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Presbyopia: Age Related Long Sight

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INTRODUCTION

Presbyopia is a condition where the eye exhibits a progressively diminished ability to focus on near objects with age. Presbyopia's exact mechanisms are not known with certainty; the research evidence most strongly supports a loss of elasticity of the crystalline lens, although changes in the lens's curvature from continual growth and loss of power of the ciliar muscles (the muscles that bend and straighten the lens) have also been postulated as its cause. Like gray hair and wrinkles, presbyopia is a symptom caused by the natural course of aging. The first sign of presbyopia is eyestrain, difficulty seeing in dim light, problems focusing on small objects

and or fine print are usually first noticed between the ages of 40 and 50. The ability to focus on near objects declines throughout life, from an accomodation of about 20 dioptres (ability to focus at 50 mm away) in a child, to 10 dioptres at age 25 (100 mm), and levels off at 0.5 to 1 dioptre at age 60 (ability to focus down to 1–2 meters only). The expected maximum and minimum amplitudes of accommodation for a corrected patient of a given age can be determined using Hofstetter's formulas: Expected amplitude (D) = 18.5 - 0.3 x (age in years), Maximum amplitude (D) = 25 - 0.4 x (age in years), Minimum amplitude (D) = 15 - 0.25 x (age in years) [1,2].

The word presbyopia comes from the Greek word presbys meaning "old man" or "elder", and the Neolatin suffix -opia, meaning "sightedness", giving rise to the laymen's definition often seen in consumer articles or medical glossaries, "old eyes"[3].

Two different presbyopia definitions are used. Functional presbyopia is defined as needing a significant optical correction added to the presenting distance refractive correction to achieve a near visual acuity criterion. Objective presbyopia is defined as needing a significant optical correction (1.00 D) added to the best distance optical correction to improve near vision to a near visual acuity criterion of N8. Perhaps the key epidemiological consequence of the difference between functional and objective presbyopia is that people with low to moderate uncorrected myopia never develop functional presbyopia but are likely to develop objective presbyopia [4].

Presbyopic patients often believe that the gradual loss of near vision represents a visual impairment that will degrade the quality of their lives. In actuality, the inevitable loss of accommodative power in human visual systems begins as early as infancy, with virtually everyone fully realizing its adverse effects by 50 years of age. According to 2010 U.S. Census, there are approximately 100 million people over the age of 50 living in the United States which provides only a glimpse of the global influence of this ocular condition. Already in 2005, presbyopia was estimated to impact 1.04 billion people worldwide, with 410 million people classified as visually impaired due

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to lack of adequate near corrections. The projected magnitude of this phenomenon underlies the attention devoted to pursuing innovative surgical approaches to manage this treatable condition. The total power of a human eye is determined by the relationship between cornea, crystalline lens, and the axial globe length. Since the first two elements are relatively modifiable via surgical interventions, it is easy to understand why refractive procedures—including those for presybyopia are typically of either lens-based or cornea-based approaches. Lens-based methods include clear lens exchange, and cataractous lens extraction followed by multifocal intraocular lens (IOL) insertion. Reduced stereoacuity in monovision modality and compromised contrast sensitivity in multifocal modality may hinder postoperative patient satisfaction. Current cornea-based management options typically result in alteration ofcorneal curvatures, such as monovision LASIK/PRK, PresbyLASIK and conductive keratoplasty. However, postoperative risks of optical and visual disturbances, reduced uncorrected distance vision, irreversible structural changes, regression of treatment effects and possible corneal ectasia have limited clinical applications of these surgical procedures [5,6,7].

