton Transpalpebral Tonometer | *Google Images*

Icare tonometer | *Google Images*

Perkins Tonometer | *Google Images*

Pascal tonometer| *Google Images*

Goldmann Applanation Tonometer | *Google Images*

The **Goldmann Applanation Tonometer** is considered the gold standard in testing intraocular pressure. Eye doctors who treat glaucoma use this device to diagnose and/or monitor glaucoma. Normal intraocular pressure is considered to be 10 to 21 mmHg (millimeters of mercury).

If during the eye examination, the intraocular pressure is elevated or the optic nerves appear suspicious for glaucoma damage, further testing will be performed to diagnose whether you have glaucoma.

Visual Field Testing or Testing Your Side Vision

Photo from Google

In the beginning, you cannot tell whether you have any side vision loss. You may not have a complete loss of side vision in an area of your side vision but cannot see as well in the peripheral portion of your vision.

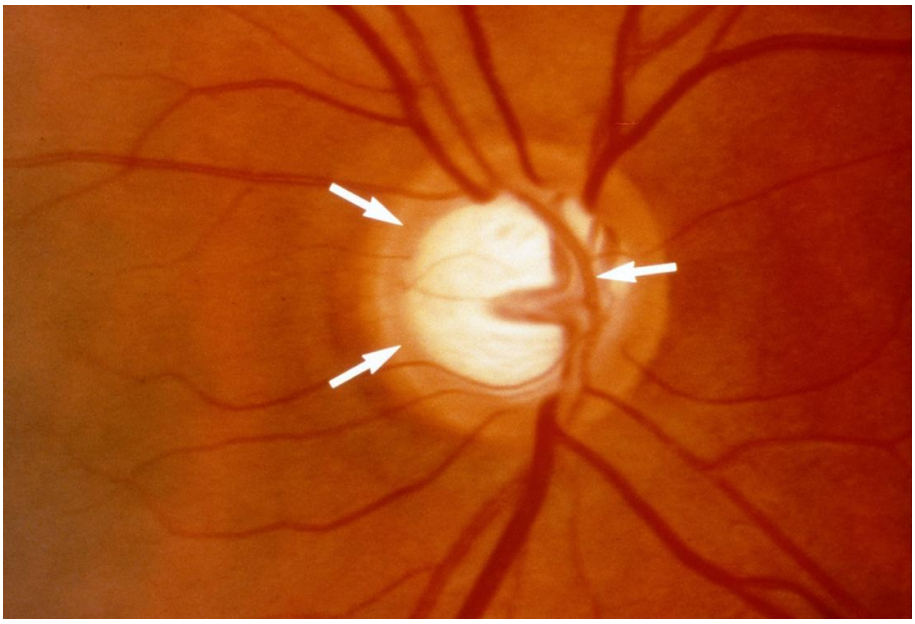
Instruments that measure the side vision can detect very small changes in the peripheral vision. Visual field instruments can discover a tiny decrease in the amount or intensity of light the eye can see in your visual field, not just a dark area without vision. Computers run these visual field machines programmed to present varying intensities of light inside the visual field instrument. They test your ability to see varying light intensities in a

programmed pattern. The eyes are tested one eye at a time as the non-tested eye is patched.

The person is positioned in front of the visual field machine shaped like a half-moon white bowl. The instrument flashes small lights of varying light intensities, colors, patterns, and sizes depending on the type of test performed. You are instructed to push a button on a clicker attached to the machine when you see any lights. You are to keep your eyes fixated on a fixation target during the test. The instrument records the number of times you correctly pushed the button when a light was shown. It records the intensity of the light and records anytime you push the button when there is no light being shown.

The computer in the instrument compiles and provides the results. The computer also stores the results to compare them between different tests. The standard of care is the visual field test, usually performed yearly for people diagnosed with glaucoma or those at risk of developing glaucoma. It may be performed more often in severe glaucoma cases.

Optic nerve analysis | *Google Images*



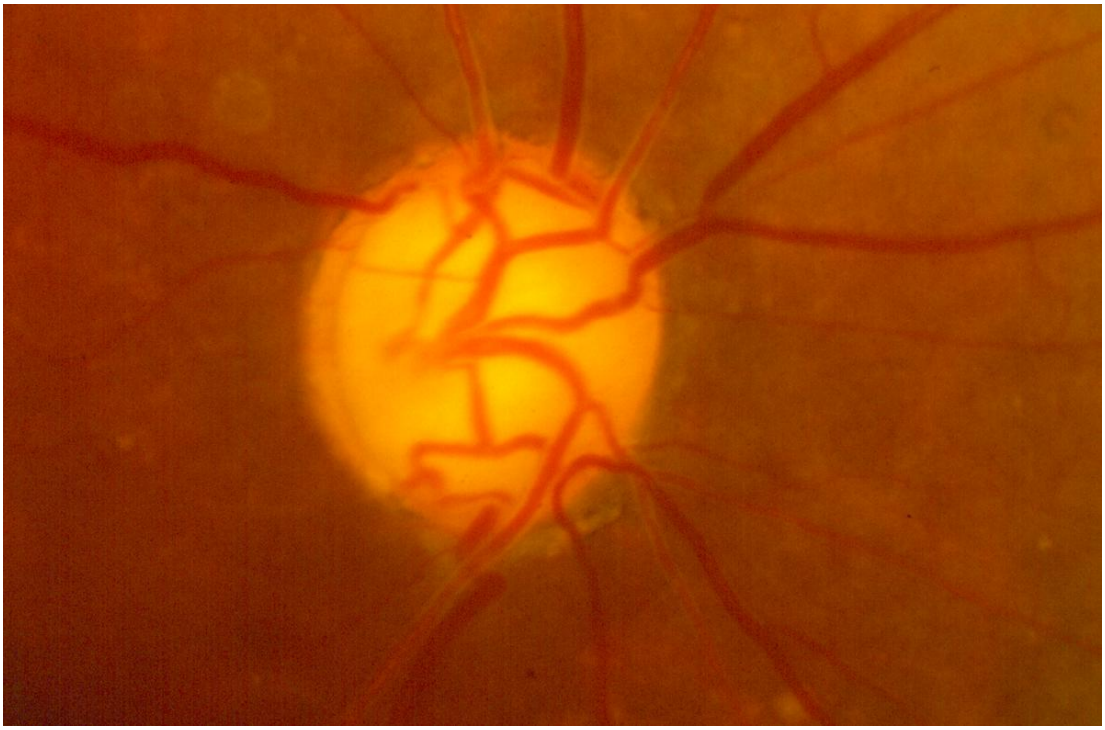
Arrows pointing to central cupping or hole in the optic nerve | *Google Images*

During a complete exam, the pupils are dilated so the eye doctor can see inside the eye. The eye doctor will examine the retina and optic nerve and record the appearance of the optic nerve. Just like other parts of the body, the optic nerve can be of different sizes and shapes.

The optic nerve contains over 1.5 million nerve fibers. If a person has a small optic nerve, the nerve will be completely full of nerve fibers. There will be no hole or opening in the nerve or what is called cupping of the nerve or cup-to-disc ratio of the nerve. If a person has a large optic nerve, there may be a large opening or cup-to-disc ratio but still the normal number of nerve fibers and not glaucoma. When a person has had damage to the optic nerve from glaucoma, nerve fibers are lost, resulting in increased cupping or increased cup-to-disc ratio.

In cases where someone has a large cup-to-disc ratio, a glaucoma workup needs to be done to ensure that glaucoma did not cause the increased cupping. In some cases, it may be difficult to tell if glaucoma has damaged the nerve. The appearance of the optic nerve can vary significantly from person to person. Other glaucoma tests will need to be performed to either confirm there is glaucoma or that the person does not have glaucoma as they were born with a large optic nerve and cupping. The eye doctor will have a picture of the optic nerve taken so that any changes in the nerve can be seen by comparing the original picture to the current status of the nerve.

Normal optic nerve with small central cup-to-disc | *Google Images*



Large cup-to-disc damage from glaucoma – only a small rim of nerve tissue remaining | *Google Images*

Other Optic Nerve Evaluation Systems

Optic Nerve and Nerve Fiber Layer Imaging

Optical Coherence Tomography (OCT)

The ZEISS CIRRUS HD-OCT 5000 optical coherence tomograph (OCT), developed and manufactured in Dublin, California: no imaging diagnostic system from ZEISS would work without complex algorithms.

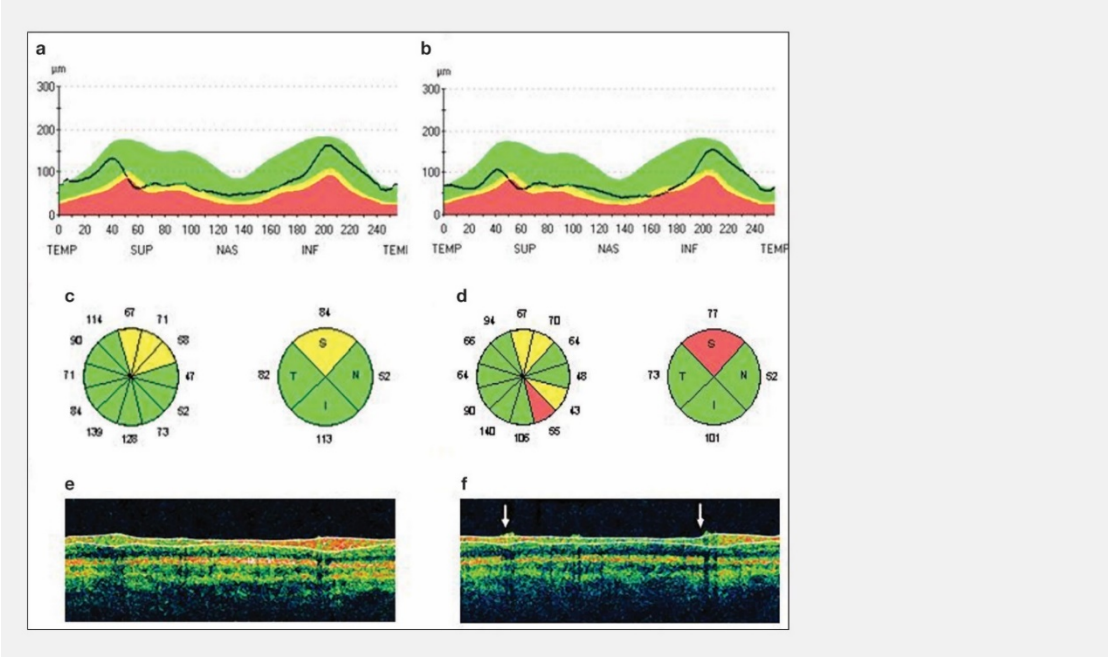
CIRRUS HD-OCT enables three-dimensional representation of deeper layers of tissue in the eye. With this information, retinal diseases such as progression of dry age-related macular degeneration (AMD) and glaucoma conditions can be examined and assessed.

Optical Coherence Machine Made by Zeiss | *Google Images*

OCT or **optical coherence tomography** is a laser-scanning imaging system used to image or visualize the layers of the nerve fibers in the retina and the size and shape of the optic nerve. The OCT images and analyses the contour or topography of the optic nerve. It determines the thickness of the nerve fiber layer just before the nerves enter the optic nerve itself.

The OCT can also image the macula for any macular disease. The computer in the OCT records all this data and provides an analysis of the data in a variety of reports, such as an analysis of the health of the optic nerve and nerve fiber layer entering the optic nerve.

The OCT is one of the best tests for determining the health of the nerve fiber and optic nerve for evidence of glaucoma and other diseases. The OCT is usually performed yearly for people with glaucoma or at risk of developing glaucoma. Some companies that make OCTs are Zeiss, Heidelberg Engineering Inc., Nidek, Optovue, and Topcon.



A report of an OCT scan| *Google Images*

Confocal Scanning Laser Ophthalmoscopy (CSLO)

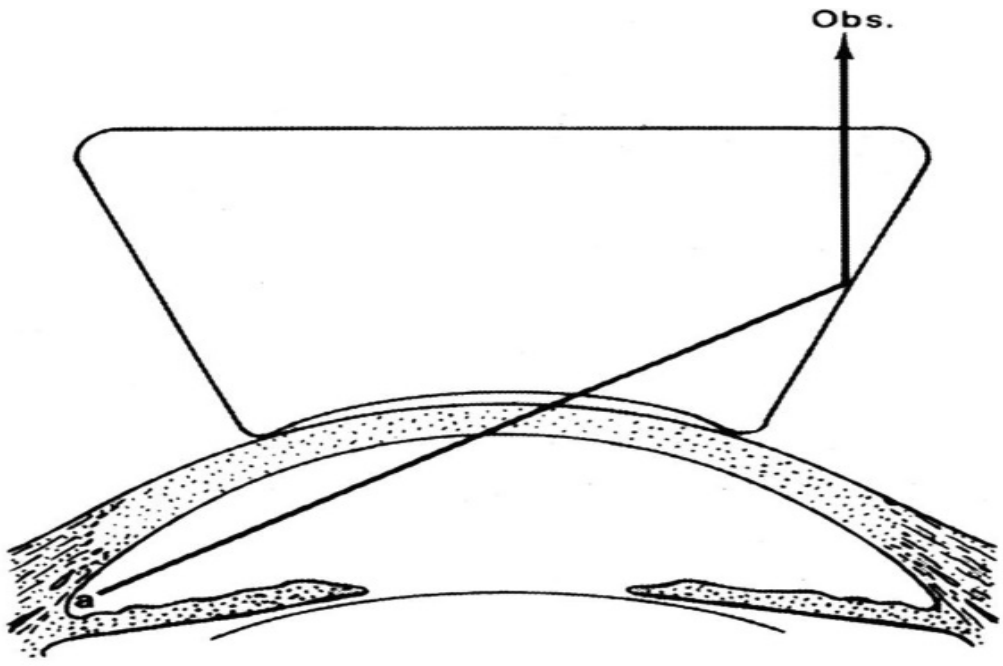
Confocal scanning laser ophthalmoscopy (CSLO) is an instrument for imaging the optic nerve and nerve fiber layer. CSLO uses laser scanning technology to produce up to 64 transaxial laser scans through the optic nerve and the retina adjacent to the optic nerve. This technology produces a 3D image of the optic nerve. The information from the CSLO instrument is

used to produce a computer report about the condition of the optic nerve and retinal fiber layer.

