Lesson 1: Anatomy and Diseases of the Eye

Introduction

The first lesson introduces you to the parts of the eye, their functions, and the impacts disease and aging have on the eyes and vision. Described are several eye conditions, including glaucoma, cataracts, age-related macular degeneration, diabetic retinopathy, presbyopia, dry eye syndrome, and stroke-related hemianopsia. These conditions are common to individuals over age 60 and the effects they have on daily activities. Many people with visual impairments are not provided adequate information about their condition to understand the cause, impact on vision, and prognosis. This leads to numerous questions and a feeling of uncertainty. The goal of this lesson is to answer those questions in plain language. Having this information helps people better understand why they see what they see and effectively utilize the suggestions and adaptive techniques in the remaining lessons of this course.

Lesson Goals

- Identify the parts of the human eye that can be affected by the disease.
- Explain age-related eye conditions, including the part of the eye affected by each condition, the effects of each condition on vision, and the treatments for each condition.
- Describe ways each condition impacts daily activities.

Parts of the Eye

Sclera

The outer, white part of the eye that can be seen is called the sclera. It covers the entire eyeball except for the cornea, which will be described next. The two purposes of the sclera are to give shape and to protect the rest of the eye.

Cornea

The clear, dome-shaped front of the eye is called the cornea. It's often called the window of the eye, allowing light to pass into the eye then

through the pupil to the back of the eye. The cornea is a type of lens that produces 80 percent of the eye's focusing power. It makes it possible for people with normal vision to read and see images.

Because the cornea is clear, it does not have blood vessels to nourish it or protect it from the disease. These essential functions are carried out by a thin membrane called the conjunctiva, along with tears on the outside of the eye and a fluid called the aqueous humor on the inside.

Iris and Pupil

The first thing most people with sight notice about someone's eyes is the color of the iris. The iris regulates the amount of light that enters the eye through the hole in the iris' center, called the pupil. Muscles in the iris open the pupil more to allow light when in a dark environment such as a movie theatre or close the pupil in bright light such as a sunny day at the beach. Thus, the pupil is a hole that lets light into the back of the eye where light is converted into electrical impulses. These impulses are carried to the brain, where they are changed into the visual images seen by people with normal vision.

Aqueous Humor

Between the cornea and the iris is a space filled with aqueous humor, a clear, watery fluid that helps bring nutrients to the eye tissue, especially the cornea. The fluid is produced by the ciliary body, located just behind the iris, and flows from there to the front of the eye. Along with nourishing the eye's tissue, the aqueous humor regulates the pressure within the eye. When the aqueous fluid flow is obstructed, the pressure inside the eye can increase and cause glaucoma.

Ocular Lens

The ocular lens lies directly behind the pupil. Like the cornea, the lens is composed of crystal-clear tissue. Together, the cornea and ocular lens focus light and images on the retina. This flexible lens's primary function is to change its shape so the eyes can focus on objects and people nearby or at a distance. The lens becomes more rounded to focus on near objects, and it flattens to focus on objects far away.

Over time, the lens begins to lose some of its elasticity and, therefore, loses some of its ability to focus on nearby objects. This condition, known as presbyopia, starts to develop around age 40 and is the reason people need reading glasses as they age.

Vitreous Humor

Between the ocular lens and the back of the eye or the retina is a transparent jelly-like substance called the vitreous humor. The vitreous is tightly attached to the retina when we are born, but over time, it begins to separate from the retina and becomes liquefied. Parts of the vitreous can develop a "stringy" consistency and look like something floating around in your eyes. These are known as "floaters" and can be caused by several other conditions, such as hemorrhages in the retina from diabetic retinopathy and a detaching retina.

Retina

The retina lines the inside, back of the eye. The light-sensitive cells in the retina convert incoming light into electrical impulses that make it possible for the brain to produce visual images. The retina is made of two types of cells: cones and rods. Most of the cones appear in the macula, a small area of the retina responsible for central vision and where the sharpest vision occurs, making it possible to read and see colors. These cells function best under good lighting. The rods form the majority of the periphery of the retina, along with a few cones. Rods are not color sensitive and do not have the focusing power of the cone-rich macula. These cells function well at night or in places with low lighting, such as movie theaters.