Mechanism of the crystalline lens and focusing
The crystalline lens, or simply lens, is a transparent, biconvex (lentil-shaped) structure in the eye that, along with the cornea, helps to refract light to be focused on the retina. The lens, by changing shape, functions to change the focal distance of the eye so

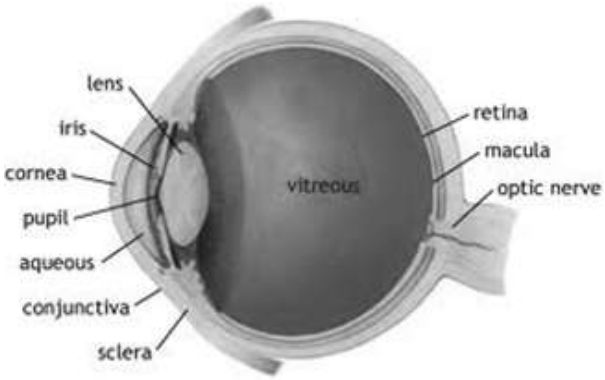

Figure 1: Contents of Eye

that it can focus on objects at various distances, thus allowing a sharp real image of the object of interest to be formed on the retina [8].

The lens is located in the anterior segment of the eye. Anterior to the lens is the iris, which regulates the amount of light entering the eye. The lens is suspended in place by the zonular fibers, which attach to the lens near its equatorial line and connect the lens to the ciliary body. Posterior to the lens is the vitreous body, which, along with the aqueous humor on the anterior surface, bathes the lens [9]. The lens is flexible and its curvature is controlled by ciliary muscles through the zonules. By changing the curvature of the lens with these tiny ciliary muscles, one can focus the eye on objects at different distances from it. This process is called accommodation. At short focal distances, the ciliary muscles contract, zonule fibers loosen, and the lens thickens, resulting in a rounder shape and thus high refractive power. Changing focus to an object at a distance requires the stretching of the lens by the ciliary muscles, which flattens the lens and thus increases the focal distance [10].

Note that there is some confusion in various articles and textbooks over how the focusing mechanism of the eye actually works. In the classic book, Eye and Brain (Gregory 1994), the lens is said to be suspended by a membrane, the zonula, which holds it under tension. The tension is released, by contraction of the ciliary muscle, to allow the lens to fatten for close vision. This would seem to imply that the ciliary muscle, which is outside the zonula, must be circumferential, contracting like a sphincter, to slacken the tension of the zonula pulling outwards on the lens. This is consistent with the fact that our eyes seem to be in the "relaxed" state when focusing at infinity, and also explains why no amount of effort seems to enable a myopic person to see further away. Many texts, though, describe the ciliary muscles (which seem more likely to be just elastic ligaments and not under any form of nervous control) as pulling the lens taut in order to focus at close range. This

has the counterintuitive effect of steepening the lens centrally (increasing its power) and flattening peripherally [11].

In optics, the closest point at which an object can be brought into focus by the eye is called the eye's near point. A standard near point distance of 25 centimeters is typically assumed in the design of optical instruments, and in characterizing optical devices such as magnifying glasses [12].

It is believed that the major cause of presbyopia is the loss of elasticity of the lens. As people age, the crystalline lens becomes less elastic and less flexible. In addition, the ciliary muscles become less powerful, and this is believed to contribute to the condition. Because of these reasons, there is inadequate adjustment of the lens for close distances and objects appear blurry [13].