Scanning Laser Polarimetry (SLP)

Scanning laser polarimetry is an instrument that measures the retinal nerve fiber layer thickness adjacent to the optic nerve before the nerves enter the optic nerve. It records the information and creates a computerized report of the condition of the nerve fiber layer. The instrument can also compare the results of the test to normal data.

During the eye examination, the eye doctor may use a contact lens with a prism that looks into the angle of the anterior chamber. The angle's width and condition are evaluated, as well as the amount of pigment or debris in the trabecular meshwork. The angle can also be evaluated with OCT and ultrasound gonioscopy.



Gonioscopy | *Google Images*

Pachymetry | *Google Images*

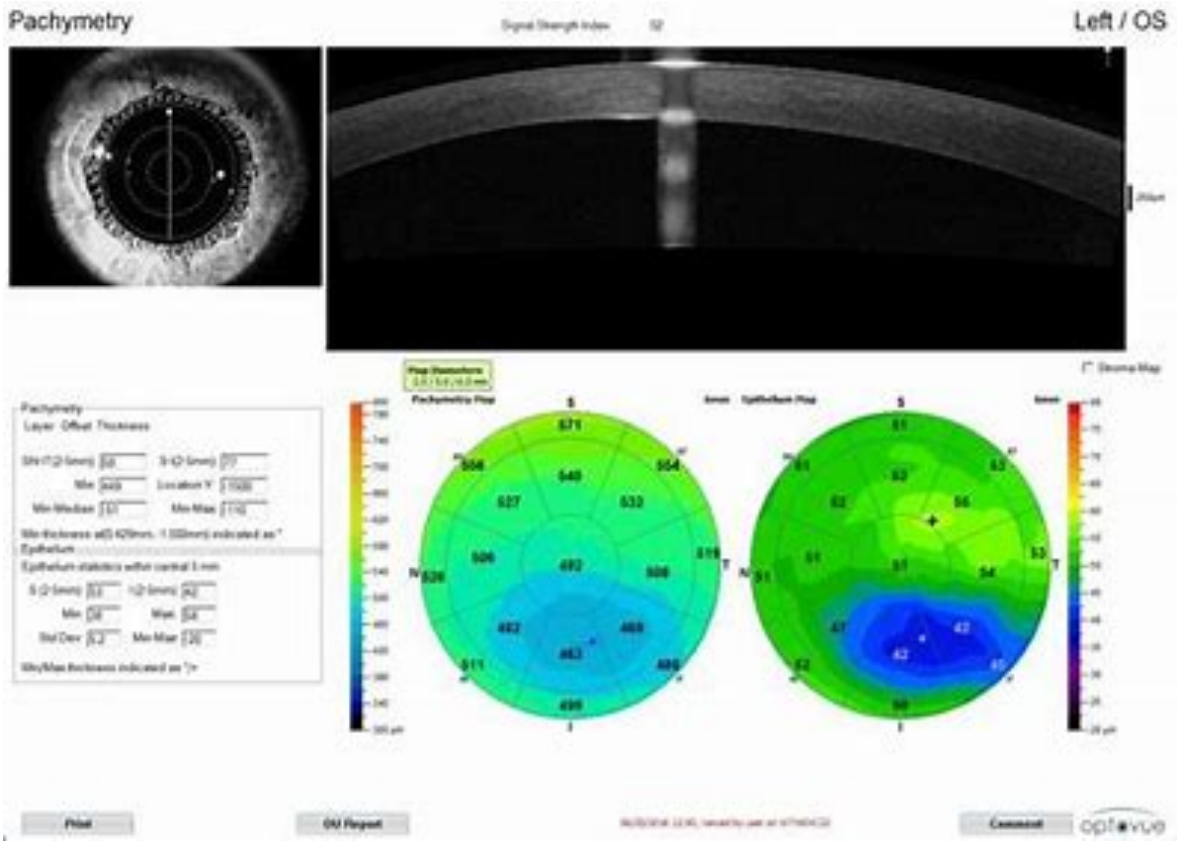
Pachymetry is a test that measures the thickness of the cornea. The test is very easy to perform. An anesthetic eye drop is instilled into the eye to numb the eye. A pachymetry probe is applied to the cornea to measure the cornea thickness. Other machines do not use ultrasound and do not touch the cornea.

The corneal measurement is important as the thickness of the cornea can affect the measurement of the intraocular pressure. There was a study in 2002, called the Ocular Hypertension Study (OHTS) study. The findings of the study found that corneal thickness has a significant effect on measuring eye pressure. The thickness of the cornea alters the measurement of the intraocular pressure.

If the cornea is thicker than normal, the intraocular pressure will measure higher than the true intraocular pressure inside the eye. This is secondary to the increased resistance of the thicker corneal tissue. If the cornea is thinner

than normal, the intraocular pressure will measure lower than the true intraocular pressure which is secondary to the decreased resistance of the thinner corneal tissue.

The normal thickness of the cornea is 550 microns. People can be born with thicker- or thinner-than-normal corneas, but someone who has had LASIK, PRK, or LASEK will have thinner corneas after their laser, as the laser removes corneal tissue to correct a person's vision. After these procedures, these people will have their intraocular pressures measuring lower than the true pressure inside the eye. These faulty intraocular pressure readings can present a problem in diagnosing and treating glaucoma.



Pachymetry measurement report of a non-contact machine | *Google Images*

Ocular Response Analyzer

An **ocular response analyzer** or **ORA** is a technology in which a tonometer measures corneal hysteresis. **Corneal hysteresis** is the difference in the inward and outward pressure values of the cornea obtained during the dynamic bi-directional applanation process with the ORA. Corneal hysteresis is characterized by the visco-elastic properties of the cornea, which is the cornea's ability to absorb and dissipate energy. In simple terms, it means how pliable the cornea is. This can affect the measurement of the intraocular pressure.

Photo from Google

Visual Evoked Potentials (VEP)

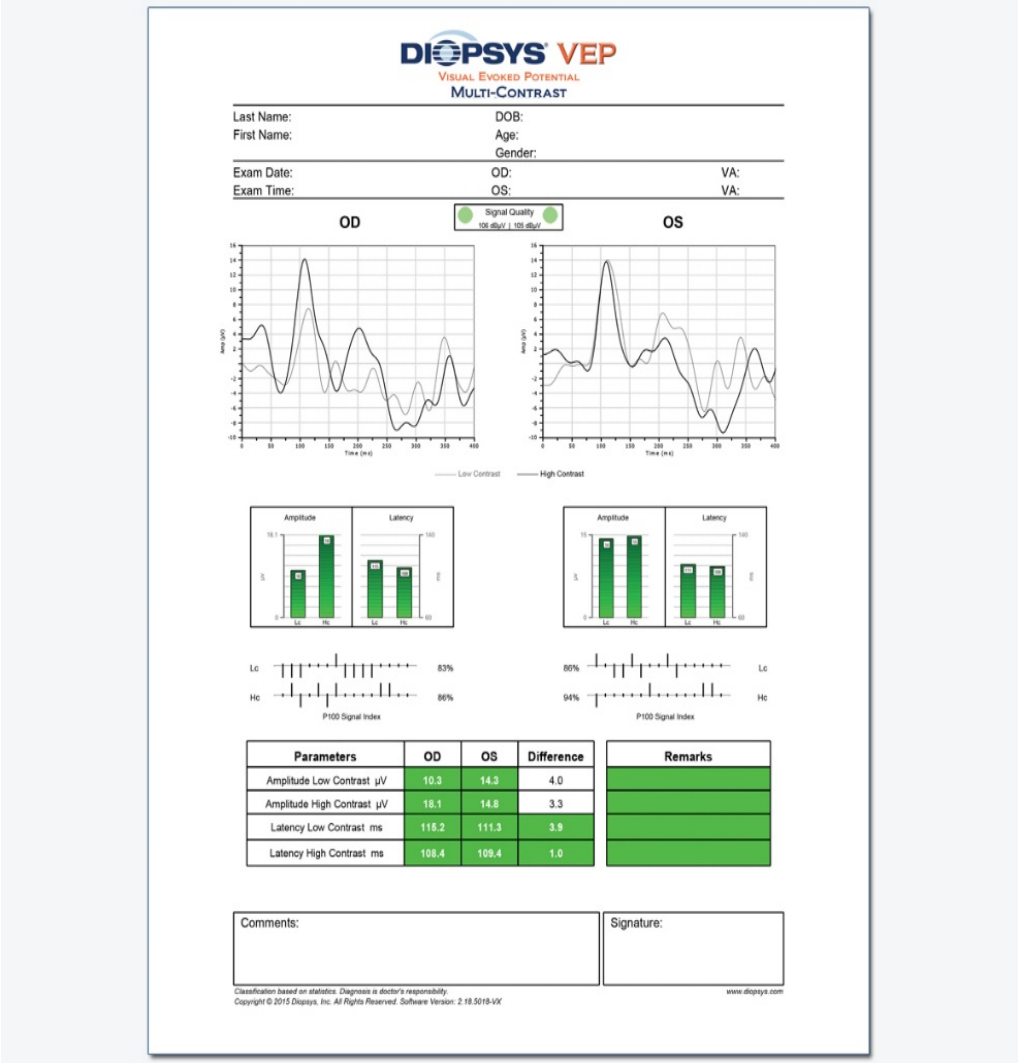
The **VEP** test has been used in universities for many years. The VEP objectively measures and evaluates the presence of any pathology, damage, or abnormality in the vision system. At the beginning of the test, a light was flashed into the eyes of a person during the test. Today, a black-and-white checkered board pattern is shown to the person taking the test.

Like in an EEG which tests brain activity, electrodes are placed on the scalp on the back of the skull, which is where the vision center is located in the brain. The black-and-white checkerboard pattern is reversed back and forth to stimulate the vision process. The computer running the machine can change the size of the checkerboard blocks and the amount of contrast of the grey to white to black grey scale can be changed. A high-contrast test and a low-contrast test are usually performed. The low-contrast test is usually the most sensitive method of determining the presence of an abnormality.

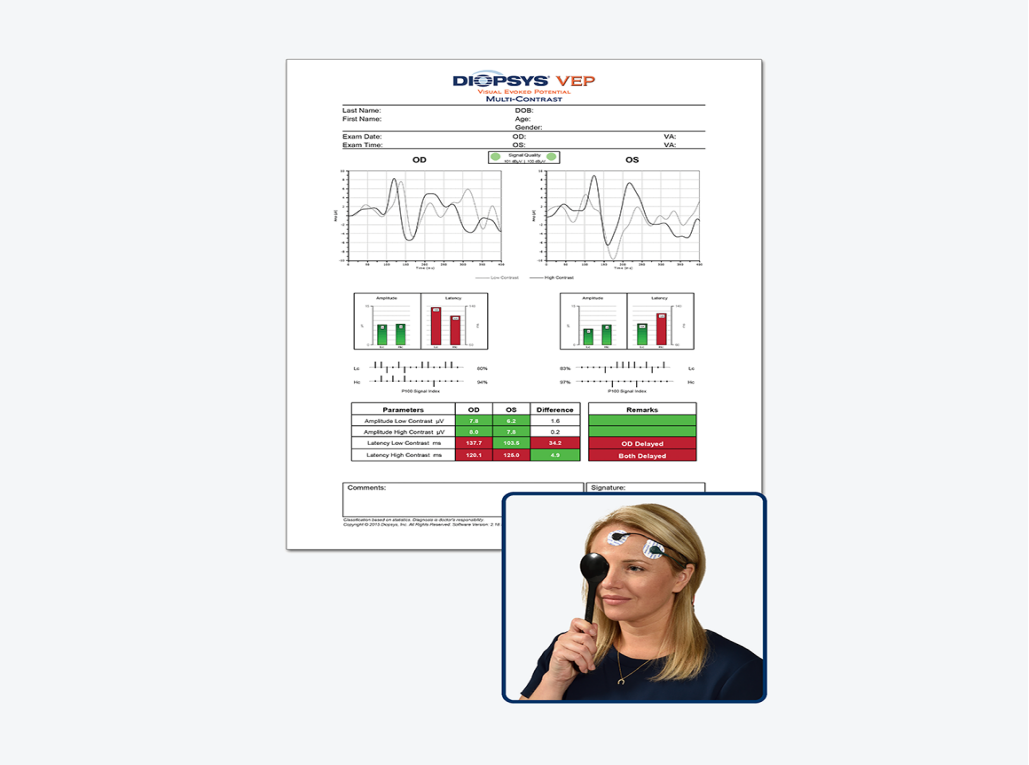
During the test, a person is seated in front of a computer screen. They are asked to watch the pattern change back and forth. The amplitude or strength of the response in the vision center is measured. Also, the time it takes for the stimulus to reach the occipital lobe is recorded. Many different diseases can affect the strength of the signal and the time or latency of the visual stimulus to reach the vision center. MS or multiple sclerosis classically increases the latency of the stimulus as well as the amplitude.

The VEP is so sensitive that it can detect a reduction in cell function before any permanent damage has occurred to the nerve. The test will show damage as well. The VEP is a very sensitive test and needs to be done by a well-trained technician in a well-controlled environment for consistent results.