Several diseases are associated with the retina, including macular degeneration, diabetic retinopathy, and retinitis pigmentosa, but only one disease is specifically associated with aging, age-related macular degeneration (AMD).

Optic Nerve

Attached to the retina at the back of the eye is the optic nerve. It consists of more than one million nerve fibers attached to the retina and links the eye directly to the brain's vision centers. The brain takes the optic nerve's information and converts it to the visual images that the eyes see. In the

optic nerve center, where it connects with the eye, is the optic disc. The optic disc creates a blind spot because it contains no rods or cones needed for the brain to create visual images.

Exterior Parts of the Visual System

On the outside of the eye are five essential components of the visual system: the bony orbit, the extraocular muscles, the conjunctiva, the tear film, and the eyelids.

Bony Orbit and Extraocular Muscles

The bony orbit is the bone structure, composed of numerous small bones surrounding and contains the eyeball. The bony orbit protects the eye and provides connections for the six extraocular muscles that move each eye. These muscles attach to six different places on the eyeball and insert into six locations on the bony orbit.

Conjunctiva

Covering the sclera's outside surface and lining the eyelids' inner surface is a thin, somewhat transparent membrane called the conjunctiva. It provides nutrients and infection-fighting substances to the external surface of the eye. It also helps prevent friction from eye movements and blinking.

Eyelids and Tears

The eyelids help protect the front of the eye from injury and excessive exposure to light. They also help spread the tear film over the surface of the eyes. The tear film has multiple purposes. It keeps the eyes moist, supplies nutrients to the cornea, and is essential for maintaining the cornea's transparency and health. Tears also fight infection, flush away bacteria, protect the cornea from drying out, and eliminate dust, allergens, and other airborne irritants. A condition called dry eye syndrome can occur due to the quality and quantity of tears.

Eye Conditions

Dry Eye Syndrome

Healthy tear film consists of three essential components that come from three separate areas of the eyelids:

- The innermost layer is the mucin layer. This layer consists of thick, slippery mucus material. It acts as a protective lubricant and provides a smooth surface for even tear film distribution over the eye's surface.
- The middle layer is the aqueous layer. This layer consists of water, proteins, oxygen, and salts (the reason for the salty taste of tears). It provides nutrients to the surface of the eye, removes waste products, and prevents infection.
- The outermost layer is the lipid layer. This layer consists of oils that coat the aqueous layer, acts as a sealant to stop the tears from evaporating, and prevents the tears from flowing over the lower eyelid.

If any one of these components is missing, the quality and function of the tears are affected.

As people age and produce fewer and poorer-quality tears, such as those with an improper balance of water, oil, and mucus, the incidence of dry eye increases. Dry eye can cause irritation, itchiness, a gritty sensation, a feeling that something is in the eye, sensitivity to light, and blurry vision. Some medications and medical conditions reduce the eye's ability to produce all three components of high-quality tears, leading to a dry eye. Eye diseases, eye surgeries, contact lenses, and eye drops containing preservatives can affect the tears' quality or damage nerves that sense and respond to dryness.

The cornea's dryness can stimulate a reflex tear production, though these reflex tears are of poor quality and do not relieve dry eye. Keep in mind the importance of high-quality tears for the health of the eye, especially the cornea. Severe damage can occur to the cornea if dry eye is left untreated. Certain types of artificial tears are helpful. Discuss with your doctor which artificial tears you should use.

Presbyopia

Presbyopia is a common type of vision disorder that occurs with aging. It is a normal part of aging and affects virtually everyone, usually becoming noticeable after age 40.

Presbyopia results in the inability to focus up close. Presbyopia is a problem that is associated with refraction in the eye. The eye cannot focus light directly on the retina due to the hardening of the natural lens. Aging also affects muscle fibers around the lens, making it harder for the eye to focus on up-close objects. The ineffective lens causes light to focus behind the retina, creating poor vision for objects that are up close.

People with presbyopia typically hold reading materials at arm's length to bring the words into focus. They may experience headaches or eyestrain while reading, viewing a computer screen, or doing close work. Presbyopia can be corrected with reading glasses, bifocals or variable focus lenses, or contact lenses. Using bright, direct light when reading is also helpful.

