



## **Early Diagnosis Is Key to Correcting Age-related Vision Problems Among Pilots**

*The most widespread vision problem among those over age 40 is presbyopia, the difficulty focusing on close objects that is considered one of the first indications of aging.*

—  
*Stanley R. Mohler, M.D.*

Aging brings gradual changes to the structure of the eye and the quality of vision. These changes can result in problems ranging from difficulty focusing on close objects to dry eyes to diseases such as glaucoma and macular degeneration. In many instances, early diagnosis of vision problems enables action to be taken to correct the problems so that pilots can continue flying safely.

The eye of a person with normal vision functions this way: Light enters the cornea (the transparent dome on the eye's surface) and the pupil (the black area in the center of the eye), which is surrounded by the iris (the round, colored part of the eye). The iris controls the amount of light that enters the eye, allowing more light in when the surroundings are dark and less when they are bright. The light then passes through the lens, which focuses light on the retina, the eye's innermost lining, which senses the presence of light. The retina translates the image into electrical impulses, which travel along the optic nerve to the brain. The eyeball is made up of two fluid-filled segments: The anterior (front) segment, between the cornea and the lens, is filled with fluid called the aqueous, which provides nourishment to the lens,



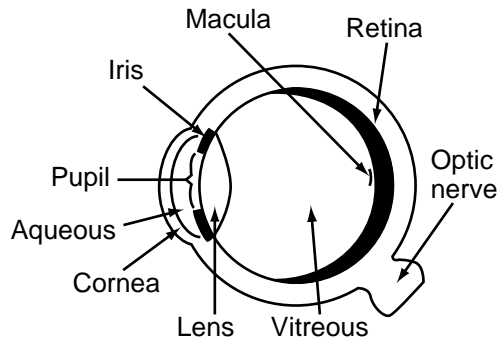
and the posterior (back) segment, between the lens and the retina, is filled with a clear gel known as the vitreous. Together, the fluids help the eyeball retain its shape (Figure 1, page 2).

In a young person, the lens is clear and flexible, and — with the help of the ciliary muscle, which aids in focusing — its shape changes, depending on the distance of the object being viewed. To view a nearby object, the ciliary muscle contracts and the lens becomes rounder and optically stronger; to view a distant object, the ciliary muscle relaxes and the lens becomes thinner.

Throughout a person's life, lens cells die, and as they do, they are compacted in the outer portions of the lens. Eventually, the accumulation of dead cells makes the lens less flexible.

Typically, as people age, the decline in flexibility of the lens makes it less capable of becoming rounder; as a result, the eyes are less able to focus on nearby objects. This condition — the most common age-related change in vision — is known as presbyopia, which generally becomes apparent to people in

## Diagram of the Human Eye



Source: Stanley R. Mohler, M.D., and Flight Safety Foundation

**Figure 1**

their early forties, although the exact age at which presbyopia occurs and the extent to which it develops vary from one person to another. Presbyopia is a natural part of the aging process and cannot be prevented. In many instances, the ability to focus on near objects continues to deteriorate gradually until about the age of 60; by the time most people reach 50, they also have lost much of their ability to focus on intermediate-distance objects (about the distance from a pilot's eyes to an aircraft instrument panel).

Individuals who had the highest distant visual acuity while they were in their twenties typically experience presbyopia sooner than those who — at the same age — had poor distant vision because of myopia, also known as nearsightedness. This relatively early onset of presbyopia occurs because people who see exceptionally well at a distance have more focusing ability to see distant objects. Conversely, some people with a small degree of myopia continue to see near objects clearly for several years after their 40th birthdays because their myopia allows them to focus at near distance without the use of correction.

The first symptoms of presbyopia are observed when an individual tries to read small print in dim light. This is because in dim light, the pupil of the eye enlarges so that the retina can receive more light; as the pupil enlarges, however, some focusing power is lost. (The red light used in older aircraft to maintain adaptation to darkness during cockpit operations at night makes focusing even more difficult because red light has the longest wavelength in the visual spectrum, and focusing the eyes is more difficult than it would be using white light.<sup>1</sup>) Eventually, as presbyopia progresses, small print becomes difficult to read even in bright light. The extra effort involved in reading small print can cause eye fatigue after prolonged reading or near the end of a long flying workday.

