

Myopia, Hyperopia and Astigmatism: A Complete Review with View of Differentiation

Dr. Sanjay Upadhyay

Assistant professor, Department of Ophthalmology, Gujarat Adani Institute of Medical Science, Bhuj, Gujarat

Abstract: *Nearsighted individuals typically have problems seeing well at a distance and are forced to wear glasses or contact lenses. The nearsighted eye is usually longer than a normal eye, and its cornea may also be steeper. Therefore, when light passes through the cornea and lens, it is focused in front of the retina. This will make distant images appear blurred. There are several refractive surgery solutions available to correct nearly all levels of nearsightedness. Farsighted individuals typically develop problems reading up close before the age of 40. The farsighted eye is usually slightly shorter than a normal eye and may have a flatter cornea. Thus, the light of distant objects focuses behind the retina unless the natural lens can compensate fully. Near objects require even greater focusing power to be seen clearly and therefore, blur more easily. LASIK, Refractive Lens Exchange and Contact lenses are a few of the options available to correct farsightedness. Asymmetric steepening of the cornea or natural lens causes light to be focused unevenly, which is the main optical problem in astigmatism. To individuals with uncorrected astigmatism, images may look blurry or shadowed. Astigmatism can be corrected with glasses, contact lenses, corneal relaxing incisions, laser vision correction, and special implant lenses.*

Keywords: Myopia, Hyperopia, Astigmatism

Myopia

1. Introduction

Nearsightedness (myopia) is a common cause of blurred vision. It can be mild, moderate, or severe. If you are nearsighted, objects in the distance appear blurry and out of focus. You might squint or frown when trying to see distant objects clearly. View a photo as seen through a normal and a nearsighted eye. Nearsightedness, or myopia, is the most common refractive error of the eye, and it has become more prevalent in recent years [1].

In fact, a recent study by the National Eye Institute (NEI) shows the prevalence of myopia grew from 25 percent of the U.S. population (ages 12 to 54) in 1971-1972 to a whopping 41.6 percent in 1999-2004. Eye care professionals most commonly correct myopia through the use of corrective lenses, such as glasses or contact lenses. It may also be corrected by refractive surgery, though there are cases of associated side effects. The corrective lenses have a negative optical power (*i.e.* have a net concave effect) which compensates for the excessive positive diopters of the myopic eye. Negative diopters are generally used to describe the severity of the myopia, as this is the value of the lens to correct the eye. *High-degree myopia*, or severe myopia, is defined as -6 diopters or worse [2].

Though the exact cause for this increase in nearsightedness among Americans is unknown, many eye doctors feel it has something to do with eye fatigue from computer use and other extended near vision tasks, coupled with a genetic predisposition for myopia.

Cause of Myopia [3]:

Myopia occurs when the eyeball is too long, relative to the focusing power of the cornea and lens of the eye. This causes light rays to focus at a point in front of the retina, rather than

directly on its surface. Nearsightedness also can be caused by the cornea and/or lens being too curved for the length of the eyeball. In some cases, myopia is due to a combination of these factors.

Myopia typically begins in childhood and you may have a higher risk if your parents are nearsighted. In most cases, nearsightedness stabilizes in early adulthood but sometimes it continues to progress with age.

Etiological Factor:

Because twins and relatives are more likely to get myopia under similar circumstances, there must be a hereditary factor, but because myopia has been increasing so rapidly throughout the developed world, environmental factors must be more important.

1) Education[4]

A common explanation for myopia is near-work. Regarding the relationship to IQ, several explanations have been proposed. One is that the myopic child is better adapted at reading, and reads and studies more, which increases intelligence. The reverse explanation is that the intelligent and studious child reads more, which causes myopia. Myopia is more common among students in gifted education.

2) Near work hypothesis [5]

The "near work" hypothesis, also referred to as the "use-abuse theory" states that spending time involve in near work strains the eyes and increases the risk of myopia. Some studies support the hypothesis while other studies do not. While an association is present it is unclear if it is causal.

3) Visual stimuli hypothesis

Although not mutually exclusive with the other hypotheses presented, the visual stimuli hypothesis adds another layer of mismatch to explain the modern prevalence of myopia. Modern humans who spend most of their time indoors, in dimly or fluorescently lit buildings are not giving their eyes

the appropriate stimuli to which they had evolved and may contribute to the development of myopia.