Cataracts

In their 60s, many people began developing another age-related problem with the ocular lens known as cataracts. In fact, according to the National Eye Institute, 50 percent of all people in the US will develop cataracts or will have cataract surgery before age 80.

Simply put, a cataract is a progressive cloudiness, hardening, and yellowing of the normally clear, transparent ocular lens. Over time, vision acquires a brownish tint, and everything becomes blurry or appears as if seen through a dirty windshield. The overall blurred vision created by cataracts causes people, objects, and colors to look hazy or washed out. For example, navy blue, brown, black, and purple are challenging to differentiate. For some people, the inability to see details can make it difficult to watch television, read a book, see the clock, identify the food on a plate, enjoy hobbies, and walk safely indoors or outside. Increased sensitivity to glare can have a disabling effect on driving at night or in bright sunlight.

Some cataracts progress more slowly than others. If a cataract is allowed to develop for an extended period, it may cause inflammation or increase the intraocular pressure.

Currently, surgery is the only treatment for cataracts. Removal of cataracts is usually successful, with 98 percent of patients having improved vision if

no other eye condition is present. It is important to note that the presence of some eye conditions, such as glaucoma, diabetic retinopathy, and Macular Degeneration, may result in complications due to surgery on the compromised eye. These should be discussed with your doctor. It is up to the patient to decide about having cataract surgery once all the risks and possible complications have been discussed.

Glaucoma

Although there are several types of glaucoma, the most common type is called open-angle glaucoma. The point at which the iris and cornea intersect creates an angle where the aqueous fluid flows out of the eye and into the bloodstream. If the angle restricts the flow of the aqueous, the pressure will build within the eye. The results of increased pressure are a loss of peripheral (or side) vision initially. Glaucoma can and should be treated to reduce the risk of vision loss, as glaucoma can result in total blindness.

The normal pressure within the eyes ranges from 10 to 21 mm. Most people with glaucoma have an IOP (intraocular pressure) measurement greater than 21 mm Hg. A tonometer is a machine that measures eye pressure. A tonometer lightly presses on the cornea and measures the amount of pressure it takes to flatten the cornea. As the eyes' pressure increases, the potential for damage to the retina and optic nerve increases. If your eye doctor suspects that you may have glaucoma, you will need to undergo additional testing to help your doctor make a more definitive glaucoma diagnosis. Left untreated, high eye pressure can cause permanent vision loss, so it is essential to schedule comprehensive eye exams to follow the condition regularly. The use of eye drops is the primary treatment, but doctors will treat it with a laser to increase the flow of aqueous and release pressure in some cases.

Early symptoms or warning signs are rare at the onset of glaucoma. Anyone who does not have regular dilated eye exams may be legally blind before noticing any signs of the disease. Glaucoma symptoms can include a visual field similar to looking through a drinking straw or a narrow tunnel, poor night vision, and frequent episodes of tripping or bumping into things

due to peripheral vision loss.

Someone with glaucoma should continually look around, scanning the environment to compensate for peripheral vision loss. It is easy to overlook things on a counter, in an oven, in a drawer, etc. Also, if peripheral field loss impacts a person's ability to move around safely, they may benefit from orientation and mobility training and the use of a white cane. Unless much of the central vision is left intact, reading from line to line can be difficult. The eyes may also take longer to adapt when going from bright to dark lighting conditions, such as going into a movie theater on a sunny day.

Age-Related Macular Degeneration

Age-related macular degeneration (AMD) is the leading cause of vision loss in people age 60 and older in the US. AMD is a gradual, progressive, painless deterioration of the macula, the small area in the retina center responsible for focusing on fine details. Someone with AMD may find it difficult to read a book or public restroom sign. Because the disease usually does not affect peripheral vision, they have no difficulty walking around, especially in familiar areas. However, the individual should still consider using a white cane to enhance safety. For example, if a traveler has some sight but doesn't always trust his or her vision, a white cane can help by detecting obstacles or elevation changes, leading to fall prevention.

There are two types of AMD, wet and dry. Most cases start as the dry type, but 10 to 20 percent develop into the wet type. AMD always occurs in both eyes but does not necessarily progress at the same pace in both. For this reason, it's possible to have wet AMD in one eye and dry in the other.