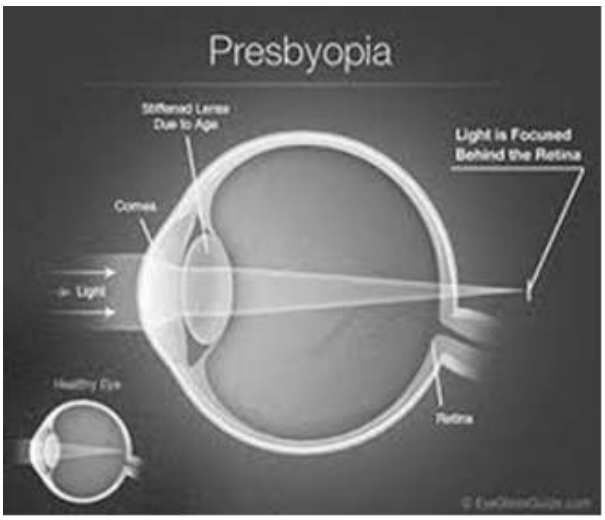

Figure 2: Mechanism of Presbyopia

Presbyopia is a problem attributed to age-related loss of accommodation. At age 20, the crystalline lens is soft and deforms easily with contraction of the ciliary muscles. Average amplitude of accommodation at that age is 11.0 ± 2.0 D. At age of 40, however, average accommodation has decreased to 6.0 ± 2.0 D, and, at age 52, it is down to 2.5 ± 1.5 D. A person unable to maintain 3.0 D of accommodation for any length of time is considered to have symptoms of presbyopia. Near vision has been improved or restored in presbyopic eyes with bifocal spectacles or monovision contact lenses and with refractive surgery [14,15]. Refractive surgery procedures include those that steepen the cornea by means of the excimer laser, the holmium:YAG laser,11 or radiofrequency energy. Procedures that expand or relax the sclera intracorneal implants, multifocal IOLs, and accommodative IOLs have also been used. Some of these procedures are actively being investigated and appear promising, but others are controversial and have questionable efficacy, safety, or both. Of the laser procedures that modify corneal shape, monovision hyperopic laser in-situ keratomileusis (H-LASIK) has been the most successful, although use of H-LASIK for monovision is off-label and involves all of the risks of flap creation, severing of corneal nerves that causes dry eye, night time starbursts, reduced contrast sensitivity, and possibility of diffuse lamellar keratitis. In monovision surgery, the patient has 1 eye corrected for near tasks, and the other eye is left uncorrected or has distance vision sharpened to serve as the distance eye [16]. Success depends on interocular suppression of blur. This effect has been defined as the ability of the ocular system to suppress detrimental blurred information from the defocused eye so that it does not interfere with the in-focus image in the other eye. For example, the image from the near eye is suppressed for distance binocular vision. The suppression occurs regionally between corresponding retinal areas [17,18].

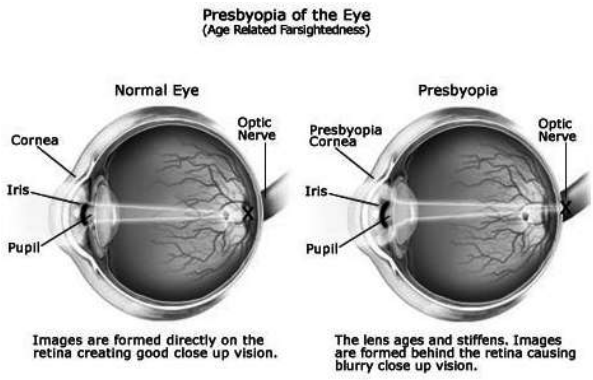

Figure 3: Changes in Presbyopia

Prevalence of Presbyopia: Functional presbyopia,

experienced by people who cannot see clearly at near, affects more than 1 billion people, 517 million of whom do not have adequate near vision correction. Significant near vision disability is experienced by 410 million people. Access to spectacles for correction of presbyopia is not equal across the world 67% of people with presbyopia and 94% of people with significant near vision disability due to uncorrected presbyopia live in less- or least-developed countries. When the number of people with significant near vision impairment due to near uncorrected refractive error (410 million) is added to those with blindness or impaired vision due to distance uncorrected refractive error (153 million),4 the number of people who would benefit from spectacles is an estimated 563 million. If the goal of Vision 2020 to eliminate unnecessary blindness and impaired vision, in this case due to uncorrected refractive error, is to be achieved, planning will have to include the provision of human resources, affordable spectacles, and systems of delivery for these half-billion people in need [19,20,21,22].

Symptoms: The first symptoms most people notice are difficulty reading fine print, particularly in low light conditions, eyestrain when reading for long periods, blur at near or momentarily blurred vision when transitioning between viewing distances. Many extreme presbyopes complain that their arms have become "too short" to hold reading material at a comfortable distance [23].

