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Optical degenerative diseases: Manifestations and curative measures

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Abstract

Human eye is a vital and intricate sensory organ that helps to perceive light, color, and depth. The current lifestyle mandates more from a human than ever. It necessitates prolonged screen viewing, overloading work, stress, and lower physical activity levels. However, it led to many degenerative diseases in humans. The aging process, genetic predispositions, environmental factors, and systemic diseases also contribute to the development of these conditions. Common optical degenerative diseases include refractive error, age-related macular degeneration, cataracts, dry eyes, glaucoma, and diabetic retinopathy. These ocular pathologies can lead to irreversible blindness or impaired vision loss from preventable causalities. Hence, the importance of eye health cannot be overstated. Early detection through regular eye examinations is crucial for timely intervention, monitoring disease progression, and implementing appropriate treatment options. Pharmacological interventions, surgical procedures, lifestyle modifications, dietary modification, and visual rehabilitation approaches can serve a role in treating optical degenerative diseases. Promoting awareness and prioritizing eye health can improve quality of life and overall well-being. The current paper aims to provide a concise overview about degenerative optical disorders, to raise awareness about their impact and emphasizing the need for early detection, effective treatment strategies, and need to further investigation to combat the relevant challenging conditions.

Keywords: Cataracts, lifestyle modification, refractive error, optical degenerative diseases, vision loss

1. Introduction

Eyes are vital organs, critical for daily life activities and primary in vision. It allows a person to perceive the world around them, recognize faces, read, drive, and enjoy the beauty of nature (Anonymous, 2022 b) ^[1]. Optical degenerative diseases are a group of conditions that affect the eyes and can lead to vision loss or blindness. These diseases are often associated with aging but can also be driven by other factors such as genetics, injury, or exposure to harmful substances. Today, about a million people unknowingly suffer from impaired vision from treatable or preventable causes. The twenty-first-century lifestyle demands more than ever eyesight (Aragona *et al.*, 2021) ^[2]. One of the most common optical degenerative diseases is macular degeneration. This condition affects the macula, the part of the eye responsible for sharp, central vision, making it difficult to do daily activities. Another common optical degenerative disease is glaucoma, leading to loss of peripheral vision (Anonymous, 2022 c) ^[3]. Cataracts are another degenerative disease that causes the lens to become cloudy and further makes it difficult to see clearly (Anonymous, 2023) ^[4]. A hike in blood glucose level can also damage the blood vessels of retina, leading to vision loss, known as Diabetic retinopathy. In addition to these conditions, many other optical degenerative diseases can affect the eyes and lead to vision loss (Muth, 2017) ^[5]. An annual eye examination helps determine and diagnose the changes in eye conditions that can affect the visibility function and help to maintain a healthy eye status, recommended by American Optometric Association (AOA) (Boyd, 2022 b) ^[6].

1.1 Prevalence

According to the vision atlas mentioned by IAPB (International Agency for Prevention of Blindness, 2020), globally, around 1.1 billion people are living with vision loss. Out of this, ninety percent of vision loss is preventable or can be corrected with the help of proper treatment. According to the atlas in southern Asia, a crude prevalence of blindness is 18.2%, i.e., approximately 340 million people are completely lost the visibility. As per the projections by IAPB, vision loss will rise to 1.7 billion people by the year 2050.

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In other words, there will be an increase of fifty-five percent i.e., 600 million people over the next thirty years (Anonymous, 2022 a) ^[7]. Furthermore, the condition of complete vision loss or blindness is severe in underdeveloped to developing countries. The major contributory factors are income inequality, aging followed by gender biasness. In conformity with the data, ninety per cent of the affected population belongs to low and middle-income countries. Out of these, approximately seventy-three per cent population is above the age of fifty, whereas fifty per cent represents women and girls. Among children and adolescents, ninety million of them are directly affected by vision impairment. Of these, approximately two million are blind whereas thirty million are experiencing moderate to severe vision loss, and fifty-eight million experience mild vision impairment (Anonymous, 2022 a) ^[7].