Approximately 80 to 90 percent of individuals who experience AMD are diagnosed with the dry type. Dry AMD occurs when small white or yellow deposits called drusen form on the retina beneath the macula, causing the macula to deteriorate and thin over time. Dry AMD seems to progress more slowly than the wet type of AMD, but unlike the wet type, there is no approved treatment or cure at this time. Nutrition, weight control, and nutritional supplements may all delay or reduce dry macular degeneration severity.

The signs of dry AMD include blurry distance and near vision, a need for increased lighting for near-vision tasks, difficulty going from bright light to low light, such as when entering a dimly lit room from outdoors, trouble recognizing faces, and a reduction in the vividness of colors. The dry condition usually affects both eyes, but some might experience symptoms in only one eye. People with dry AMD often have delayed awareness of vision symptoms in their non-dominant eye.

Although the wet type of AMD affects less than 20 percent of cases, it accounts for 90 percent of all severe vision loss cases from the disease. In wet AMD, abnormal blood vessels develop under the retina and begin growing toward the macula. These blood vessels may leak fluid or blood, blurring or distorting the central vision. Vision loss from wet AMD can occur faster and may be more noticeable than the dry type. The longer the abnormal blood vessels leak or grow, the higher the risk of losing a more detailed vision. In some cases, the dry type of macular degeneration turns to wet over time.

An early symptom of wet AMD is visual distortion. Typically, straight lines, such as the lines on a piece of graph paper or the lines between tiles in a bathroom, appear wavy or crooked. The central vision will have gray or blank spots. The sizes of objects may appear different when viewed with each eye. Individuals with dry macular degeneration are encouraged to use an Amsler grid (a simple graph with lines) to help spot these changes early so that they can obtain treatment before damage occurs. If you have been diagnosed with age-related macular degeneration, ask your eye care professional for an Amsler Grid you can use at home.

Injections directly into the eye are the standard treatment for wet AMD. The treatment targets a specific chemical in the body that causes the abnormal blood vessels to grow under the retina. The injected medication reduces the blood vessels' growth, slows the leakage, and helps slow vision loss. This treatment has delayed the progression of wet AMD for many people.

AMD affects all tasks that require the ability to focus on fine details, such as reading, writing, threading a needle or fishing line, hammering a nail, watching television, and playing cards. It is possible to learn new ways of

doing all of these tasks.

Diabetic Retinopathy

Diabetic retinopathy, another disease that affects the retina, is the leading cause of new cases of adult-onset blindness in the US, especially among African Americans, Latinos, and Native Americans. Diabetic retinopathy occurs when the walls of tiny blood vessels in the retina are weakened by prolonged exposure to high levels of blood sugar. This damage can cause blind spots, blurry vision, and vision loss. With diabetic retinopathy, vision can fluctuate from day to day or even from morning to evening.

In a healthy eye, small blood vessels nourish tissue and nerve cells in the retina. In the early stages of diabetic retinopathy, some blood vessels bulge and leak fluid into the retina, causing blurred vision. As the disease progresses, the retina's blood vessels become blocked, interfering with the blood supply that nourishes the retina. The damaged retina then signals the eye to produce new blood vessels. These new blood vessels are weak. When they break, they can bleed into the vitreous. This breakage can lead to scar tissue that pulls on the retina, causing further damage and sometimes causing the retina to pull away from the eye's blood-rich wall.

If floaters and flashing lights appear, a small hole may have occurred in the retina that could eventually cause the retina to detach. Because the retina needs continuous contact with the eye's blood-rich layer, a detached retina can cause total blindness within the eye unless surgery occurs rather quickly. Left untreated, the disease can progress rapidly and result in severe vision loss.

The course of treatment will be determined by the type and severity of the condition. For mild to moderate non-proliferative diabetic retinopathy, doctors may choose not to treat it and monitor any progression. When caught at the early stage, progression can be slowed or stopped by effective diabetes management.