The VEP can show early damage to the optic nerve from glaucoma or even provide an indication of what is going to occur if the damage is not treated. Oftentimes, you can see an improvement in the test results after starting treatment and lowering the intraocular pressure. Nerve fibers that once were not functioning normally but undead returned their function once the intraocular pressure was reduced.



A normal VEP Pattern | *Google Images*

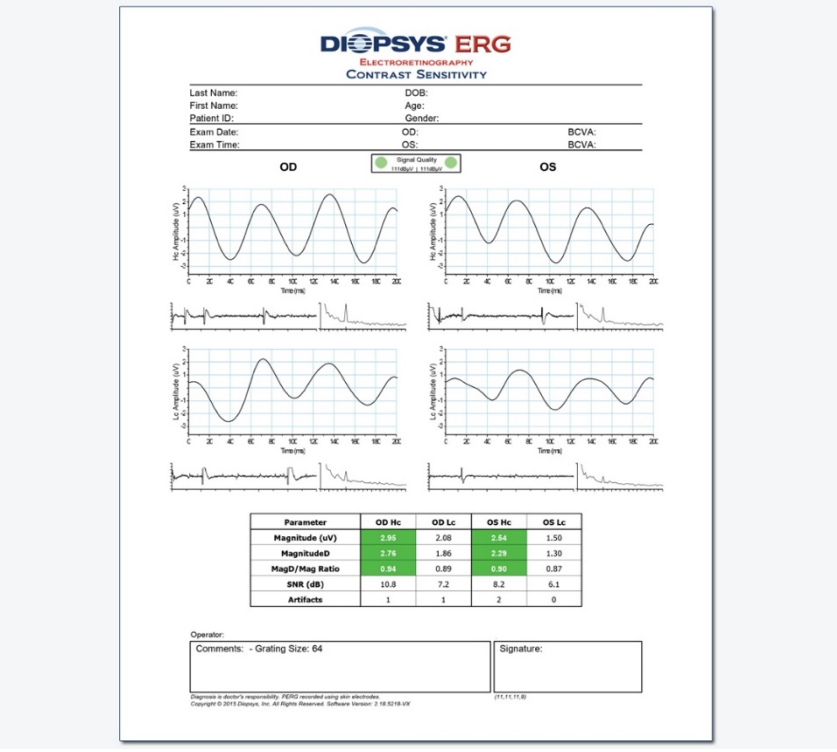


An abnormal VEP Pattern | *Google Images*

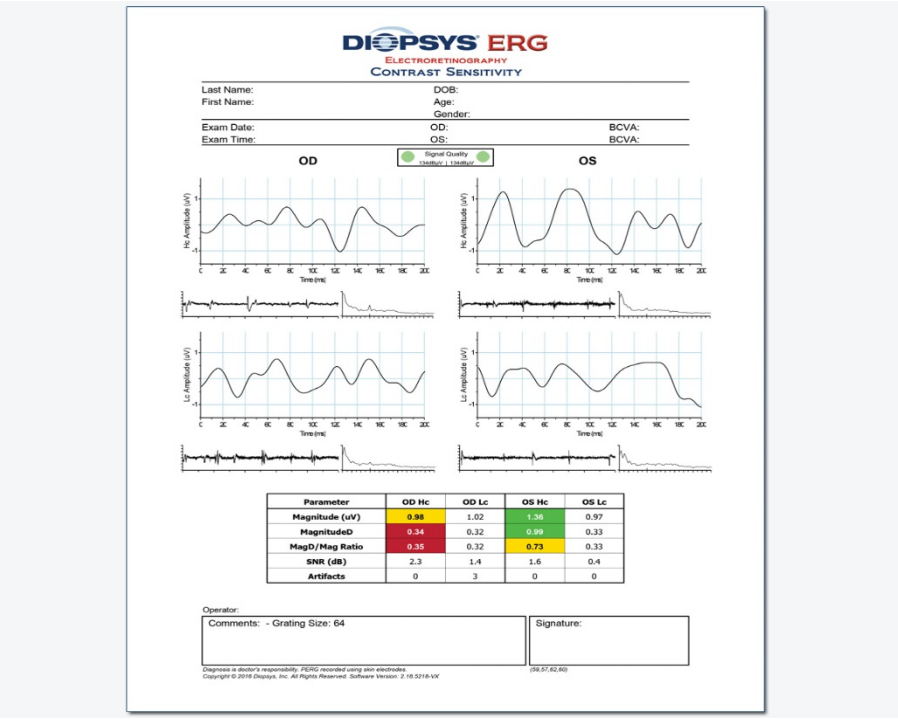
Electroretinography (ERG)

ERG is a different electrical test from a VEP in that it measures the size and speed of the electrical activity in the retinal cells. Like the VEP, the eye is stimulated either with light or a pattern. A pattern or PERG is the most common type of test. The ERG measures the amount of electrical activity in the retinal ganglion cells. Like the VEP, the PERG can detect tiny abnormalities in cell function before any cell loss has occurred.

A person is placed in front of the computer screen of the instrument, and electrodes are placed just under the lower eyelid and on the forehead. There are two protocols or test sequences used with the PERG. One test protocol is a **16-degree circle projected onto the retina**, and the waveform of activity is generated and measured. This type of PERG can be used to diagnose macular edema from diabetic retinopathy, age-related macular degeneration, and retinal toxicity. It is very useful in detecting any damage to the macula from a medication called Plaquenil, which collects in the macula and causes permanent vision loss. Another test protocol is a **concentric stimulus field**. A 24-degree circle is projected onto the retina, and a waveform of electrical activity is generated from the stimulus. This protocol is used to detect glaucoma damage. The PERG is useful in the early detection of glaucoma, diabetic retinopathy, and other diseases of the visual pathway.



Normal ERG pattern | *Google Images*



An abnormal pattern from glaucoma | *Google Images*

Glaucoma Treatments

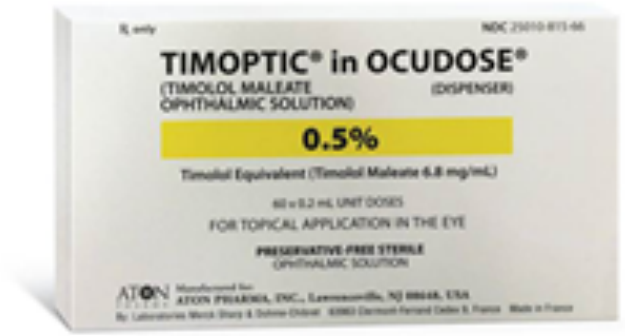
There are three basic methods for controlling or treating glaucoma, which are **medications**, **lasers**, and **surgery**.

Medications for the Treatment of Glaucoma

In most cases, eye medications are initially used to treat glaucoma or ocular hypertension. Glaucoma medications do have their problems, such as patient compliance and side effects from usage. Since glaucoma does not cause any symptoms until significant damage has occurred, many patients tend to become less compliant with using their medications over time. They don't

feel any different or see any changes in their vision. People with glaucoma need to be educated on the importance of using their medications no matter what. Damage to the optic nerve and eventual vision loss is permanent.

Beta Blockers: Timolol, Betimol, Istalol, and Timoptic Ocudose PF



Timoptic Ocudose | *Google Images*

These eye drops are non-selective beta-adrenergic receptor blockers. It is thought that the drug slows down the production of the aqueous humor in the eye and therefore decreases intraocular pressure.

Precautions and Side Effects

- Redness
- Decreased heart rate
- Irritation
- Stinging on instillation

- Depression
- Erectile dysfunction
- Wheezing or difficulty breathing
- Swelling
- Blurred vision

This medication should not be used if you have asthma, COPD, heart block, bradycardia, and/or congestive heart failure. You must tell the eye doctor about all the medications you take. Many people think that they are just going to the eye doctor and it is not necessary to provide a list of all medications they are taking. Beta-blockers should be used with caution in people with significant allergy problems.

Administration and Dosage

Timolol or **Timoptic** was approved for the treatment of open-angle glaucoma or ocular hypertension many years ago. The medication will be prescribed as 1 drop in the eye once or twice a day.

Photo from Google

Betaxolol hydrochloride: Betoptic 0.5% and Betoptic S 0.25%

Photo from Google

Betoptic is different from other beta blockers as it is a cardioselective beta-adrenergic receptor inhibitor. It is approved for the treatment of glaucoma and ocular hypertension. This beta blocker is different from other beta blockers used to treat glaucoma in that it does not affect the receptors in the lungs. It can be used with caution in people with a history of asthma and COPD. Just like the other beta blockers, **Betaxolol** is believed to lower the eye pressure by reducing the amount of fluid produced inside the eye.

Precautions and Side Effects

- Itching
- Dry eye sensation
- Swelling
- Eye pain
- Blurred vision
- Depression
- Temporary discomfort
- Fatigue
- Insomnia
- Erectile dysfunction

Contraindications for Betaxolol

- Greater than first-degree block
- Sinus bradycardia
- Cardiogenic shock
- Overt cardiac failure

Administration and Dosage

Betaxolol is prescribed as one drop in the affected eye or eyes two times a day. **Betoptic** is supplied sterile eye drop dispensers in 10 and 15 mL bottles.

Latanoprost, Xalatan, Xalatan PF (preservative-free)

Photo from Google

Latanoprost is a proteinoid-selective FP receptor agonist. Latanoprost is thought to lower intraocular pressure by increasing the outflow of the aqueous humor from the eye. The onset of action of Latanoprost begins to work about 3 to 4 hours after instillation. The maximum effect of Latanoprost is 8 to 12 hours after instillation. The intraocular pressure reduction is good for 24 hours.

Precautions and Side Effects

- Burning on instillation
- Redness
- Irritated eyelids
- Ocular inflammation
- Foreign body sensation
- Punctate keratitis
- Stinging
- Dizziness
- Blurred vision
- Increased pigmentation of the iris
- Increased eyelash growth
- Flu-like symptoms

Administration and Dosage

Latanoprost 0.005% is a clear, sterile liquid supplied in a 2.5 mL eye drop dispenser. Latanoprost is indicated for the treatment of open-angle glaucoma or ocular hypertension. Any extra bottles not being used should be stored in a refrigerator. Contact lenses should not be used until 15 minutes after installation of the medication.

Latanoprost causes increased pigmentation of the iris and sometimes in the skin around the eye. Blue-eyed individuals usually do not see any increased pigmentation. The dosage of Latanoprost is 1 drop in the affected eye at bedtime.

Travatan Z

Photo from Google

Travatan Z (travoprost ophthalmic solution) 0.004% is a synthetic prostaglandin F analog. Travatan Z is approved for the treatment of open-angle glaucoma and ocular hypertension. Travatan Z is similar to other prostaglandin analogs and is believed to lower eye pressure by increasing the outflow of the aqueous humor through the uveoscleral tract and trabecular meshwork.

Precautions and Side Effects

- Itching and irritation
- Redness
- Watery eyes

- Photophobia or light sensitivity
- Discharge
- Blurred vision
- Flu-like symptoms
- Macular edema
- Increased pigmentation of the iris
- Increased inflammation in the eye

Travatan Z has fewer chemical preservatives and may cause less irritation than the other prostaglandin analogs.

Administration and Dosage

Travatan Z is instilled into the affected eye or eyes once daily at bedtime or evening. Travatan Z is supplied in a sterile eye drop dispensing bottle with a turquoise-colored top in 2.5 mL and 5 mL sizes. The reduction of the intraocular pressure begins within 2-3 hours of instillation and reaches its maximum effect at 12 hours.

Lumigan

Photo from Google

Lumigan (bimatoprost ophthalmic solution) 0.01% is a synthetic prostamide analog that reduces intraocular pressure. Lumigan has been approved for the treatment of glaucoma or ocular hypertension. Lumigan is believed to lower intraocular pressure by increasing the outflow of the aqueous humor through the uveoscleral tracts and trabecular meshwork.

Precautions and Side Effects

- Redness
- Itching and irritation
- Pain in and around the eye
- Photophobia or sensitivity to light
- Blurred vision
- Stinging upon instillation
- Flu-like symptoms
- Increased pigmentation of the iris
- Increased ocular inflammation
- Macular edema

Lumigan causes increased thickness and length of the eyelashes. Allergan sells the same medication under the brand name of **Latisse**, which is marketed as a medication to increase the fullness, thickness, and length of the eyelashes. The medication is applied to the upper lid adjacent to the eyelashes once a day.

Administration and Dosage

Lumigan is indicated in the treatment of open-angle glaucoma or ocular hypertension. Lumigan is supplied in sterile eye drop dispenser bottles with a turquoise bottle cap in 2.5 mL, 5 mL, and 7.5 mL sizes. The reduction of the intraocular pressure begins approximately 4 hours after instillation. The maximum effect happens at about 10 to 12 hours after instillation. Lumigan is administered in the affected eye or eyes once daily at bedtime. Dosage is important, as it has been found that more frequent administration may actually decrease the intraocular pressure-lowering effect of the drug.

Brimonidine (Brand Name is Alphagan P)

Photo from Google

Alphagan P (brimonidine tartrate ophthalmic solution) 0.1% and 0.15% is an alpha-adrenergic receptor agonist. Brimonidine is a relatively selective alpha-2 adrenergic receptor agonist. Brimonidine is believed to have a dual mechanism of action. Brimonidine reduces aqueous humor production and increases uveoscleral outflow. Alphagan P is indicated for the treatment of open-angle glaucoma and ocular hypertension.

Precautions and Side Effects

- Burning sensation
- Allergic conjunctivitis, conjunctival redness, and eye pruritus or itching
- Itchy eyes
- Visual disturbance

- Bradycardia
- Headache
- Fatigue
- Flu symptoms
- Dry mouth
- Depression
- Miosis or small pupil
- Hypotension
- Respiratory depression

Administration and Dosage

Alphagan P is supplied in sterile eye drop dispensers with a purple top in sizes of 5 mL, 10 mL, and 15 mL. Alphagan P is available in two strengths, 0.1% and 0.15%. Brimonidine (generic) comes in a 0.2% solution.