The expected increase in visibility impairment incidences among the population is primarily due to the uncontrolled population growth and aging process. Whereas, nowadays, the incidental increase of partial to severe visibility impairment is due to the indirect environmental causes such as increased urbanization, sedentary lifestyles, and a low-nutrient diet. These causes further contribute to the dramatic increase in the global prevalence of physiological changes such as obesity, diabetes, myopia etc. Whereas a large population lives with partial to severe visibility impairment due to poor eye care services (Anonymous, 2022 b) ^[11].

According to Baldev *et al.* (2017) ^[8] the ocular conditions (cataracts, corneal opacity, glaucoma, refractive error, diabetic retinopathy, macular scar, AMD) are the leading cause of severe visual impairment among the Northern Indian population with the low socioeconomic status. As the researches show that although cataracts continue to be the leading cause of blindness however, glaucoma, and corneal disorders are now recognized as significant contributors to an increase in the incidences of blindness and visual impairment.

2. Optical Degenerative Diseases

Optical degenerative diseases refer to the conditions that affect the eyes and result in progressive deterioration of vision over time. These diseases can affect various structures within the visual system, including the retina, optic nerve, lens, and other eye components (Anonymous, 2022 b) ^[11]. Although, some optical degenerative diseases are associated with aging, while others may have genetic, environmental, or physiological impact on eye. These conditions can significantly impact a visual acuity of a person, contrast sensitivity, color perception, and overall quality of vision. The symptoms and progression of optical degenerative diseases can vary based on the condition and severity.

Common visual diseases include night blindness (difficulty for the eye to see in low light); dry eye syndrome (condition of the eye where tear glands are not able to make enough tears in the eye); refractive errors (short-sightedness, farsightedness, distorted vision); glaucoma (increased intraocular pressure (IOP) may provoke damage to the optic nerve); blepharitis (inflammation of the eyelid causing dry eyelid, and grittiness); cataracts (an opacity inside the eyes transparent lens); retinal detachment (pulling the retina away from its usual position at the rear of the eye); inflammation of the blood arteries of the eye, and optic nerve) etc. (Muth, 2017) ^[5]. Each disease has distinct characteristics, affects different parts of the eye, and may lead to varying degrees of

vision loss or impairment (Anonymous, 2022 a) ^[7].

2.1 Refractive Errors

Refractive errors are the ocular condition in which clear visibility becomes challenging for the patient. It happens when the shape of the eye keeps light away from focusing correctly onto the retinal plane, resulting in blurred images (Anonymous, 2022 a) ^[7]. Various studies indicate that refractive errors are the primary reason for visual impairment worldwide, and prevalence may vary due to differences in genetic background and diverse environmental factors (Mohammed Dhaiban *et al.*, 2021) ^[10]. However, the school-going children are at more considerable risk and are reported to be the most vulnerable section of the population. The condition of refractive errors further causes the lifelong vision impairment in children (Besufikad *et al.*, 2022) ^[11]. Visual impairment due to uncorrected refractive errors may have immediate and long-term effects, such as lost opportunities in education and employment sectors and furthermore directly affects the quality of life.

Types of refractive errors includes myopia or short-sightedness or near-sightedness (unclear vision of far-away objects due to high refractive power concerning to length of the eyeball) (Mohammed Dhaiban *et al.*, 2021) ^[10], hyperopia or long-sightedness or far-sightedness (unclear or blur vision of nearby objects due to low refractive power) (Besufikad *et al.*, 2022) ^[11], and astigmatism, or irregularly curved cornea (nearby and distant things may appear distorted or hazy) (Bergin & Geetha, 2022) ^[12].