4) *Other risk factors*

In one study, heredity was an important factor associated with juvenile myopia, with smaller contributions from more near work, higher school achievement and less time in sports activity. Long hours of exposure to daylight appears to be a protective factor. Researchers at the University of Cambridge have found that a lack of outdoor play could be linked to myopia. Another explanation is that pleiotropic gene(s) affect the size of the brain and the shape of the eye simultaneously

Symptoms of Myopia [1]:

The main symptom is blurred vision when looking at distant objects. If you can see well enough to read newspaper print but you struggle to see things that are farther away, you are probably nearsighted. You may have trouble clearly seeing images or words on a blackboard, movie screen, or television. This can lead to poor school, athletic, or work performance.

Your child may be nearsighted if he or she squints or frowns, gets headaches often, or holds books or other objects very close to his or her face. Children who are nearsighted may sit at the front of the classroom or very close to the TV or movie screen. They may not be interested in sports or other activities that require good distance vision.

Diagnosis of Myopia [6]:

A diagnosis of myopia is typically confirmed during an eye examination performed by a specialized doctor who is an expert in refractive conditions of the eye, the optometrist, or by an ophthalmologist or orthoptist. Frequently an autorefractor or retinoscope is used to give an initial objective assessment of the refractive status of each eye, then a phoropter is used to subjectively refine the patient's eyeglass prescription.

Classification of Myopia [7]:

a) By cause

Borish and Duke-Elder classified myopia by cause:

Axial myopia is attributed to an increase in the eye's axial length.

Refractive myopia is attributed to the condition of the refractive elements of the eye. Borish further subclassified refractive myopia:

- Curvature myopia is attributed to excessive, or increased, curvature of one or more of the refractive surfaces of the eye, especially the cornea.
- Index myopia is attributed to variation in the index of refraction of one or more of the ocular media.

b) Clinical entity

Various forms of myopia have been described by their clinical appearance:

- Simple myopia, more common than other types of myopia, is characterized by an eye that is too long for its optical power (which is determined by

the cornea and crystalline lens) or optically too powerful for its axial length.

- Degenerative myopia, also known as malignant, pathological, or progressive myopia, is characterized by marked fundus changes, such as posterior staphyloma, and associated with a high refractive error and subnormal visual acuity after correction.
- Nocturnal myopia, also known as night or twilight myopia, is a condition in which the eye has a greater difficulty seeing in low-illumination areas, even though its daytime vision is normal. A stronger prescription for myopic night drivers is often needed. Younger people are more likely to be affected by night myopia than the elderly.
- Pseudomyopia is the blurring of distance vision brought about by spasm of the ciliary muscle.
- Induced myopia, also known as acquired myopia, results from exposure to various pharmaceuticals, increases in glucose levels, nuclear sclerosis, oxygen toxicity (e.g., from diving or from oxygen and hyperbaric therapy) or other anomalous conditions.
- Index myopia is attributed to variation in the index of refraction of one or more of the ocular media. Cataracts may lead to index myopia.
- Form deprivation myopia occurs when the eyesight is deprived by limited illumination and vision range, or the eye is modified with artificial lenses or deprived of clear form vision.
- Nearwork-induced transient myopia (NITM) is defined as short-term myopic far point shift immediately following a sustained near visual task.
- Instrument myopia is defined as over-accommodation when looking into an instrument such as a microscope.

c) Degree

Myopia, which is measured in diopters by the strength or optical power of a corrective lens that focuses distant images on the retina, has also been classified by degree or severity:

- Low myopia usually describes myopia of -3.00 diopters or less (i.e. closer to 0.00).
- Medium myopia usually describes myopia between -3.00 and -6.00 diopters.
- High myopia usually describes myopia of -6.00 or more. People with high myopia are more likely to have retinal detachments and primary open angle glaucoma.

d) Age at onset

Myopia is sometimes classified by the age at onset:

- Congenital myopia, also known as infantile myopia, is present at birth and persists through infancy.
- Youth onset myopia occurs in the early childhood or teenage, and the ocular power can keep varying until the age of 21, before which any form of corrective surgery is usually not recommended by ophthalmic specialists around the world.
- School myopia appears during childhood, particularly the school-age years. This form of myopia is attributed to the use of the eyes for close work during the school years.