The recommended dosage is one drop in the affected eye or eyes three times a day. Because of compliance issues of having to use the medication during the day, many eye doctors prescribe the medication twice a day. Alphagan P reaches its maximum effect within 2.5 hours after instillation and the effect on the intraocular pressure rapidly decreases afterwards.

Dorzolamide (generic) or Trusopt or Azopt

Photo from Google

Trusopt (dorzolamide hydrochloride ophthalmic solution) 2% is a carbonic anhydrase II inhibitor. Inhibition of carbonic anhydrase in the ciliary body decreases the aqueous humor production by the ciliary body, which results in a lowering of the intraocular pressure. The ciliary body is located behind the iris. Dorzolamide has been shown to lower eye pressure by 3 to 5 mmHg.

Warning

Dorzolamide contains a sulfonamide in its chemical structure and should not be used by anyone allergic to any sulfa-containing medications.

Precautions and Side Effects

- Burning on instillation
- Superficial punctuate keratitis
- Eye redness
- Dryness
- Bitter taste in the mouth
- Conjunctivitis
- Blurred vision
- Tearing or epiphora
- Photophobia or light sensitivity
- Dry mouth
- Contact dermatitis

Administration and Dosage

Dorzolamide is supplied in white eye drop bottles. It is supplied in 5 mL in 10 mL bottles and 10 mL in 10 mL bottles. The recommended dosage of dorzolamide is 1 drop in the affected eye or eyes three times a day. Because of compliance with using the eye drop in the middle of the day, most eye doctors will have their patients use the medication two times a day. If the intraocular pressure is not controlled with a two-times-a-day dosage, then it is increased to three times a day.

Combigan (brimonidine tartrate/timolol maleate solution) 0.2%/0.5%

Photo from Google

Combigan is the combination of brimonidine and timolol in a single bottle. Combigan is indicated in the treatment of open-angle glaucoma and ocular hypertension. Combigan lowers the intraocular pressure by decreasing the production of the aqueous humor inside the eye and increasing the uveoscleral outflow of aqueous humor from the eye. The maximum effect for brimonidine is 1 to 4 hours after instillation. The maximum effect for timolol is 1 to 3 hours after instillation.

Precautions and Side Effects

- Allergic conjunctivitis, conjunctival redness, and eye itching
- Itchy eyes
- Redness
- Burning sensation
- Visual disturbance
- Blurred vision
- Headache
- Bradycardia
- Fatigue
- Flu symptoms
- Depression
- Miosis or small pupil
- Hypotension
- Respiratory depression
- Dry mouth
- Irritation
- Depression
- Erectile dysfunction
- Wheezing or difficulty breathing
- Swelling
- Decreased heart rate
- Stinging on instillation

A person with asthma, bradycardia, heart block, COPD, and/or congestive heart failure should not use this medication. It is very important that you inform the eye doctor about all the medications you take. This type of medicine should be used with caution in people with significant allergy problems and diabetes.

Administration and Dosage

Combigan is supplied in sterile eye drop dispensing bottles with a blue top. It is supplied in 5 mL in 10 mL bottles, 10 ml in 10 mL bottles, and 15 mL in 15 mL bottles. The dosage is 1 drop in the affected eye or eyes two times a day.

Dorzolamide/Timolol (Brand Names are Cosopt and Cosopt PF)

Photo from Google

Cosopt is a combination of two medications, which are a carbonic anhydrase inhibitor and a beta-adrenergic receptor-blocking medication. It combines dorzolamide and timolol in a single bottle.

Side Effects

- Burning on instillation
- Eye redness
- Blurred vision
- Tearing or epiphora
- Dryness
- Bitter taste in the mouth
- Superficial punctuate keratitis

- Conjunctivitis
- Photophobia or light sensitivity
- Dry mouth
- Contact dermatitis
- Irritation
- Wheezing or difficulty breathing
- Swelling or edema
- Depression
- Erectile dysfunction
- Decreased heart rate

You should not use this medication if you have asthma, bradycardia, COPD, heart block, and/or congestive heart failure. Make sure you inform your eye doctor of all the medications you take. **Cosopt** should be used with caution in people with significant allergy problems and diabetes.

Dosage and Administration

Cosopt and **Dorzolamide/Timolol** is supplied in sterile white eye drop dispensing bottles with a white cap and is supplied in 10 mL in 18 mL bottles.

Cosopt PF is preservative-free and is supplied in a foil pouch containing 15 low-density 0.2 mL single-use eye drop dispensers.

The recommended dosage is one drop in the affected eye or eyes two times a day.

Simbrinza (brinzolamide/brimonidine tartrate ophthalmic solution) 1%/0.2%

Photo from Google

Simbrinza is a combination of brinzolamide, which is an anhydrase inhibitor, and brimonidine, which is an alpha-2 adrenergic receptor agonist. Simbrinza is indicated for the reduction of intraocular pressure in people with open-angle glaucoma or ocular hypertension. Simbrinza has the same mechanism of action as dorzolamide and brimonidine.

Side Effects

- Eye redness
- Dry eyes
- Tearing
- Photophobia or light sensitivity
- Superficial punctuate keratitis
- Conjunctivitis
- Blurred vision

- Dry mouth
- Contact dermatitis
- Bitter taste in mouth
- Allergic conjunctivitis, conjunctival redness, and eye pruritus or itching
- Burning sensation
- Itchy eyes
- Visual disturbance
- Bradycardia
- Respiratory depression
- Fatigue
- Flu symptoms
- Headache
- Depression
- Miosis or small pupil
- Hypotension
- Dry mouth

Administration and Dosage

Simbrinza is supplied in white eye drop bottles with a light green cap and is supplied in 8 mL in 10 mL bottles. The usual dosage is one drop in the affected eye or eyes two times a day.

Vyzulta (latanoprostene bunod ophthalmic solution) 0.024%

Photo from Google

Vyzulta is a new prostaglandin analog indicated for the reduction of intraocular pressure in open-angle glaucoma or ocular hypertension patients. The reduction of the intraocular pressure begins about 1 to 3 hours after the instillation of the medication. Vyzulta reaches its maximum effect at 11 to 12 hours after instillation. Vyzulta is believed to lower intraocular pressure by increasing the outflow of the aqueous humor from the eye through the trabecular meshwork and uveoscleral route.

Precautions and Side Effects

- Eye irritation
- Redness
- Eye pain
- Increased pigmentation of the iris and periorbital tissue
- Eyelash changes with increased length, thickness, and number of lashes
- Intraocular inflammation
- Macular edema
- Bacterial conjunctivitis

Dosage and Administration

Vyzulta is supplied in a sterile 7.5 mL eye drop dispensing bottle with a turquoise cap with a total of 5 mL. Vyzulta is prescribed as one drop in the affected eyes or eye in the evening.

Rhopressa (netarsudil ophthalmic solution) 0.2%

Rhopressa is an RHO kinase inhibitor indicated for the reduction of eye pressure in patients with ocular hypertension and open-angle glaucoma. Rhopressa is believed to lower the intraocular pressure in the eye by improving the outflow of the aqueous humor through the trabecular meshwork.

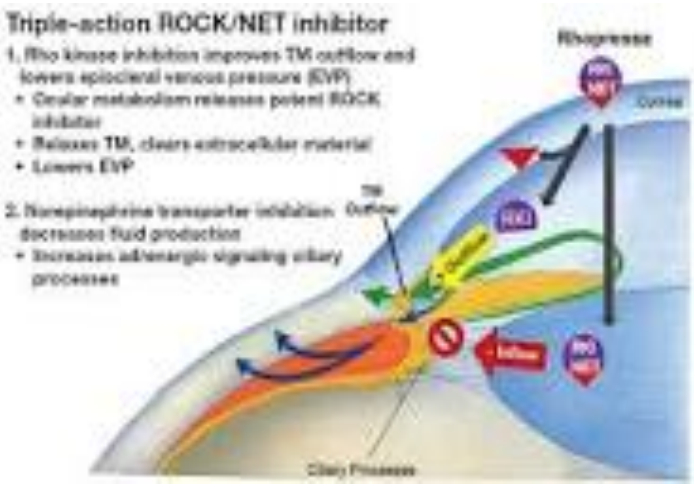


Photo from Google

Side Effects

- Pain on instillation
- Blurred vision
- Conjunctival hyperemia
- Tearing or epiphora
- Eyelid redness
- Corneal verticillate
- Conjunctival hemorrhage
- Bacterial conjunctivitis

Dosage and Administration

Rhopressa is supplied in sterile, white, opaque dispensing eye drop bottles with a white cap with 2.5 mL in a 4 mL bottle. Rhopressa is prescribed as 1 drop in the affected eye or eyes in the evening or at bedtime.

Acetazolamide or Brand Name Diamox

Photo from Google

Diamox is an orally administered carbonic anhydrase inhibitor for the reduction of intraocular pressure. Orally administered Diamox is a strong carbonic anhydrase inhibitor. Diamox controls fluid secretion and is used for several diseases such as glaucoma, altitude sickness, treatment of certain cases of epilepsy, and other instances of fluid retention.

Contraindications

Diamox is contraindicated in patients with sodium/potassium blood serum levels that are depressed, in hyperchloremic acidosis, kidney and liver disease, and suprarenal gland failure. Since Diamox is a sulfonamide derivative, it should be used with caution in people allergic to sulfa.

Side Effects

- Malaise
- Numbness and tingling of extremities and face
- Loss of appetite
- Nausea
- Headache
- Fatigue
- Fever
- Hepatobiliary disorders

Dosage and Administration

Diamox is supplied as Diamox Sequels 500 mg capsules. It is also available as Diamox tablets in 250 mg and 125 mg strengths.

Diamox Sequels are prescribed one by mouth 2 times a day.

Diamox tablets are usually prescribed as 250 mg or 125 mg tablets four times a day.

Durysta (bimatoprost implant)

The **Durysta implant** delivers 10 mcg of bimatoprost by injecting it into the anterior chamber of the eye. This is the first biodegradable sustained-release implant for the treatment of open-angle glaucoma. The implant can last several months. It can be inserted in the doctor's office.

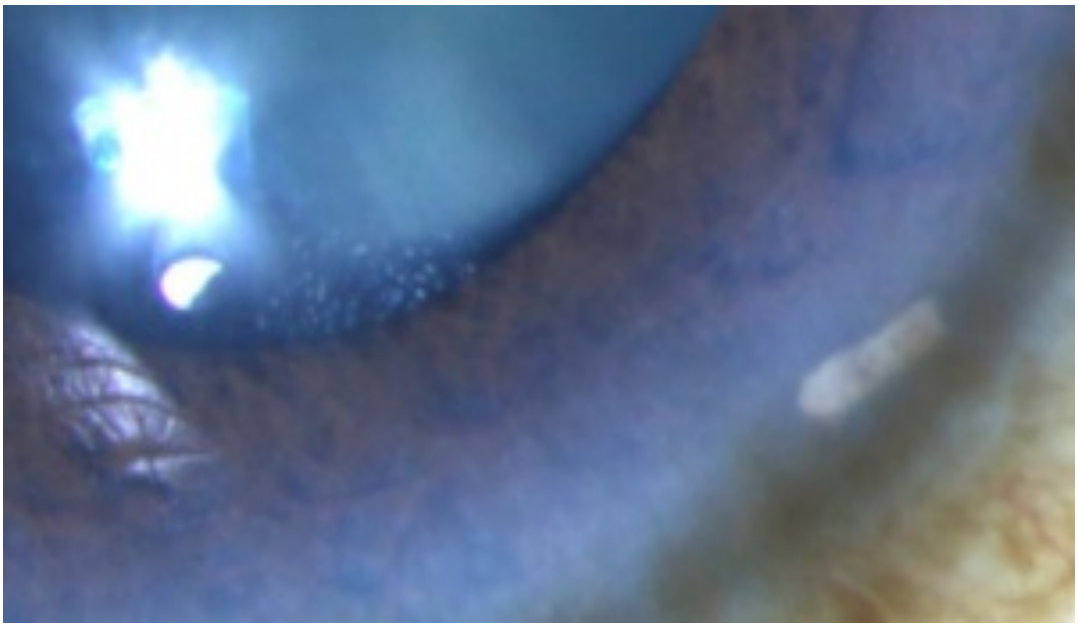


Photo from Google

Laser Treatment for Glaucoma

Argon Laser Trabeculoplasty (ALT)

ALT was the first laser treatment that was used to lower intraocular pressure in patients with ocular hypertension and open-angle glaucoma. This laser has been replaced by a newer laser with better results and fewer side effects.

Argon lasers are used to open the trabecular meshwork. The ALT laser has been shown to lower intraocular pressure in 75% of cases. With the ALT, one-half of the trabecular meshwork is treated in a treatment procedure. The second one hundred eighty degrees can be treated later if the intraocular pressure is not controlled. The ALT can only be used once in treating glaucoma, as more treatment may actually increase eye pressure.

Selective Laser Trabeculoplasty (SLT)

SLT is different from ALT in that it causes less scarring and destruction of the trabecular meshwork. The SLT more selectively treats the trabecular meshwork with less scarring. The laser stimulates the body's healing response to remove the obstruction of the trabecular meshwork to lower the eye pressure. SLT improves the outflow of the aqueous humor through the trabecular meshwork, which lowers the intraocular pressure.

The SLT laser is attached to a slit lamp examination equipment in the eye doctor's office. An anesthetic or numbing eye drop is instilled into the eye for anesthesia. A contact lens, which allows the eye doctor to see the trabecular meshwork, is placed on the eye. The SLT laser has an aiming beam that shows the doctor where the laser treatment will be applied. The SLT

laser treatment is applied in a circular fashion around the inside of the eye in the trabecular meshwork. The strength or power setting is adjusted according to the response seen inside the eye by the doctor. The entire procedure only takes a few minutes to perform. The treatment is very effective and can last for many years. The SLT laser can be repeated if necessary.