Presbyopia symptoms, like other focus defects, become much less noticeable in bright sunlight due to the action of the iris closing to a smaller diameter [24]. As with any lens, increasing the focal ration of the lens increases depth of field by reducing the level of blur of out-of-focus objects (compare the effect of aperture on depth of field in photography). A delayed onset of seeking correction for presbyopia has been found among those with certain professions and those with miotic pupils. In particular, farmers and homemakers seek correction later, whereas service workers and construction workers seek eyesight correction earlier [25].

Focusing mechanism of the eye: In optics, the closest point at which an object can be brought into focus by the eye is called the eye's near point. A standard near point distance of 25 cm is typically assumed in the design of optical instruments, and in characterizing optical devices such ying glasses. Without correction, the near point is at 3 inches (7 cm) at age 10, to 6 inches (16 cm) at age 40, to 39 inches (1 meter) at age 60. As a result, a 60-year-old must use corrective lenses to read books or magazines at a comfortable distance [26]. There is some confusion in articles and even textbooks over how the focusing mechanism of the eye actually works. In the classic book, 'Eye and Brain' by Gregory, for example, the lens is said to be suspended by a membrane, the 'zonula', which holds it under tension. The tension is released, by contraction of the ciliary muscle, to allow the lens to become more round, for close vision. This implies that the ciliary muscle, which is outside the zonula must be circumferential, contracting like a sphincter, to slacken the tension of the zonula pulling outwards on the lens. This is consistent with the fact that our eyes seem to be in the 'relaxed' state when focusing at infinity, and also explains why no amount of effort seems to enablea myopic person to see farther away. Many texts, though, describe the 'ciliary muscles' (which seem more likely to be just elastic ligaments and not under any form of nervous control) as pulling the lens taut in order to focus at close range. This has the counter-intuitive effect of steepening the lens valve cytokinesis centrally (increasing its power) and flattening peripherally [27].

Interaction with myopia: Many people with myiopic (near-sightedness) can read comfortably without eyeglasses or contact lenses even after age 40. However, their myopia does not disappear and the long-distance visual challenges remain. Myopes considering refractive syurgery are advised that surgically correcting their nearsightedness may be a disadvantage after age 40, when the eyes become presbyopic and lose their ability to accomodate or change focus because they will then need to use glasses for reading. Myopes with astigmatism find

near vision better, though not perfect, without glasses or contact lenses when presbyopia sets in, but the more astigmatism the poorer their uncorrected near vision [28].

A surgical technique offered is to create a "reading eye" and a "distance vision eye", a technique commonly used in contact lens practice, known as monovision. Monovision can be created with contact lenses or spectacles so that candidates for this procedure can determine if they are prepared to have their corneas reshaped by surgery to cause this effect permanently [29].

Presbyopia and the "payoff" for the nearsighted Many people with myopia (nearsightedness, ability to see close objects but far objects are blurred) are able to read comfortably without eyeglasses or contact lenses even after age 40. However, their myopia does not disappear and the long-distance visual challenges will remain. Myopes with astigmatism will find near vision better though not perfect without glasses or contact lenses once presbyopia sets in, but the greater the amount of astigmatism the poorer their uncorrected near vision. Myopes considering refractive surgery are advised that surgically correcting their nearsightedness may actually be a disadvantage after the age of 40 when the eyes become presbyopic and lose their ability to accommodate or change focus because they will then need to use glasses for reading. A surgical technique offered is to create a "reading eye" and a "distance vision eye," a technique commonly known in contact lens practice as monovision [30].

Signs and tests: The health care provider will perform a general eye examination, including measurements to determine a prescription for glasses or contact lenses. Test may include; [31]

- Examination of the retina
- Muscle integrity test
- Refraction test
- Slit-lamp test
- Visual acuity

Treatment: Treatment for presbyopia has advanced significantly in recent years, thanks to widened availability of Optometry care as well as over-the-counter vision correction.