Treatment [8]:

The goal of treating nearsightedness is to improve vision by helping focus light on your retina through the use of corrective lenses or refractive surgery.

a) Corrective lenses

Wearing corrective lenses treats nearsightedness by counteracting the increased curvature of your cornea or the increased length of your eye. Types of corrective lenses include:

- **Eyeglasses.** This is a simple, safe way to correct vision problems caused by myopia. The variety of eyeglasses is wide and includes bifocals, trifocals and reading lenses.
- **Contact lenses.** These lenses are worn right on your eyes. They are available in a variety of types and styles, including hard, soft, extended wear, disposable, rigid gas permeable and bifocal. Ask your eye doctor about the pros and cons of contact lenses and what might be best for you.

b) Refractive surgery

Refractive surgery improves vision and reduces the need for eyeglasses or contact lenses. Your eye surgeon uses a laser beam to reshape the cornea. This type of surgery has become routine, but it's usually not recommended until the eyes have fully developed, in the 20s.

Refractive surgical procedures for nearsightedness include:

- **Laser-assisted in-situ keratomileusis (LASIK).** With this procedure, your eye surgeon makes a thin, hinged flap in your cornea. He or she then uses an excimer laser to remove layers from the center of your cornea to flatten its domed shape. An excimer laser differs from other lasers in that it doesn't produce heat. After the excimer laser is used, the thin corneal flap is repositioned.
- **Laser-assisted subepithelial keratectomy (LASEK).** Instead of creating a flap in the cornea, the surgeon creates a flap only in the cornea's thin protective cover (epithelium). He or she then uses an excimer laser to reshape the cornea's outer layers and flatten its curvature and then repositions the epithelial flap. You may need to wear a bandage contact lens for several days afterward to encourage healing.
- **Photorefractive keratectomy (PRK).** This procedure is similar to LASEK, except the surgeon removes the epithelium. It will grow back naturally, conforming to your cornea's new shape. You may need to wear a bandage contact lens for a few days afterward.
- **Intraocular lens (IOL) implant.** These lenses are surgically implanted into the eye, in front of the eye's natural lens. They may be an option for people with moderate to severe myopia. IOL implants are not currently considered a mainstream treatment option.

Some of the possible complications that can occur after refractive surgery include:

- Undercorrection or overcorrection of your initial problem
- Visual side effects, such as a halo or starburst appearing around lights
- Dry eye
- Infection
- Corneal scarring
- Rarely, vision loss

2. Hyperopia

Farsightedness, or **hyperopia**, as it is medically termed, is a vision condition in which distant objects are usually seen clearly, but close ones do not come into proper focus. Farsightedness occurs if your eyeball is too short or the cornea has too little curvature, so light entering your eye is not focused correctly. Common signs of farsightedness include difficulty in concentrating and maintaining a clear focus on near objects, eye strain, fatigue and/or headaches after close work, aching or burning eyes, irritability or nervousness after sustained concentration [9].

In mild cases of farsightedness, your eyes may be able to compensate without corrective lenses. In other cases, your optometrist can prescribe eyeglasses or contact lenses to optically correct farsightedness by altering the way the light enters your eyes. People experience hyperopia differently. Some people may not notice any problems with their vision, especially when they are young. For people with significant hyperopia, vision can be blurry for objects at any distance, near or far. It is an eye focusing disorder, not an eye disease. Farsightedness usually is present at birth and tends to run in families. You can easily correct this condition with eyeglasses or contact lenses. Another treatment option is surgery [10].

Causes of Hyperopia [10]:

Farsightedness is the result of the visual image being focused behind the retina rather than directly on it. It is mainly caused by two reasons-

- Low converging power of eye lens because of weak action of ciliary muscles.
- Eyeball being too short because of which the distance between eye lens and retina decreases.

Farsightedness is often present from birth, but children have a very flexible eye lens, which helps make up for the problem. As aging occurs, glasses or contact lenses may be required to correct the vision. Farsightedness is hereditary.

Classification of Hyperopia:

Hyperopia is typically classified according to clinical appearance, its severity, or how it relates to the eye's accommodative status.