The eye doctor will have the patient use an anti-inflammatory eye drop such as a prednisone medication four times a day for several days after the treatment. Your vision should be clear in a few minutes and you should be able to drive home once your vision is good. After the eye or eyes have been treated, the eye doctor will have you return for follow-up visits to check the status of the intraocular pressure. The total amount of intraocular pressure lowering effect occurs about six weeks after the procedure.

The SLT is very safe and has few side effects. In a small percentage of patients, there may be some mild inflammation after the procedure. In very rare cases, there may be a transitory rise in the intraocular pressure. The amount of intraocular pressure improvement is usually equivalent to the best eye drop medication or better in most cases.

SLT Laser | *Google Images*

Laser Iridotomy for Narrow-Angle Glaucoma or Acute Angle-Closure Glaucoma

Peripheral iridotomy is the treatment indicated for narrow angles that are at risk of closing or an angle-closure glaucoma attack.

Acute angle-closure glaucoma is an eye medical emergency and needs to be treated as soon as possible. The acute rise in intraocular pressure can permanently damage the eye with loss of vision and secondarily cause a permanent rise in intraocular pressure. In acute angle-closure glaucoma, the iris is too close to the cornea. The iris suddenly comes into contact with the cornea and totally blocks the flow of fluid out of the eye. The intraocular pressure rapidly rises to dangerous levels.

Before the laser procedure, the pupil is constricted with eye drops so the iridotomy can be placed in the peripheral portion of the iris. A numbing eye drop is instilled into the eye for anesthesia. The laser makes a small opening in the iris. The iridotomy opening allows the aqueous humor direct access to the trabecular meshwork, bypassing the longer pathway through the pupil. Iridotomy is like putting a safety valve in the eye to stop the angle from closing.

After the procedure, there could be some minor bleeding and inflammation. This is only temporary. The iridotomy could close later from loose pigment plugging the opening and retreatment may be necessary. You will use anti-inflammatory eye drops, usually prednisone, for several days after the procedure.

Microinvasive Glaucoma Surgery (MIGS)

MIGS procedures are a relatively new category of surgical procedures for the treatment of mild to moderate glaucoma. Many different types of procedures encompass this less invasive method of treating glaucoma. There are 4 basic categories of these microinvasive procedures.

1. Increasing trabecular outflow
2. Suprachoroidal shunts
3. Reducing aqueous humor production
4. Subconjunctival filtration

Procedures for Increasing Trabecular Flow

These MIGS procedures are designed to increase the outflow of the aqueous humor from the eye by treating the area of the juxtacanalicular system and/or trabecular meshwork. The increased resistance of the aqueous humor exit from the eye through the trabecular meshwork is the primary source or reason for the development of open-angle glaucoma. These procedures are designed to bypass or remove the trabecular meshwork. The inner wall of Schlemm's canal, located behind the trabecular meshwork, is also removed for access to Schlemm's canal. The aqueous humor is then able to flow from the eye through the collector channels in Schlemm's canal.

There are people with high episcleral venous pressure where these procedures may not be as effective. Also, people with diseases such as Graves' disease, people who need very low intraocular pressures, and people who have had retinal detachment surgery with a scleral buckle are not good candidates for these procedures.

iStent

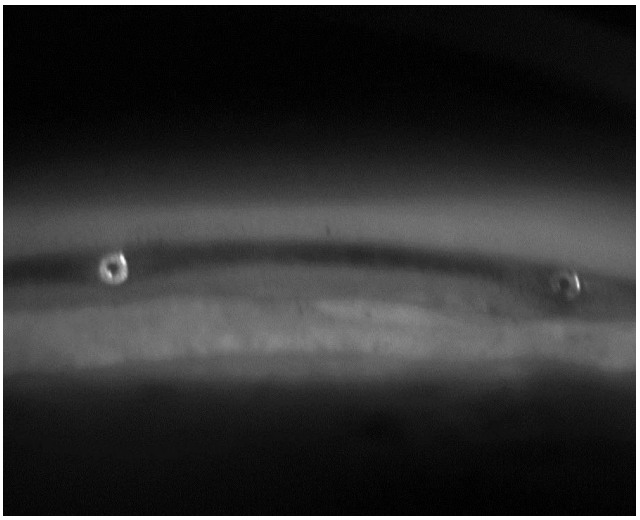
iStent was approved by the U.S. Food and Drug Administration (FDA) in 2012 to be placed in the eye during cataract surgery for the treatment of mild to moderate open-angle glaucoma. iStent was developed by Glaukos Corporation in Laguna Hills, California. iStent was the first of this type of procedure approved by the FDA and is the first-generation trabecular meshwork bypass device. The device connects the aqueous humor in the anterior chamber into Schlemm's canal. The iStent is heparin-coated and is composed of a non-ferromagnetic titanium stent that is 1x0.3 mm in size.

iStent | *Google Images*

Once cataract surgery has been completed, the iStent is placed into Schlemm's canal. Before inserting the iStent, the anterior chamber is formed with a viscoelastic gel to keep the eye formed during the operation. A gonio prism is placed on the eye so the eye surgeon can see the trabecular meshwork. The iStent is attached to the tip of an inserter that has a button release. The iStent is inserted through the trabecular meshwork and into Schlemm's canal. The iStent looks like a snorkel, and once the trabecular meshwork is penetrated, the iStent is inserted in a sideways fashion.

iStent on a penny | *Google Images*

Several clinical studies have shown that the iStent lowers the intraocular pressure by at least 20% in 66% of cases versus cataract surgery alone lowering the intraocular pressure by 48%. You can insert more than one iStent to lower the intraocular pressure further, but that is not approved in the United States at this time. Complications include a chance that the stent could dislodge, and many people will have a small hemorrhage that usually resolves in a few days.



Two iStents in trabecular meshwork | *Google Images*

Kahook Dual Blade

The **Kahook Dual Blade** is used to remove a section of the trabecular meshwork. It is designed to remove the trabecular meshwork in a manner that removes a more complete or total excision of the meshwork versus other procedures. Removing a wider area or band of tissue should decrease the eye's ability to scar the meshwork closed after the surgery. The Kahook Dual Blade procedure is approved to be performed alone or during cataract surgery.

Either an incision is made in the cornea to perform the procedure by itself, or the incisions used in the cataract surgery can be used to perform the procedure. The anterior chamber is then filled with viscoelastic to maintain the shape of the eye and to allow access to the trabecular meshwork. To see the trabecular meshwork, the patient's head is rotated 30 to 45 degrees away from the eye surgeon. A gonio lens is placed on the eye to allow the surgeon to visualize the trabecular meshwork. The Kahook Dual Blade is inserted into the anterior chamber and the trabecular meshwork is penetrated and passed into Schlemm's canal. The blade is advanced along the trabecular meshwork for several clock hours inside the eye. The Kahook blade is rotated 180 degrees and inserted into the meshwork on the opposite side of the eye. The Kahook blade is advanced back towards the other treatment site to join the 2 incisions. A free-floating piece of the trabecular meshwork is accomplished. A total of 180 degrees of trabecular meshwork can be removed. The trabecular meshwork piece and the viscoelastic are removed with an irrigation and aspiration instrument.

Clinical studies have shown that on average, there is a reduction in intraocular pressure by 30%. The most common complication of the Kahook procedure is a small hemorrhage that usually resolves in a few days.

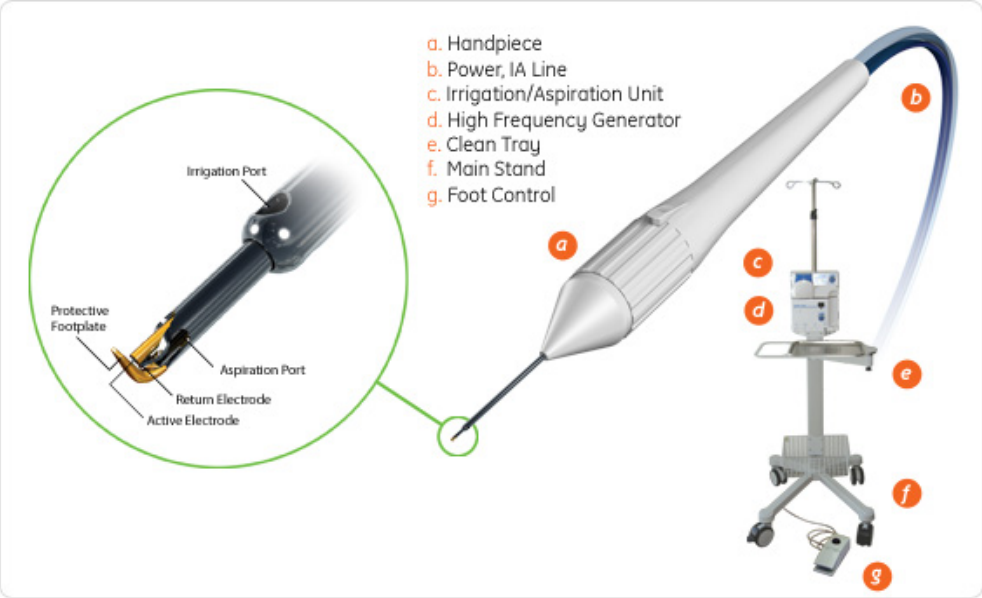
Kahook Dual Blade | Google Images

Trabectome

Trabectome was developed by a company in Tustin, California called Neomedix. The Trabectome procedure was approved by the FDA in 2004. The Trabectome removes the trabecular meshwork or performs a trabeculotomy using a handpiece. The Trabectome handpiece is a 19.5 gauge in diameter probe with an electrocautery connected to it. It is combined with an irrigation and aspiration system connected to a control console.

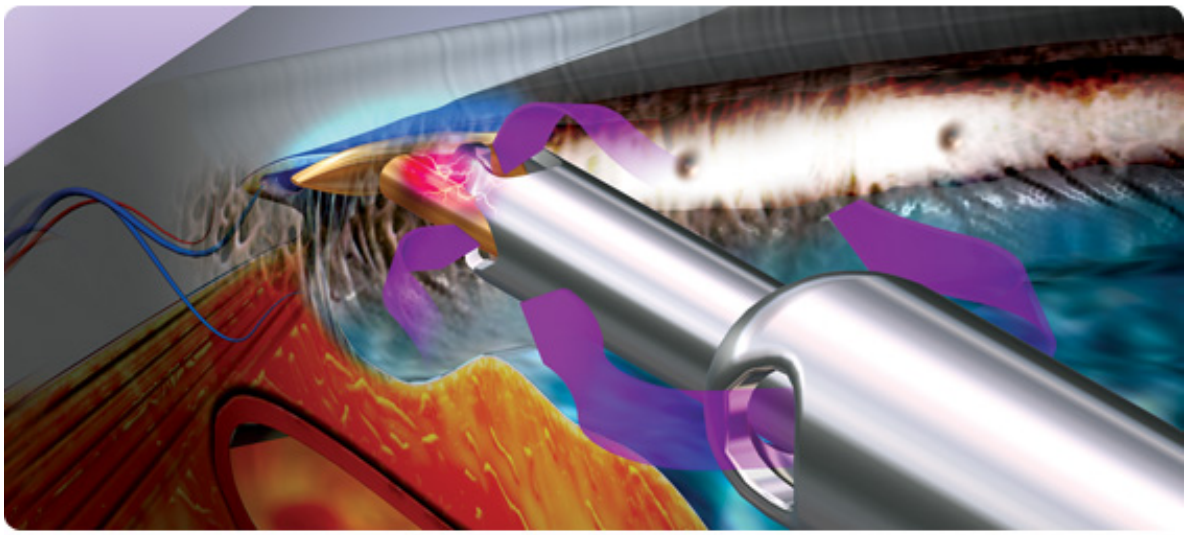
An incision is made in the cornea and the anterior chamber is filled with a viscoelastic gel. A gonioscopy prism lens is placed on the eye to view the trabecular meshwork; the instrument is passed through the trabecular meshwork and along the trabecular meshwork. The instrument removes a strip of trabecular meshwork and the inner wall of Schlemm's canal. Typically, 120 degrees of the trabecular meshwork is excised. This allows the aqueous humor in the anterior chamber direct access to the collector

channels in Schlemm's canal. The aqueous humor exits these channels into collector veins to be drained from the eye.



Trabectome | *Google Images*

Clinical studies have shown that the Trabectome procedure lowers the intraocular pressure by about 30% from the baseline intraocular pressure. There is usually some mild bleeding from Schlemm's canal, but this usually resolves within a few days.



Trabectome procedure | *Google Images*

GATT (Gonioscopy-Assisted Transluminal Trabeculotomy)

GATT is an ab interno trabeculotomy that is minimally invasive. Two incisions are made in the cornea to gain access to the anterior chamber. A viscoelastic gel is injected into the anterior chamber to maintain the structure of the eye during the procedure. A super sharp blade is used to make a tiny incision in the trabecular meshwork into Schlemm's canal. A microcatheter (iTrack-Ellex) with illumination on the tip is inserted into Schlemm's canal. A microsurgical forceps is used to grasp the microcatheter and pass the catheter 360 degrees all the way around the eye, and the catheter exits the opening in the trabecular meshwork. The catheter is grasped using the microsurgical forceps, and the catheter cuts or pulls through the trabecular meshwork the entire 360 degrees around the eye. A total 360-degree trabeculotomy is performed with this procedure.

Clinical studies have shown that a GATT produces a 30% reduction in intraocular pressure. The most common complication is a hemorrhage inside the eye. The hemorrhage usually absorbs in a few days or so.