2.1.1 Symptoms of Refractive Errors

There are some of the common symptoms associated with refractive errors include diplopia (double vision), dim vision (occurrence of hazy vision or clouded vision), perceiving a halo (or glare) surrounding brilliant lights, squinting headaches, the strain on the eye (tiredness or soreness of eye), difficulty in concentration while reading or using electronic gadgets (Bergin & Geetha, 2022) ^[12].

2.1.2 Causes of Refractive Errors

Multiple determinants can contribute to the development of refractor errors, such as genetic factors, environmental factors, and physiological factors especially eye-related abnormalities. Refractive errors tend to run in families, indicating a genetic relation and increased risk of developing the disease (Anonymous, 2022 a) ^[7]. People with excessive and prolonged use of digital screens may strain the eyes which further leads to the development of myopia. Also, reading has been a predictor of myopia in school-going children due to the prolonged hours of reading with no breaks or rest to the eye (Bergin & Geetha, 2022) ^[12]. Specific eye abnormalities, such as a change in the shape of the eyeball, can lead to the development of myopia, hyperopia, or astigmatism. However, aging process reduces the ability of the eye lens by changing its structure and focus which further affects the near vision and can lead to presbyopia (Anonymous, 2022 a) ^[7].

2.1.3 Treatment of Refractive Errors

Refractive errors can be corrected and controlled using appropriate eyeglasses under the consultation of ophthalmologists. In the case of myopia, glasses with diverging lenses can correct the image formation by adjusting

the displacement of a focal point in the same direction (Bergin & Geetha, 2022)^[12]. Whereas, in hyperopia, a converging lens is prescribed as it will focus on the retinal image of a distant object, from its original position behind the eye to the retina at the retinal plane, and help the patient to perceive a clear image. In some cases refractive surgery can be opted for the correction of myopia by flattening the cornea with the help of laser treatment application (Besufikad *et al.*, 2022)^[11]. Here, the radius of curvature of the corneal surface is increased (Anonymous, 2022 a)^[7]. Myopia at the severe stage may trigger to further cause retinal detachment, glaucoma, cataracts, or other optical disorder.

2.2 Age-Related Macular Degeneration

Age-Related Macular Degeneration (AMD) is an ocular condition, immobile grey spots positioned at the centre of the eye, which contributes to blurry vision to sharper one, especially for the central vision, which is required for the performance of some specific activities such as reading, driving, recognizing faces and objects (Stahl, 2020)^[13]. Although, it cannot cause complete blindness in the person while the loss of the central vision can further make it harder to recognize faces during driving or work with closer input (Anonymous, 2022 c)^[3]. Early AMD can be pinpointed with the formation of drusen (appearance of extracellular white-yellow deposits deep to the retina) and pigmentary changes at the macula region of the eye leads to mild to severe vision loss. Progressive degradation of this sensitive part of the eye is termed as macular degeneration and further initiates the formation of a macular-hole (Gopaldasamy *et al.*, 2016)^[14].

AMD is a multifactorial disease with a complex interplay between aging, genetic susceptibility, and consistent modifiable risk factors such as smoking and diet (Schwartz & Loewenstein, 2015)^[9]. AMD can be of two forms: dry AMD and wet AMD. Dry AMD, also known as atrophic AMD, begins with characteristics of yellow drusen deposits in the macula of the eye. Patients still have good vision in the early stages, but with the passing of time, these deposits are further grown in size and multiply in number, and initiates the distorted vision, advances the atrophy of tissues. On the other hand, wet AMD, or neovascular AMD, is a late-stage AMD that is less common but causes prominent vision loss comparatively faster than the dry AMD. Here, the blood vessels at the back of the eye grow abnormally and damage the macular part of the eye (Gopaldasamy *et al.*, 2016)^[14].