- Simple hyperopia
- Pathological hyperopia
- Functional hyperopia

Symptoms of Hyperopia [10]:

Symptoms of farsightedness can include:

- Blurred vision, especially at night.
- Trouble seeing objects up close. For example, you can't see well enough to read newspaper print.
- Aching eyes, eyestrain, and headaches.

Children with this problem may have no symptoms. But a child with more severe farsightedness may:

- Have headaches.
- Rub his or her eyes often.
- Have trouble reading or show little interest in reading.

Diagnosis of Hyperopia

Visual acuity screening is recommended to detect hyperopia as well as other eye conditions. The gold standard for visual acuity testing is to use the Snellen chart using manifest and cycloplegic refraction. The difference between Cycloplegic hyperopia and Manifest (Noncycloplegic) hyperopia is Latent hyperopia.

Subjective refraction can be performed with a visual acuity chart at far distance (20ft or 6m) and near distance (1ft or 0.33m). These screenings typically are performed by teachers, primary care physicians (e.g. pediatricians, family physicians, etc.), optometrists, and/or ophthalmologists. The charts used for visual acuity screening include, but are not limited to, Snellen, Allen, HOTV, Tumbling E, etc.

Objective refraction can be performed using an autorefractor machine or retinoscopy. This first uses rays to measure at what distance an object is focused on the retina. Retinoscopy is the method preferred in babies and children. It requires a cycloplegic, retinoscope, and a series of lenses or a phoropter to determine when light rays are focused onto the retinal plane. The tester neutralizes the movement of the reflected light with one of the lenses in the series.

Differential diagnosis of Hyperopia:

Orbital tumors, serous elevation of the retina, posterior scleritis, presbyopia, hypoglycemia, cataracts, and/or post refractive surgery may present in a similar fashion to hyperopia.

Management of Hyperopia [11]:

The standard, and safest, treatment for symptomatic hyperopia is corrective lenses. Mild hyperopia does not need treatment. Hyperopic correction can be achieved by glasses lenses, contact lenses, or refractive surgery. The lenses required to correct hyperopia are convex lenses that converge light rays entering the eye to bring the focal point of the eye onto the retina. Glasses lenses are tolerated better in babies and children. Contact lenses are typically not preferred until adolescence or later, however the decision is based on the responsibility level of the patient or caregiver. A survey of practitioners revealed a common threshold for treatment intervention of hyperopia was 3.00D to 5.00D of asymptomatic hyperopia in children at age.

Refractive surgery is typically not preferred until the refractive error of the eye has stabilized and growth of the eye has stopped, which typically occurs in the third decade of life. Surgical options for hyperopia include thermal laser keratoplasty (TLK), conductive keratoplasty (CK), spiral hexagonal keratotomy, excimer laser, clear lens extraction with intraocular lens implantation or phakic intraocular lens implantation.

Astigmatism

Astigmatism is a common eye condition that's usually corrected by eyeglasses, contact lenses, or surgery. Astigmatism is caused by an eye that is not completely round and occurs in nearly everybody to some degree. For vision problems due to astigmatism, glasses, contact

lenses, and even vision correction procedures are all possible treatment options.

A person's eye is naturally shaped like a sphere. Under normal circumstances, when light enters the eye, it refracts, or bends evenly, creating a clear view of the object. However, the eye of a person with astigmatism is shaped more like a football or the back of a spoon. For this person, when light enters the eye it is refracted more in one direction than the other, allowing only part of the object to be in focus at one time. Objects at any distance can appear blurry and wavy[12].

Causes of Astigmatism[12]:

Astigmatism is a natural and commonly occurring cause of blurred or distorted vision that is usually associated with an imperfectly shaped cornea. The exact cause is not known.

Symptoms of Astigmatism [13]:

Although astigmatism may be asymptomatic, higher degrees of astigmatism may cause symptoms such as blurry vision, squinting, eye strain, fatigue, or headaches. Some research has pointed to the link between astigmatism and higher prevalence of migraine headaches.