TRAB 360 | *Google Images*

The **TRAB 360** surgical device is a disposable, non-powered instrument used to perform an interno 360-degree trabeculotomy. It is indicated in the treatment of open-angle glaucoma. The instrument is made by a company called SightSciences.

The procedure begins with the patient's head being turned to the side by approximately 45 degrees away from the surgeon under a microscope. A small incision is made in the cornea if the TRAB 360 is not being performed during cataract surgery. The anterior chamber is filled with a viscoelastic gel to keep the eye formed during the operation. A gonioprism is placed on the eye so the eye surgeon can visualize the trabecular meshwork. The device is inserted into the anterior chamber and the tip of the TRAB 360 is used to make a small opening in the trabecular meshwork into Schlemm's canal. The TRAB 360 probe is inserted into Schlemm's canal. The flexible nylon cannula is advanced 180 degrees in one direction. The TRAB 360 is pulled away from the meshwork, which opens 180 degrees of Schlemm's canal. The cannula is pulled back into the device and the probe is reinserted into Schlemm's canal. The cannula is then passed 180 degrees in the opposite direction. The probe is again pulled away from Schlemm's canal and the other 180 degrees of Schlemm's canal is opened.

Clinical studies of the TRAB 360 show an approximately 35% reduction in intraocular pressure following the procedure. Like the other trabecular meshwork procedures, the most common complication was intraocular hemorrhage, which usually resolves in a few days or so.

Hydrus Microstent

The **Hydrus Microstent** was developed and manufactured by Ivantis for the treatment of open-angle glaucoma. The Hydrus Microstent is an intracanalicular scaffold that increases aqueous humor fluid outflow through the trabecular meshwork by serving as a scaffold for Schlemm's canal. The Hydrus Microstent is a highly flexible scaffold device made from a highly flexible biocompatible alloy of nickel and titanium, which measures 8 mm in length. There is a 1 mm inlet segment which resides in the anterior chamber, and the scaffold segment resides in Schlemm's canal.

Clinical studies of the Hydrus Microstent show a 20% reduction in intraocular pressure after the surgery. Similar to other trabecular meshwork surgeries, hemorrhages are a common complication that resolves in a few days or so. Another complication is that there was some peripheral anterior synechiae or scar formation, which did not affect the outcomes.

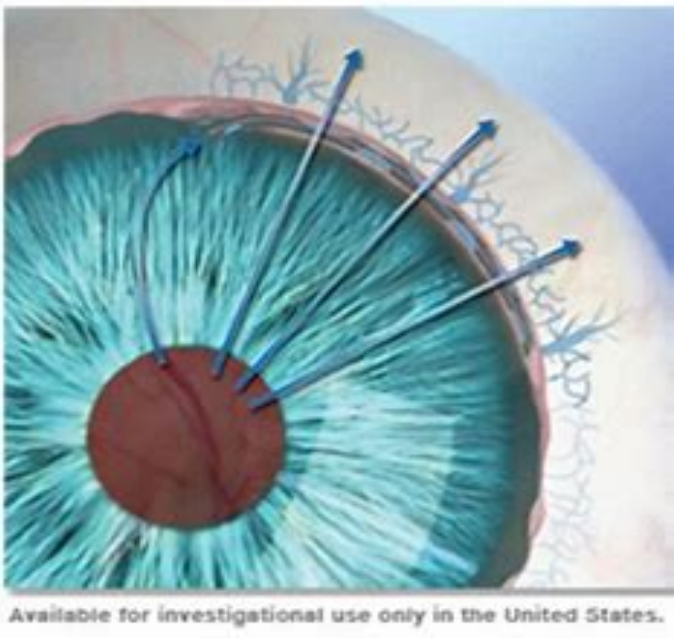


Photo from Google

The Hydrus Microstent is a unique procedure in that it can scaffold Schlemm's canal for several clock hours inside the eye.

Excimer Laser Trabeculostomy (ELT)

The **Excimer Laser** uses a 308 nm xenon chloride laser to cut openings in the trabecular meshwork. There are two devices currently available to perform ELT, which are **AIDA; Glautec AG, Nuberg, Germany** and **AIDA; TUI-Laser, Munich, Germany**.

Under a microscope, a small temporal incision is made in the cornea. A viscoelastic gel is injected into the anterior chamber to maintain its structure. The excimer laser probe is placed into the anterior chamber and passed across the anterior chamber toward the trabecular meshwork on the other side of the eye. The laser probe is directly applied to the trabecular meshwork. The laser has a wavelength of 308 nm, a spot size of 200 microns, an energy setting of 1.2 mJ, and a duration of 80 ns. The normal procedure is to apply 10 laser applications to the nasal trabecular meshwork approximately 500 microns apart. The eye may suffer some mild bleeding from the trabecular meshwork. The hemorrhage will usually resolve in a few days.

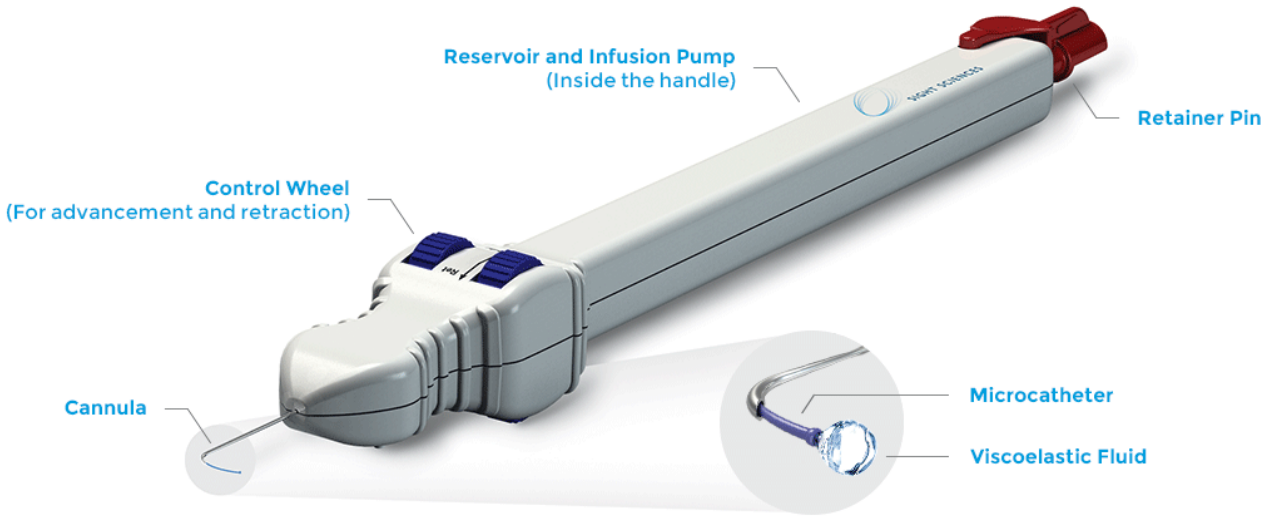
Clinical studies show that there is a reduction of the intraocular pressure of approximately 30% along with a reduction in the number of medications used by 30 to 40%.

Visco 360

Visco 360 is a very similar surgery to TRAB 360 and is manufactured by the same company, SightSciences. It is the first non-implantable MIGS surgery device indicated for ab interno microcatherization and vasodilation of Schlemm's canal in patients with open-angle glaucoma.

Under a microscope, a small corneal incision is made temporally if the procedure is not performed during cataract surgery. A viscoelastic gel is injected into the anterior chamber to keep the structure of the anterior chamber open. The probe is inserted into the anterior chamber and a small opening is made in the trabecular meshwork. A flexible nylon cannula is passed 360 degrees around the eye. Once this has been accomplished, a viscoelastic gel is injected into Schlemm's canal as the cannula is retracted back around Schlemm's canal.

This device is still under investigation by the FDA currently.



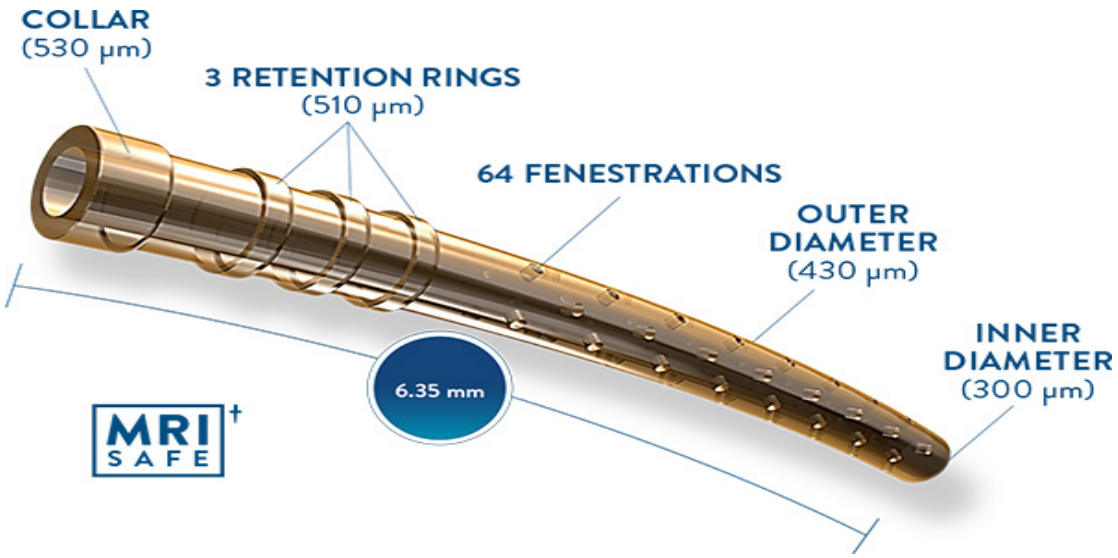
Visco 360 | *Google Images*

Suprachoroidal Shunts

The supraciliary space inside the eye for aqueous humor outflow has been used for the treatment of glaucoma for many years. The problem in the past was those procedures for using the supraciliary space had significant complications. The newer MIGS procedures are having very good success with minimal complications.

Cypass

Alcon designed and manufactured the **Cypass Micro-stent**. The Cypass is a suprachoroidal shunt designed to increase the uveoscleral flow of the aqueous humor from the eye. The Cypass is a flexible polyamide device. The Cypass Micro-stent is 6.35 mm long and has a 510-micron external diameter and a 300-micron lumen. The shunt is fenestrated with micro holes along its whole length, which allows a circumferential egress of aqueous humor from the stent into the suprachoroidal space.



Cypass Shunt | *Google Images*

The Cypass is manufactured with a pre-loaded guide wire that is retractable from the stent. A 1.5 mm corneal incision is made temporally if the shunt is not being performed during cataract surgery. A viscoelastic gel is injected into the anterior chamber to keep the anterior chamber formed during the procedure. The Cypass is inserted into the supraciliary space between the ciliary body and sclera. Once in place, the guide wire is removed.

Clinical studies have shown a nearly 35% reduction in intraocular pressure following the procedure. The most common complication was bleeding in the eye, which resolved in a few days. Peripheral anterior synechiae or scarring formed around the stent. Occasionally, postoperative inflammation occurred, which was temporary.

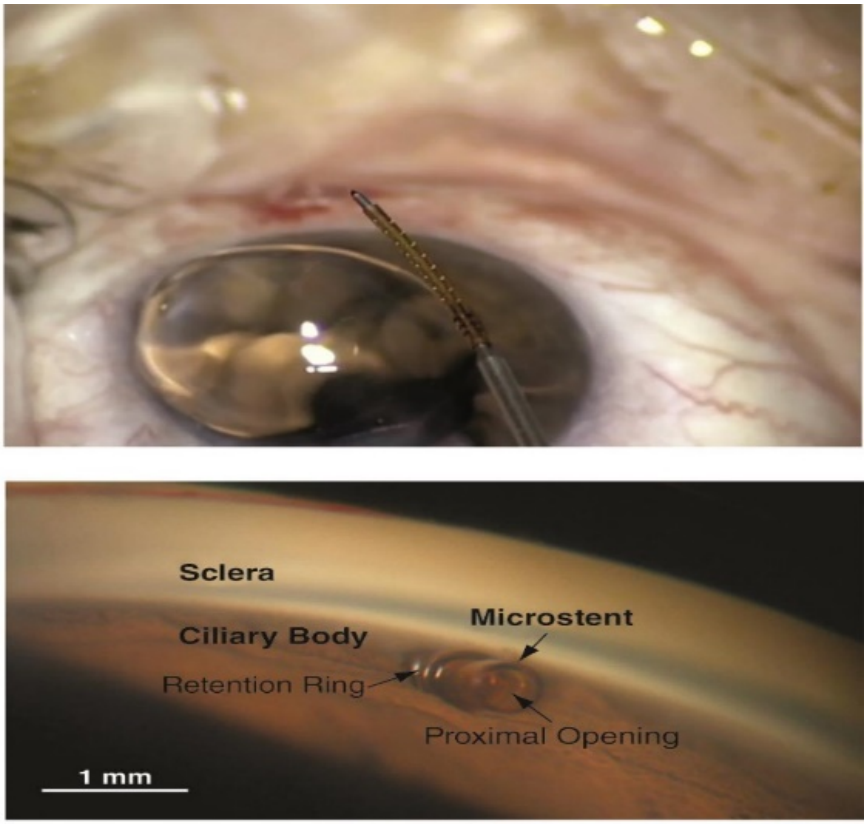


Photo from Google

iStent Supra

iStent Supra, made by Glaukos Corporation, is a suprachoroidal stent that is designed to increase the flow of aqueous humor from the eye through uveoscleral outflow. The iStent Supra is 4 mm in length with a 0.16 - 0.17 mm lumen made of polyethersulfone, has a titanium sleeve, and is heparin-coated. The iStent Supra is designed with retention ridges to secure it in place. The iStent Supra has been approved to be used as a separate procedure or during cataract surgery.