The physiological changes in the eye that accompany presbyopia preclude “empty field myopia,” also known as “space myopia,” a condition that can affect pilots when they search for other air traffic in hazy skies or for approach lights

during a low-visibility instrument approach. Empty field myopia occurs when the eye looks into an “empty” visual field, such as fog, haze or extreme darkness, and the lens tends to adjust to a focal point about 10 feet to 20 feet (three meters to six meters) in front of the eye. In low-visibility, low-ceiling approaches, if empty field myopia is present, a few more seconds than usual may be required to recognize the sudden appearance of the runway environment. Empty field myopia cannot occur, however, if the lens does not become rounder because of mature presbyopia — an advantage for older pilots.

Presbyopia can be corrected with eyeglasses — either reading glasses to correct near vision (many people prefer half-moon eyeglasses that allow distant vision over the top of the frame), bifocals to correct both near vision and distant vision, trifocals to add a third segment of correction for intermediate vision, or progressive lenses, which include a range of corrections from those for distance at the top of the lenses to those for viewing near objects at the bottom and which lack lines between viewing segments (see “Guidelines for Choosing Multifocal Eyeglasses,” page 3).

Bifocal contact lenses also can be prescribed, but civil aviation regulations in most countries do not permit pilots to wear bifocal contact lenses; therefore, presbyopic pilots who wear contact lenses to correct their distant vision generally wear eyeglasses over their contact lenses to correct their near vision.

Civil aviation regulations in most countries also prohibit use of monovision contact lenses, which correct for near vision in one eye and for distant vision in the other eye, because they may interfere with the lens-wearer's depth perception and distant imaging.

In some countries, a surgical procedure has been used to correct presbyopia by implanting a four-piece “scleral expansion band” in the sclera, the white part of the eye.<sup>2</sup> The procedure is the subject of clinical testing in the United States and in Canada and has not been approved by either government.

In England, implantation of the scleral expansion band has been approved by the government, but Tony Evans, M.D., head of medical standards and certification for the U.K. Civil Aviation Authority, said that the Medical Division has not assessed any applicants for pilot medical certificates who have undergone the procedure.<sup>3</sup>

“However, we would caution against any type of surgery on a healthy eye because of any possible complications or side effects,” Evans said.

Several other procedures for correcting presbyopia are being studied, including:<sup>4</sup>

- Anterior ciliary sclerotomy, in which incisions are made in the sclera to create more room for the ciliary muscles to work;

- The use of small-diameter corneal inlays, small lenses that are inserted into the cornea to create a bifocal vision correction; and,
- Implantation of multifocal intraocular lenses to replace the eyes' natural lenses.

Unlike presbyopia, which is experienced by virtually everyone, other conditions, such as cataracts or glaucoma, tend to develop most often in older people, but they also may occur in those who are much younger.

Cataracts often are associated with age-related changes in the protein structure that cloud the normally transparent tissue in the eye's lens. Cataracts generally develop after age 50, and most develop slowly, with symptoms that include blurred vision, a loss of color-perception acuity, glare, double vision, halos around objects and a need for more light to see clearly. In their early stages, cataracts sometimes can be treated with a change in eyeglass prescription; when cataracts become severe, however, surgery is needed to replace the clouded lens with an artificial one.

In addition to aging, other factors appear to increase the likelihood of developing cataracts, including cigarette smoking; diabetes; galactosemia, an inherited disorder that interferes with the metabolism of milk; exposure of unprotected eyes to intense sunlight; exposure to high levels of ionizing radiation, such as x-rays used at aircraft maintenance facilities, and to high levels of industrial microwave radiation; and

specific physical injuries to the eye, such as being struck by a baseball, a bullet fragment or a dart.

Preventive measures that may help mitigate formation of cataracts include sunglasses that provide protection against the ultraviolet wavelength in sunlight, goggles or some other form of eye protection to guard against injury, proper control of diabetes and avoiding exposure of unprotected eyes to high-energy sources of heat and light (such as are experienced by welders and glass-blowers). Some specialists believe that vitamins A, C and E and the mineral selenium also may lower the risk of developing cataracts. (The vitamins are antioxidants, which counteract the harmful effects of "free radicals," naturally occurring molecules that can damage cells in the eye and other parts of the body.)