For proliferative diabetic retinopathy or onset of macular edema, treatment will be necessary to slow the damage. There are several treatment options, including vascular endothelial growth factor (VEGF) medication injections,

photocoagulation, also known as focal laser treatment, pan-retinal photocoagulation, which is often called scatter laser treatment, or a surgical procedure called a vitrectomy. These treatments may be used in conjunction with each other or be part of a progressive treatment plan.

Because diabetes is a chronic condition, there is potential for diabetic retinopathy to progress. Regular appointments with a specialist are needed to monitor the condition and adjust the treatment plan. Some patients can stop the progression with effective diabetes management and ophthalmological treatments.

The constant fluctuation in vision that accompanies diabetic retinopathy can interfere with many, if not most, everyday activities. Blurred vision from the macula's swelling can affect reading, television watching, color matching, and crafting. Reduced acuity can interfere with seeing the markings on an insulin syringe or reading on a glucose monitor. Patchy vision and blind spots can make it difficult to visually search for items on a counter or floor or in faces in a room. Decreased depth perception can make it difficult to see curbs and steps and safely walk without a mobility tool, such as a white cane.

Stroke-Related Vision Loss

A brief description of how the eye sees can help explain how a stroke affects vision. The retinal cells and optic nerve fibers on each eye's right side see the left side of the world. The cells and fibers on the left side of each eye see the right side of the world. The cells and fibers on the upper part of each eye see the lower part of the world, and the cells and fibers on the lower part of the eye see the upper part of the world. A stroke causes damage to the optic nerve fibers, not to the eye itself. A stroke can occur in various locations along the optic nerve because the nerve fibers that transmit vision have a long course from the eyes to the brain's vision area. The type of vision loss (right side, left side, top, or bottom of the visual field) depends on where the stroke occurs along the optic nerve. This type of loss is called hemianopsia.

Someone with hemianopsia can easily overlook things on a counter, in an oven, or a drawer, but can also compensate for the blind side of their vision

by visually searching (scanning) frequently. When walking, scanning can prevent bumping into a pole, missing a doorway, or overlooking someone standing on a sidewalk.

Sub-Conjunctival Hemorrhages

Subconjunctival hemorrhages become more common as we age and occur when small blood vessels break and create a large red blotch between the conjunctiva and the sclera. Some risk factors for these hemorrhages are diabetes, high blood pressure, and the use of blood thinners. Though a hemorrhage may look frightening, it is not painful or harmful to the eye. The eye will absorb the leaked blood within two or three weeks without treatment.

Charles Bonnet Syndrome

Many vision professionals have found that a significant number of adults who acquire low vision later in life from a variety of retinal diseases, specifically age-related macular degeneration, diabetic retinopathy, and glaucoma, experience Charles Bonnet Syndrome (CBS), a condition that causes vivid, recurring visual hallucinations. Although CBS is not an eye disease, the percentage of people who experience it is so significant it merits mentioning. A variety of studies have shown 11 to 27 percent of people with retinal diseases experienced CBS. Studies have shown that as many as 21% of AMD patients have CBS related visual hallucinations at least once a month.

Visual hallucinations associated with CBS range from colorful, dreamlike, animated images to everyday images like people, animals, vehicles, and houses. Those who see experience CBS-related visions know that the images are not real. People with CBS may initially second-guess themselves but ultimately accept that these images have no substance.

Charles Bonnet Syndrome does not have a cure or treatment. People who experience CBS are not crazy or developing dementia. If you have a retina disease and are experiencing visual hallucinations, contact your eye care physician for a referral to a counselor familiar with CBS.

Summary

In this lesson, we looked at the parts of the eye and how various eye conditions affect those parts. Knowing this information will help you better understand your eye condition and more easily communicate with your doctor. You may also find it helpful to share a brief explanation of your visual condition with family and friends. In later lessons, you will learn more about how your vision functions, how to maximize your remaining vision, and how to compensate for the vision you have lost.

Suggested Activities

Answer the following questions:

- What is the name of your eye condition/s?
- Which parts of the eye are affected?
- Make a list of any questions or concerns you have about your vision condition, which you can share with your doctor or other rehabilitation professionals.
- Read "Lesson 2: Navigating Eyecare, Medical Eye Treatment and Rehabilitation Training" to gain information about preparing for appointments and professionals who can help.