Photo from Google

A viscoelastic gel is injected into the anterior chamber to keep the anterior chamber formed. A gonio prism lens is placed on the eye to allow the eye surgeon to visualize the angle. The iStent Supra is inserted between the ciliary body and sclera into the suprachoroidal space.

Clinical studies have shown an intraocular pressure reduction of approximately 35% after the procedure. The most common complication was bleeding, which resolved in a few days.

Decreasing Aqueous Humor Production

Endocyclophotocoagulation (ECP)

Photo from Google

ECP is performed using a laser device to apply laser photocoagulation to the ciliary body which produces the aqueous humor. Cauterizing the ciliary body reduces the production of aqueous humor. ECP is a cyclodestruction of the ciliary body. The ciliary body is not able to produce the same amount of fluid which reduces the production of aqueous humor inside the eye and therefore reduces the intraocular pressure. The ECP laser probe consists of a laser source, an aiming beam light, and a camera. The laser's wavelength is 810 nm and the laser fires in a continuous energy application.

ECP is approved to treat many types of glaucoma including open-angle glaucoma, congenital glaucoma, pigmentary glaucoma, and others. The

procedure is approved for a stand-alone procedure and during cataract surgery.

The laser probe is inserted into the anterior chamber and advanced across the eye. The laser is aimed behind the iris at the ciliary body. The laser treatment is applied to the ciliary body processes until there is whitening of the ciliary body processes. The eye surgeon can treat approximately 240 degrees through a single incision. If more treatment is warranted, another incision can be made in the cornea to treat the other areas.

Clinical studies have shown that ECP reduces intraocular pressure by about 8 mmHg with fewer medications needed to control the intraocular pressure. One of the significant complications is that the ECP treatment can cause a significant inflammatory response inside the eye. Sometimes aggressive steroid treatment is needed. Other complications include an intraocular pressure spike and bleeding.

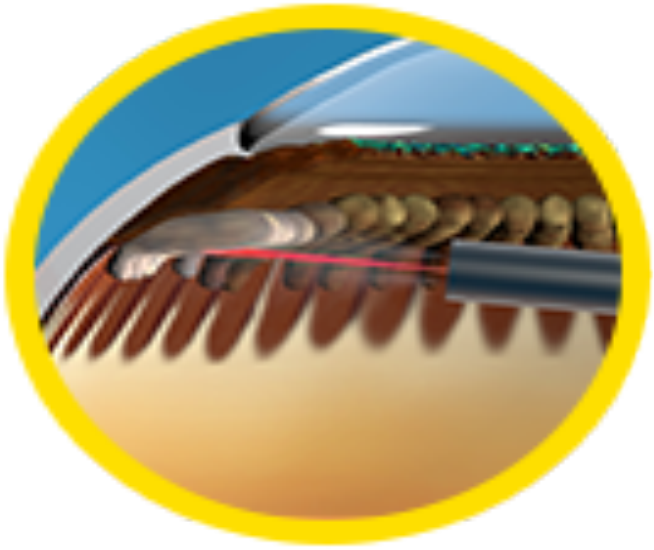
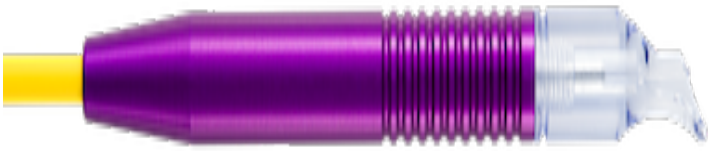


Photo from Google

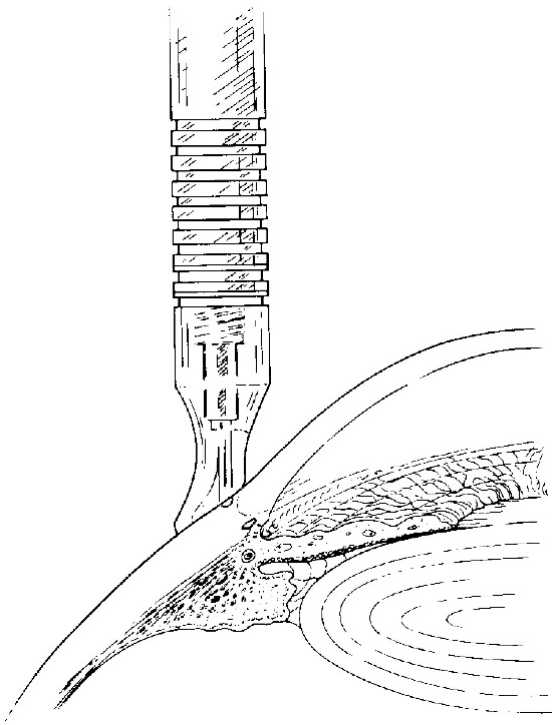
Micropulse P3 Cyclophotocoagulation (MP3)

Micropulse P3 | *Photo from Google*

The **Micropulse P3** is like the G-Probe. Both are made by Iridex. Micropulse P3 is a safer treatment procedure for the ciliary body. The MP3 laser device is a finely tuned machine that controls the laser application to the eye. The Micropulse P3 laser uses very short micropulses to perform transscleral (from outside the eye on the sclera) cyclophotocoagulation to the ciliary processes. The short micropulses avoid overheating and burning any ocular tissue.



Cyclo Probe | *Google Images*



Probe position on the eye | *Google Images*

The procedure is usually performed in an outpatient surgery center but can be performed in an office. The patient is given a short-acting anesthesia drug in an IV, and while they are asleep, a numbing medication is injected behind the eye to provide anesthesia for the procedure. The laser is performed on half an eye per treatment cycle. The superior and inferior halves are treated for a total of 90 seconds.

The MP3 probe is placed on the eye just posterior to the limbus (where the clear portion of the eye and the white portion meet). The laser probe is passed along the limbus back and forth for 90 seconds. The probe is moved at a rate of 1 clock hour every 10 seconds. The other half of the eye is treated in the same manner.

Clinical studies have shown that intraocular pressure is reduced by an average of 30 to 40%. The laser procedure does cause an inflammatory reaction and is treated with topical steroid eye drops.

DEVICE COMPARISON	G-PROBE	G-PROBE Illuminate	MP3 PROBE
Glaucoma Treatment Stage	Refractory	Refractory	Primary Open Angle
Repeatable Procedure	Yes	Yes	Yes
MicroPulse Technology	No	No	Yes
Transillumination	No	Yes	No
Destructive	Yes	Yes	No[2,3]
Therapy Location	Office & OR	Office & OR	Office & OR
CPT Code	66710	66710	66710
SmartProbe Technology	Laser Parameter Memory Enabled	Laser Parameter Memory Enabled	Laser Parameter Memory Enabled
Patented Probe Design	Wedge	Wedge	Curve

Device comparison | *Google Images*

Subconjunctival Filtration

XEN Gel Stent

Allergan manufactured the **XEN Gel Stent** which is used for the treatment of open-angle glaucoma. The stent is designed to allow the aqueous humor to flow from the anterior chamber and through the eye to filter under the conjunctiva. The aqueous humor is absorbed by the ocular surface tissues. The conjunctiva is a tissue that contains the blood vessels that cover the white portion of the eye. The XEN Gel Stent is made of gelatin and glutaraldehyde and is loaded on a 27-gauge needle disposable injector. The XEN Gel Stent is available in three sizes which are based on the size of the lumen, which is the XEN 45 (45-micron lumen, 63-micron lumen, 140-micron lumen). The larger the lumen stent, the more fluid is drained from the eye. The XEN Gel Stent is approved for use in patients with open-angle glaucoma, pigmentary glaucoma, and/or pseudoexfoliation glaucoma.

A viscoelastic gel is injected into the anterior chamber to keep the anterior chamber open. A gonioscopy prism lens is placed on the eye to visualize the angle. The XEN Gel Stent is inserted through the sclera ab interno into the space under the conjunctiva. The aqueous humor that filters through the stent forms a filtering bleb or bubble of fluid under the conjunctiva where the fluid is absorbed. The eye surgeon may choose to inject an antimetabolite, such as Mitomycin C, beneath the conjunctiva to reduce scarring and help the bleb maintain its function.

In clinical studies, the XEN 45 reduced eye pressure by 20% in 75% of patients. Needling of the bleb or opening of the subconjunctival space was needed in about 30% of patients. Larger stents are under study at this time.

InnFocus Microshunt

Santen Inc. designed and manufactured the **InnFocus Microshunt** for the treatment of open-angle glaucoma. This device is placed ab externo or from outside the eye. The device is 8.5 mm long and 0.350 mm in diameter with a lumen of 70 microns. The InnFocus Microshunt is composed of polystyrene-block-isobutylene-block-styrene. The InnFocus Microshunt may be inserted as a stand-alone procedure or in conjunction with cataract surgery.

After the injection of a local anesthetic, a small conjunctival peritomy or incision is made on the superior portion of the eye. A needle is used to create a channel through the sclera into the anterior chamber. The tip of the XEN Microshunt is passed through the channel into the anterior chamber. The conjunctival incision is repaired. Mitomycin C is usually injected subconjunctivally in the area of the shunt.

Complications of the XEN Microshunt include iris-shunt touch, bleeding, and incision-healing problems. The average intraocular pressure went from 24 mmHg to 11 mmHg, with the mean number of glaucoma medications reducing from 2.4 to 0.9 medications.

Summary of MIGS

MIGS procedures are a new category of glaucoma treatment surgical procedures that are less invasive than traditional glaucoma surgery. They provide a moderate amount of reduction in intraocular pressure. MIGS procedures are another alternative or option in the treatment of glaucoma. Many companies are researching other MIGS-like procedures for the treatment of glaucoma.

Major Surgical Procedures for Glaucoma

Shunts for Glaucoma

At the beginning of shunts being available, they were originally used in people who had a trabeculectomy glaucoma operation that failed; if there was scarring of the conjunctiva and a trabeculectomy could not be performed; in neovascular glaucoma; in patients with chronic inflammation of their eyes; or in other eye disorders. There are two camps of eye surgeons; there are eye surgeons who prefer shunts and those who prefer trabeculectomy as their primary glaucoma operation. These tubes or shunts are made of silicone or polypropylene material that is well tolerated by the body and does not cause an inflammatory reaction. The shunts are available in different shapes, sizes, designs, valves, and non-valve types. The non-valved shunts are Molteno, Baerveldt, Eagle Vision shunts, and Shocket. Ahmed shunts are valve shunts.

Two Types of Shunts

Shunts without Valves

Shunts without valves have certain characteristics. These shunts require some scarring around the shunt to limit the amount of aqueous humor that flows from the eye. Sutures are usually used to limit the flow of fluid through the tube until scarring has occurred. The suture may be removed 4 to 6 weeks after the surgery. Non-valved shunts tend to lower the intraocular pressure better than valved shunts.

Shunts with Valves

Shunts with valves are designed to have a valve that regulates the amount of aqueous humor that can flow through it. The flow-limiting capability of the valve controls the amount of lowering of the intraocular pressure the valve will allow. The most common type of shunt valve device is the Ahmed valve shunt. This shunt limits how low the intraocular pressure can be lowered. Many times, patients may still need glaucoma eye medications to lower intraocular pressure.

Shunts Differences

Non-valved shunts can lower intraocular pressure to a greater extent than valved shunts. Each eye surgeon has their preference on the type of shunt they prefer to use. As a rule, patients that need low intraocular pressure may do better with non-valved shunts.

Model S2 Ahmed Glaucoma Valve Shunt | *Google Images*

Glaucoma Shunt Surgery

An incision is made in the conjunctiva in the superior temporal quadrant of the eye. The plate or reservoir of the shunt is placed between the eye rectus muscles with the anterior edge of the shunt reservoir approximately 8 to 10 mm posterior to the cornea. Once the shunt has been placed in the proper position, it is sutured in place with non-absorbable sutures. This is an important step so that the shunt will not move after the surgery.

After the reservoir is secured in place, the tube leading into the reservoir is laid across the cornea. The tube is cut at an angle with the bevel opening toward the cornea. The tube is cut so that the drainage tube will extend into the anterior chamber by 2 to 3 mm. A 23-gauge needle is used to enter the anterior chamber to provide the channel through which the tube will go through into the anterior chamber. The tube is usually secured to the sclera with an absorbable suture.

The tube is covered with a patch graft where it exits from the sclera to prevent any erosion of the tube through the conjunctiva. The graft may be composed of many different materials such as sclera, pericardium, fascia lata, cornea, and/or dura. The patch graft is sutured over the tube onto the sclera. A partial scleral flap can be made to place over the tube as well. After the shunt is secured, the conjunctiva is returned to its proper place over the shunt and the conjunctiva incision is closed sutures.

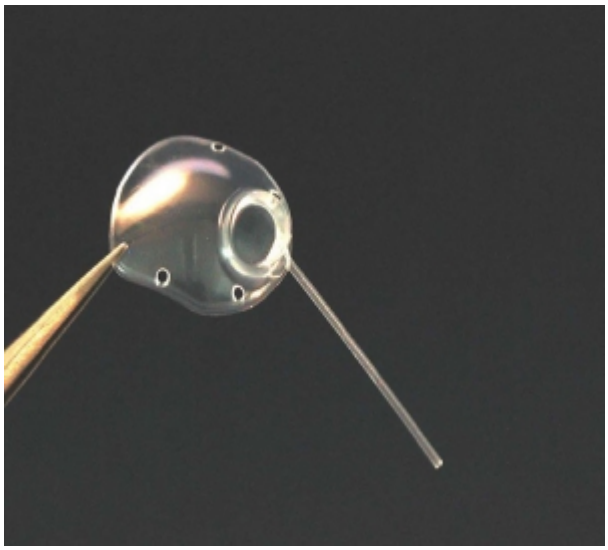


Photo from Google

Complications

- **Hypotony** – Low eye pressure.
- **Flat Anterior Chamber** – The anterior is not formed secondary to too much aqueous humor draining from the eye or, in a few cases, the eye is temporally not producing enough fluid.
- **Cataract Formation** – The shunt surgery will cause a cataract to develop much faster.
- **Choroidal Detachment** – Secondary to low intraocular pressure, fluid can expand in the choroid layer under the retina.
- **Suprachoroidal Hemorrhage** – Rupture of a blood vessel inside the eye.
- **Bleeding** – Hemorrhage in the anterior chamber.