Another eye disease that occurs most often among people older than 40 is glaucoma, which increases pressure inside the eye (intraocular pressure) and damages the optic nerve. The disease is a result of a blockage of the passages that allow drainage of aqueous fluid in the eye, but the exact cause of the blockage can vary. If untreated, glaucoma can lead to blindness. If detected in its early stages, glaucoma can be controlled — usually with eye drops or other types of medication but sometimes with surgery — without further loss of vision. Vision lost because of glaucoma cannot be restored.

There are several types of glaucoma, including open-angle (chronic) glaucoma, which — in its early stages — has no

### Guidelines for Choosing Multifocal Eyeglasses

The following are considerations in the choice and fitting of multifocal eyeglasses:

- The pilot's seating position affects the optimum positioning of the two segments of bifocal eyeglasses. The fit of bifocals should be adjusted so that the pilot can see the instrument panel without interference with distance vision. (Presbyopic pilots who fly more than one type of aircraft may need a different pair of eyeglasses for each type);
- Pilots of aircraft with wide instrument arrays or large navigational charts may prefer bifocals with a larger reading segment than usual. Bifocals with smaller near-vision segments allow for distant peripheral vision around the bifocal segment;
- Pilots who typically view an instrument panel through the upper portion of their eyeglasses may prefer bifocals that are designed with a near-vision segment at the top of the lens instead of (or in addition to) the usual near-vision segment at the bottom;

- Pilots who wear trifocals may want eyeglasses with an intermediate segment that is wider than usual to allow them to see the complete instrument panel without moving their heads;
- Changes from single-vision eyeglasses to bifocals or from bifocals to trifocals can temporarily distort peripheral vision and depth perception and can temporarily alter the visual cues that a pilot typically receives during takeoff, landing and flight maneuvers. Pilots should be aware that objects initially may appear to be larger or smaller than their actual size and that the visual scene may appear to slant; and,
- Pilots with presbyopia should be aware that use of red light in the cockpit at night complicates viewing of near objects. If red light is unavoidable, the pilot may need a near-vision segment with increased power.♦

Source: Nakagawara, Van; Wood, Kathryn; Montgomery, Ronald. *Vision Impairment and Corrective Considerations of Civil Airmen*. DOT/FAA/AM-93/21. U.S. Federal Aviation Administration. December 1993.

symptoms and can be detected only in examinations by eye-care specialists (ophthalmologists, who are physicians specializing in treating the eyes, or optometrists, who are specialists in examining the eyes and prescribing corrective lenses). In more advanced stages, blind spots (areas in the field of vision where there is no sight) develop.

Another type of glaucoma is angle-closure (acute) glaucoma, whose symptoms may include pain in the eyes, blurred vision, a loss of peripheral vision and the appearance of colored rings around lights.

People who are considered to be most at risk for developing glaucoma are black; older than 65; very near-sighted; or have diabetes, a family history of glaucoma or an elevated level of intraocular pressure. Not everyone with slightly elevated intraocular pressure has glaucoma, but high pressure can indicate that the individual is at risk of developing glaucoma and should be examined regularly by an eye specialist. Ultimately, treatment may be necessary to lower the pressure.

With age, the gel-like consistency of the eye's vitreous may become more watery, and the vitreous may shrink. Shrinkage may lead to separation of the vitreous from the retina. (Normally, the two touch in three places: around the anterior border of the retina; in the macula, the center of the retina that contains the greatest concentration of light-sensitive cells and processes the details in the center of the field of vision; and at the optic nerve disc.) In many instances, separation of the vitreous from the retina — called vitreous detachment — can cause distorted vision and the appearance of spots that seem to float across the field of vision. These “floaters” by themselves are normal and do not constitute a medical problem.

In other instances, however, when the vitreous shrinks, the retina is torn and vitreous gel seeps beneath the retina. This may lead to retinal detachment, a condition that can cause blindness if the retina is not reattached promptly by surgery or laser therapy. If the retina detaches, visual distortions may be accompanied by flashes of light and the appearance of a shadow over part of the field of vision in the affected eye. Successful treatment generally results in the pilot's return to duty.