Diagnosis of Astigmatism [13]:

Astigmatism can be diagnosed through a comprehensive eye examination. Testing for astigmatism measures how the eyes focus light and determines the power of any optical lenses needed to compensate for reduced vision. This examination may include:

- **Visual acuity**—As part of the testing, you'll be asked to read letters on a distance chart. This test measures visual acuity, which is written as a fraction such as 20/40. The top number is the standard distance at which testing is done, twenty feet. The bottom number is the smallest letter size you were able to read. A person with 20/40 visual acuity would have to get within 20 feet of a letter that should be seen at forty feet in order to see it clearly. Normal distance visual acuity is 20/20.
- **Keratometry**—A keratometer is the primary instrument used to measure the curvature of the cornea. By focusing a circle of light on the cornea and measuring its reflection, it is possible to determine the exact curvature of the cornea's surface. This measurement is particularly critical in determining the proper fit for contact lenses. A more sophisticated procedure called corneal topography may be performed in some cases to provide even more detail of the shape of the cornea.
- **Refraction**—Using an instrument called a phoropter, your optometrist places a series of lenses in front of your eyes and measures how they focus light. This is performed using a hand held lighted instrument called a retinoscope or an automated instrument that automatically evaluates the focusing power of the eye. The power is then refined by patient's responses to determine the lenses that allow the clearest vision.

Using the information obtained from these tests, your optometrist can determine if you have astigmatism. These findings, combined with those of other tests performed, will allow the optometrist to determine the power of any lens

correction needed to provide clear, comfortable vision, and discuss options for treatment.

Treatment of Astigmatism [13]:

Astigmatism may be corrected with eyeglasses, contact lenses, or refractive surgery. Various considerations involving eye health, refractive status, and lifestyle determine whether one option may be better than another. In those with keratoconus, certain contact lenses often enable patients to achieve better visual acuity than eyeglasses. Once only available in a rigid, gas-permeable form, toric lenses are now available also as soft lenses.

Laser eye surgery (LASIK and PRK) is successful in treating astigmatism. Corneal incisions if properly placed can correct astigmatism. These techniques include Mini Asymmetric Radial Keratotomy (M.A.R.K.), Astigmatic Keratotomy (AK) and Limbal relaxing incision (LRI). However these techniques are used less often than laser-performed ones.

References

- [1] Hornbeak, D.M. and T.L. Young, *Myopia genetics: a review of current research and emerging trends*. Current opinion in ophthalmology, 2009. **20**(5): p. 356.
- [2] Kohnen, T., *Refractive surgical probleml*. Journal of Cataract & Refractive Surgery, 1997. **23**(5): p. 698-702.
- [3] Chehab, K., A.H. Shedden, and X. Cheng, *Lens incorporating myopia control optics and muscarinic agents*. 2012, Google Patents.
- [4] Ip, J.M., et al., *Role of near work in myopia: findings in a sample of Australian school children*. Investigative Ophthalmology and Visual Science, 2008. **49**(7): p. 2903.
- [5] Angle, J. and D. Wissmann, *The epidemiology of myopia*. American journal of epidemiology, 1980. **111**(2): p. 220-228.
- [6] Silvertown, J., et al., *Environmental myopia: a diagnosis and a remedy*. Trends in ecology & evolution, 2010. **25**(10): p. 556-561.
- [7] Grosvenor, T., *A review and a suggested classification system for myopia on the basis of age-related prevalence and age of onset*. American journal of optometry and physiological optics, 1987. **64**(7): p. 545-554.
- [8] Hara, T. *Treatment of Myopia*. in *Third International Conference on Myopia Copenhagen, August 24–27, 1980*. 1981. Springer.
- [9] Eisner, F., *An Introduction to Vision Training*.
- [10] SHAGAM, J.Y., *Diagnosis and Treatment Of Ocular Disorders*. Radiologic technology, 2010. **81**(6): p. 565-589.
- [11] Cotter, S.A., *Management of childhood hyperopia: a pediatric optometrist's perspective*. Optometry & Vision Science, 2007. **84**(2): p. 103-109.
- [12] Read, S.A., M.J. Collins, and L.G. Carney, *A review of astigmatism and its possible genesis*. Clinical and Experimental Optometry, 2007. **90**(1): p. 5-19.
- [13] Wang, M.X. and T.S. Swartz, *Irregular Astigmatism: Diagnosis and Treatment*. 2008: SLACK Incorporated.