- **Corneal Edema** – If the drainage tube is placed too close to the cornea, the cornea endothelium will be damaged and the cornea will become swollen.
- **Valve Malfunction** – It is important to prime the shunt at the time of surgery to prevent the valve from malfunctioning.
- **Scleral Perforation** – The surgery was performed too deep or the patient can have thin sclera.
- **Hypertensive Episode** – The intraocular pressure in rare cases may dramatically increase after surgery (between 1 to 6 weeks after the surgery).
- **Tube Movement** – The reservoir and tube may move if they have not been well-secured, and the shunt can be expulsed.
- **Tube-Related Problems** – If the tube is placed too close to the cornea, it will cause the cornea to decompensate, resulting in corneal edema. If the tube is placed too close to the iris, it will cause inflammation by rubbing on the iris. The tube can become plugged with blood, fibrin, iris, or vitreous.
- **Tube Erosion** – The tube can erode through the conjunctiva over the shunt. This erosion needs to be repaired very quickly to prevent any chance of infection. A new patch graft needs to be reinserted to protect the eye.
- **Double Vision** – The eye muscles that move the eye can be damaged by the placement of the shunt.

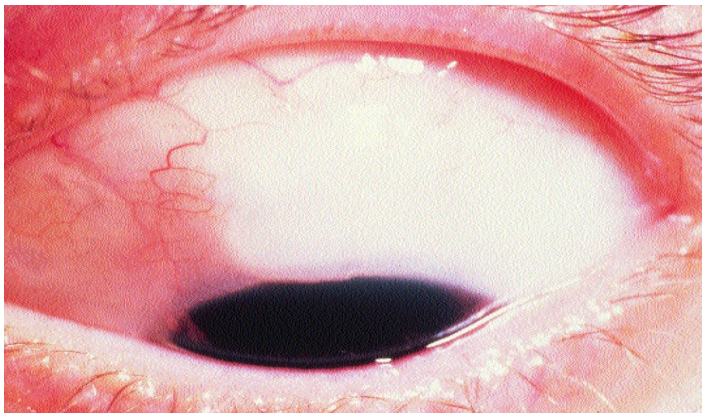
Shunt Results

The success rate is similar in both types of shunt procedures, which is approximately 90%.

Trabeculectomy

Trabeculectomy has been for many years considered the gold standard surgical procedure for treating uncontrolled glaucoma. It is indicated when other treatments for glaucoma have failed, such as medications and SLT laser treatment. The surgery is performed with local anesthesia.

An incision is made in the conjunctiva (the outer tissue layer covering the sclera or white portion of the eye). The incision is usually made in the superior area of the eye under the upper eyelid. A partial thickness scleral flap is made, and the flap is dissected into the peripheral cornea. The flap is retracted, and an opening is made into the anterior chamber. A piece of the trabecular meshwork is removed along some surrounding tissue. Most of the time, a peripheral iridectomy or opening in the iris is made. The flap is sutured back in place so that a controlled amount of the aqueous humor flows through the flap into the space under the conjunctiva. The conjunctival incision is closed. The aqueous humor will drain from the eye and collect under the conjunctiva, forming a bleb or bubble where it will be absorbed. Antimetabolites such as 5-Fluorourcil or Mitomycin C are usually used at the end of the surgery to keep the opening from scarring closed. Antibiotic and steroid eye drop medications are prescribed.



Conjunctival filtering bleb | *Google Images*

Trabeculectomy Complications

- **Flat Anterior Chamber** – The anterior chamber has not formed. This is usually due to too much aqueous humor draining from the eye or, in less common cases, the eye is not producing enough aqueous humor.
- **Bleeding** – A hemorrhage can occur inside the anterior chamber, which usually resolves without treatment.
- **Hypotony** – Low intraocular pressure.
- **No Bleb** – Usually secondary to a leak in the conjunctiva and will need to be repaired if it does not resolve soon.
- **Cataract Formation** – The trabeculectomy will cause a cataract to develop at a faster rate.
- **Choroidal Detachment** – Fluid under the choroid expands, which is located under the retina. This can result from low intraocular pressure.
- **Bleb Infection** – The conjunctival bleb becomes infected.
- **Suprachoroidal Hemorrhage** – Rupture of a blood vessel inside the eye.
- **Bleb Becomes Encapsulated** – The subconjunctival tissue forms a scar around the trabeculectomy.

Success Rate of Trabeculectomy

Clinical studies have shown that trabeculectomy has a success rate of 90%. More than 65% of patients have their glaucoma controlled without medications. About 10% of trabeculectomies fail and patients will need a repeat of the operation. About 2% of patients per year have their trabeculectomy surgery stop working. Approximately 10% of patients will develop an infection in the bleb at some point in their lifetime.

Which Glaucoma Operation is the Best?

There are a lot of discussions in the United States about which procedures eye surgeons prefer for their primary surgical procedure. The type of glaucoma surgery that is best for you is determined by many factors.

The choice of which glaucoma procedure is best can be influenced by the type of glaucoma, such as the level of intraocular pressure needed after the surgery, the health of the conjunctiva, and eye surgeon preference.

Glaucoma Treatment Summary

What You Need to Know About Treating Your Glaucoma and Keeping Your Sight Safe

Glaucoma is a complicated multi-factorial disease of the eye, specifically the optic nerve. Glaucoma is not just a simple matter of the level of intraocular pressure. Many other factors influence the presence of glaucoma damage in the eye. Some people may go blind from glaucoma with a normal intraocular pressure of 17 mmHg and other people can have an intraocular pressure of 25 mmHg and never develop glaucoma damage. Another problem with glaucoma is that in the initial stages of open-angle glaucoma, there are no symptoms. People do not walk into an eye doctor's office and say they might have glaucoma. Vision loss is so slow and insidious that most people are unaware of any vision loss.

How can you protect yourself from vision loss from glaucoma? A person with a family history of glaucoma should have their intraocular pressure checked and their eyes examined on a yearly basis after age forty.

You should have further testing and evaluation if, during your eye exam, the eye doctor measures your intraocular pressure to be above 21 mmHg, finds that the optic nerves have a very large cup-to-disc ratio, and/or finds that there is asymmetric cupping of the optic nerves. There are many people with elevated eye pressure who never develop glaucoma and there are others who have a normal eye pressure that go blind from glaucoma. Many people may have an eye pressure of 25 or 26 mmHg and never develop glaucoma. Other people may go blind with an eye pressure of 16 or 17 mmHg. So, who needs to be treated for glaucoma?

If your eyes are healthy or normal and all the glaucoma tests show no evidence of glaucoma damage, many eye doctors will not start glaucoma treatment until the eye pressure is consistently 27 or 28 mmHg. Corneal thickness is very important in determining the true intraocular pressure. The intraocular pressure at which an eye doctor will begin treatment is different for each doctor. If the intraocular pressure remains too high, this pressure puts the eye at risk of other eye diseases. In most cases, an intraocular pressure of 27 or 28 mmHg needs to be treated.

If any of the glaucoma tests show evidence of glaucoma damage, the intraocular pressure needs to be lowered to stop the progression of glaucoma damage to the optic nerve. Any damage to the optic nerve is permanent.

How low does the intraocular pressure need to be in order for the eye to be safe? What the intraocular pressure needs to be depends on many factors. A major factor in determining what the intraocular pressure needs to be is based on the **severity of the damage to the optic nerve**. If there is minimal damage to the optic nerve and/or the glaucoma tests show very minimal damage, the intraocular pressure may be safe in the range of 19 to 20 mmHg and you should be closely monitored. If there is significant

damage to the optic nerve and the glaucoma tests show significant damage, the intraocular pressure needs to be in the range of 10 to 12 mmHg. These are general guidelines, and each patient is unique.

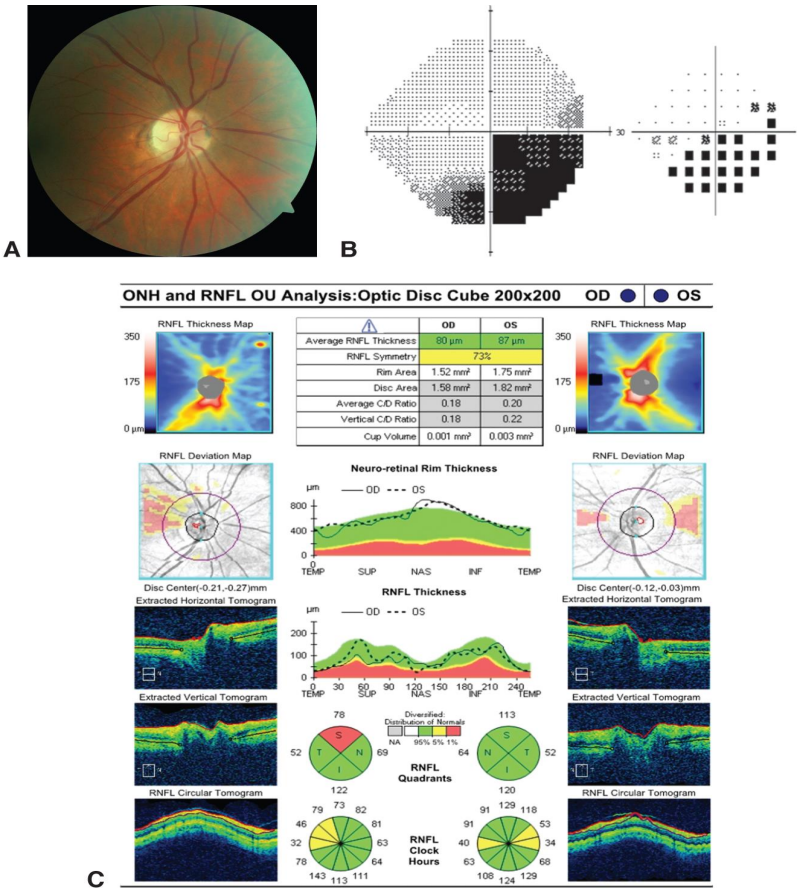
Another factor is the **initial intraocular pressure**. Typically, a 30% drop in intraocular pressure initially is a good starting point for treatment.

Another factor is the **thickness of the cornea**. In order to have a better idea of the true intraocular pressure, you need to know the thickness of the cornea. The thickness of a normal corneal is 550 microns. The thickness of the cornea is another factor in the decision-making process.

When the decision is made to treat glaucoma or you are being treated for glaucoma, a target intraocular pressure should be chosen based on all the factors discussed. You should ask your eye doctor what they believe your intraocular pressure should be for your eye to be safe from glaucoma.

There is another important factor in treating someone with glaucoma, which is **patient compliance**. Many things can affect patient compliance. This can be the inability to instill the eye drops, as many people have difficulty putting eye drops in their eyes. Elderly people may have difficulty remembering to use their eye medications. Since there are almost no symptoms from open-angle glaucoma at the beginning of glaucoma or until the end stage of the disease, many people do not see the importance of using their medications, keeping their appointments, or believing in the urgency of treating their glaucoma. If people are compliant with using their medications and keeping their follow-up appointments, most people will not go blind from glaucoma.

If you have glaucoma or are at risk of developing glaucoma, the eye doctor will have you return for eye exams every 3 to 6 months depending on the severity or stage of the glaucoma. They will check your intraocular pressure and perform many of the tests described previously.



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The most common eye tests for glaucoma are eye pressure, visual fields, OCT, examination of the optic nerve, and corneal thickness. These tests will be performed every year (scattered throughout the year) unless the eye doctor is concerned about the status of your glaucoma.

Most of the time, the initial treatment is usually eye drop medications. Some eye doctors may recommend an SLT laser treatment initially. If your glaucoma is not controlled with topical medications, an SLT laser treatment can be performed to lower the intraocular pressure. If the intraocular pressure is still not controlled, an MP3 laser may be performed to control it.

If none of these treatments can control the intraocular pressure, a surgical procedure, such as a trabeculectomy or shunt, may be indicated. If you are having cataract surgery and have glaucoma, have a discussion with your eye surgeon about having one of the MIGS performed on your eye during the cataract surgery.

There are many options available today to treat glaucoma. Make sure you educate yourself about your eye disease. Always ask questions about the current condition or status of your glaucoma when you see your eye doctor. You need to follow your eye doctor's recommendations or plan for your glaucoma treatment, stay compliant with your eye medications, keep your eye appointments, and, if you have questions or concerns about your treatment, seek a second opinion. With today's modern technologies and treatments, very few people should lose their vision from glaucoma.

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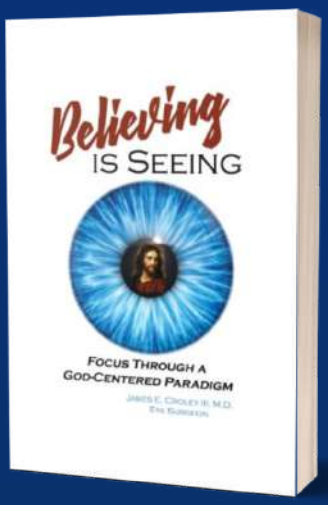

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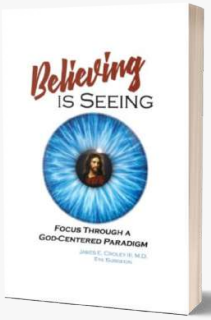

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