Another age-related ailment is degeneration of the macula, which destroys the central vision. Causes vary, but age-related macular degeneration is the leading cause of legal blindness among people over age 55. Two forms of the disease exist — “dry” macular degeneration and “wet” macular degeneration.

Dry macular degeneration occurs when the macular tissues become thinner and the light-sensing cells in the macula disintegrate. In some instances, dry macular degeneration progresses into wet macular degeneration and new blood vessels may grow, often leaking blood and fluid beneath the macula — a process that accelerates damage to the macula. The wet form of the disease accounts for about 90 percent of blindness associated with macular degeneration.

The most common early symptoms of macular degeneration are blurred vision and an inability to see clearly the details of objects in the center of the field of vision; peripheral vision (vision at the edges of the visual field) generally is not affected. Other symptoms include the apparent distortion of straight lines, with objects in the center of the field of vision sometimes appearing more distorted than objects in the periphery; appearance of a dark blurred area or a white area at the center of the field of vision; and changes in color perception.

There is no cure for macular degeneration, but early detection of the disease may allow for treatment that can slow the progress of the disease or can reduce its severity. Treatment for wet macular degeneration sometimes involves surgery or laser therapy to remove the new blood vessels generated by the disease.

Research has indicated that the progress of macular degeneration may be accelerated by unprotected exposure to bright sunlight or exposure to tobacco smoke. Hypertension (high blood pressure) also may make some forms of macular degeneration worse, especially for individuals with wet macular degeneration. Medication used to treat hypertension may slow the progress of macular degeneration. Other research has suggested that the severity of the disease may be reduced or its onset delayed by the consumption of fresh fruits and green, leafy vegetables or of vitamins C and E.

Aging also can be accompanied by changes in the quality and quantity of the tears that lubricate the eyes. Tears typically become more watery, and more of them are required to keep the eyes properly lubricated. In instances of dry eye syndrome, the tear glands fail to manufacture enough tears, and as a result, the eyes may itch or burn. If untreated, the cornea may be subject to infections and may eventually become scarred, sometimes resulting in a loss of vision. Researchers estimate that 75 percent of people over age 65 will experience dry eye syndrome, which has many causes, including environmental effects (wind, intense sunlight and extremes of temperature), the normal aging of tear glands, decreased sensitivity of the cornea, excessive evaporation of tears, specific medications (including antibiotics, diuretics, antihistamines and anti-diarrheals) and specific diseases (including Sjogren's syndrome, which is characterized by dryness of the mucous membranes). Special eye drops or a home humidifier may be recommended; on some occasions, specialized surgery may be necessary to partially block the punctum structure (the eye's tear drain) so that tears remain in the eye.

Sensitivity to light, wind or changes in temperature can cause the eyes to manufacture too many tears. Sunglasses or other forms of eye protection may correct the problem. In other instances, excess tears are a result of an eye infection or a blocked tear duct — conditions that require the attention of an ophthalmologist.

The eyes also may be affected by a number of diseases that are most common among older people, including diabetes. For example, diabetes can lead to diabetic retinopathy, in which new blood vessels may grow and then break, with blood leaking into

the vitreous. When blood clouds the vitreous, light is prevented from passing through to the retina, and images can be distorted or vision can be lost. Laser treatment often is effective.

Several other eye ailments are common among older people:

- Eyelid problems include drooping eyelids, blinking spasms or an inflammation of the rims of the eyelids. Often, these problems can be treated with medication; in other instances, surgery is needed;
- Temporal arteritis often begins with a severe headache, a sensation that blood vessels in the temple are swollen and pain in the scalp when the hair is brushed. Other symptoms typically involve pain in the jaw, chewing muscles and tongue while eating or speaking; double vision; and blurred vision. Early diagnosis and medication can prevent vision loss; and,
- A diminished supply of blood to the peripheral retina can result from diabetes, hypertension, arteriosclerosis (a disease of the arteries characterized by a thickening and hardening of their walls) or medications that restrict the diameter of the blood vessels. The resulting impairment of visual function could lead to decreased overall vision during darkness, especially above 5,000 feet, and increased difficulty locating other aircraft during daylight.

In many instances, regular eye examinations can help detect eye problems in their early stages. Early detection can lead to early treatment and, in some cases, elimination of the problem.♦

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