Corrective lenses: The increased average age and the lengthening of expected life span has given rise to an entire segment of the medical industry devoted to the needs of those over 40. Nowhere is this more evident than in the wide and ready availability of inexpensive over-the-counter reading glasses wiective lenses that cover a wide gamut of magnification levels. In addition to the availability of "vision centers" in many malls and shopping centers that provide walk-in Optometric care and rapid turnaround preparation of glasses, many large book sellers and most stores with a pharmacy section carry a selection of over-the-counter eye glasses with magnification lenses that provide a wide range of vision correction, some as high as +3.0 diopter. The internet provides those seeking even higher ranges of magnification lenses with sites that sell reading glasses of +4.0 diopter or higher. Some with presbyopia choose bifocal lenses to eliminate the need for a separate pair of reading glasses; while specialized bifocal preparations usually require the services of an optometrist, some places and sites that sell over-the-counter reading glasses also sell bifocals (often a neutral lens with a magnification lens inset in the traditional bifocal position) [32].

Contact lenses have also been used to correct the focusing loss that comes along with presbyopia. Some people choose contact lenses to correct one eye for near and one eye for far with a method called monovision, which can interfere with depth perception due to loss of focusing ability in the other eye. There are also newer bifocal or multifocal contact lenses that attempt to correct both near and far vision with the same lens [33].

Exercises: Controversially, eye exercises have been touted as a way to delay the onset of presbyopia, but their effectiveness has not been demonstrated in medical research [34].

Surgery: New surgical procedures may also provide solutions for those who do not want to wear glasses or contacts, including the implantation of accommodative interocular lenses (IOLs). Scleral expansion bands, which increase the space between the ciliary body and lens, have not been found to provide predictable or consistent results in the treatment of presbyopia. INTRACOR has now been approved in Europe for treatment of both eyes (turning both corneas into multifocal lenses and so dispensing with the need for reading glasses) [35]. Surgical treatments that reshape the cornea, such as Presby Lasik and Conductjve Keratoplasty, are also worth consideration, but some use of reading glasses will still remain when light is poor or when reading for extended periods of time, since such procedures do nothing for crystalline lens deterioration [36]. Another treatment option for the correction of presbyopia in patients with emmetropia as well as in patients with myopia, hyperopia and astigmatism is lase blended vision. This procedure uses laser refractive surgery to correct the dominant eye mainly for distance vision and the non-dominant eye mainly for near vision, while the depth of field (i.e. the range of distances at which the image is in focus) of each eye is increased. As a result of the increased depth of field, the brain merges the two images, creating a blend zone, i.e. a zone which is in focus for both eyes. This allows the patient to see near, intermediate and far without glasses. Some literature also suggests that the benefits achieved include the brain learning to adapt; assimilating two images, one of which is out of focus. Over time, many patients report they are unaware that one eye is out of focus [37,38]. Presbyopia is not routinely curable—though tentative steps toward a possible cure suggest that this may be possible—but the loss of focusing ability can be compensated for by corrective lenses including eye glasses or contact lenses. In subjects with other refractory problems, convex lenses are used. In some cases, the addition of bifocals to an existing lens prescription is sufficient. As the ability to change focus worsens, the prescription needs to be changed accordingly. Half-glasses also can be worn, in which the top is left open and used for distance vision [39]. In order to reduce the need for bifocals, trifocals, or reading glasses, some people choose contact lenses to correct one eye for near and one eye for far with a method called "monovision." If the eyes are normal for distance vision, the person may wear only one contract lens for the near vision. The brain adapts to having one eye focus for near and one for distant objects and will use the correct eye depending on the object being viewed. Monovision sometimes interferes with depth perception. There are also bifocal or multifocal contact lenses that attempt to correct both near and far vision with the same lens, such as the upper portion of the lens for viewing distant objects and the lower for reading and near objects. Bifocal contact lens requires that the lens not rotate in the eye, and thus not everyone is a candidate for such lenses [40,41].

Nutrition: At least one scientific study reported that taking lutein supplements or otherwise increasing the amount of lutein in the diet resulted in an improvement in visual acuity, while another study suggested that lutein supplementation might slow aging of the lens. Lutein is found naturally in both the lens of the eye and the macula, the central area of the retina [43].

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