2.2.1 Symptoms of AMD

A common symptom of AMD is gradual loss of central, sharp vision accelerates to the inability to read or recognize faces or affecting the performance of tasks that require detailed vision. Since AMD is a progressive disease, symptoms worsen over time as the disease progresses, and no proper treatment is administered to the patient (Stahl, 2020)^[13]. Early stages of dry AMD is asymptomatic in nature. However, AMD disease worsens from mild blurriness at the central vision to wavy or crooked hazy vision with blank spots. Whereas, with the passage of time, patients might view things less brightly than before (Schwartz & Loewenstein, 2015)^[9].

2.2.2 Treatment of AMD

Currently, no appropriate treatment for early AMD is possible, so minimizing the progression of AMD to severe stages remains a high priority in AMD management

(Gopaldasamy *et al.*, 2016)^[14]. Although, the ophthalmologist is responsible for keeping a closer track of the functionality of eyes based on regular examination while suggesting the medications to either reduce or reverse the growth of blood vessels in the back of the eye. However, the early stage detection propel patients to change their lifestyle habits for further inhibited progression of the disease. None of the studies supported retinal laser therapy as one treatment method in patients with dry AMD (Stahl, 2020)^[13].

2.3 Cataracts

Cataracts refers to the condition of opacification of the lens of the eye, which further accelerates a gradual decline in vision and is mostly common in older people. However, the lens behind the iris is crucial in focusing light directly onto the retina for clear vision (Boyd, 2022 b)^[6]; (Anonymous, 2022 c)^[3]. Based on the location of cataracts within the lens and factors responsible for their development, types of cataracts are age-related cataracts (most common and occur due to natural changes in the eye lens), cortical cataracts (white, wedge-shaped opacity that develop at the periphery of the eye lens and extends toward centre) (Boyd, 2022 b)^[6], traumatic cataracts (due to an injury or trauma to the eye), and congenital cataracts (present at the time of birth or develops during early childhood) (Feldman *et al.*, 2023)^[15].

2.3.1 Symptoms of Cataracts

The opaqueness of the eye characterises a condition of cataracts, and there is a large spectrum of visual symptoms associated with cataractous changes in the eye (Boyd, 2022 b)^[6]. Blurred vision, glare or Halo around bright light, poor light vision (difficulty seeing in low light), loss of ability to distinguish between colours, change in refractive status of the eye, and diplopia are some common symptoms associated with cataracts. Visual disturbances such as glare and reduced contrast sensitivity are predominately associated with cortical cataracts. Whereas, the traumatic cataracts can cause complete cloudiness of the eye lens gradually after the incident (Feldman *et al.*, 2023)^[15].

2.3.2 Causes of Cataracts

Cataracts development can occur as a result of aging, genetic factors, environmental factors, exposure to ultraviolet light, smoking and alcoholism, nutritional intake, and other medical conditions (such as diabetes) (Boyd, 2022 a)^[16]. Among these, age-related changes in the eye lens are a common cause of cataracts. Although, the proteins of eye lens clump together, causes cloudiness of the lens and further develops the cataracts. Age-related cataracts may develop in patients with a history of smoking, alcoholism, diabetes, or eye surgeries, like glaucoma surgery. Long-term exposure to ultraviolet light can triggers oxidative damage in the eye and result in inflammation. Diabetes, smoking, excessive alcohol consumption, or prolonged use of corticosteroids are modifiable risk factors associated with increased risk of cataracts (Anonymous, 2023)^[4].

2.3.3 Treatment of Cataracts

The primary treatment for cataracts is surgical intervention. It is a safe, effective procedure and corrects vision problems by removing a clouded natural lens and insertion of an artificial intraocular lens (IOL) to restore clear vision (Anonymous, 2023)^[4].

2.4 Dry Eyes

Dry eyes is a disabling disorder that affects visual function, which further deteriorates the quality of life, and significantly affects socioeconomic status. It is a condition where enough quality tears are not available for lubrication and nourishment of the eye of the patient. It is a typical and frequently persistent issue, especially among the elderly people (Boyd, 2022 a; Anonymous, 2022 c) ^[16, 3]. The instability of tear film in dry eye disease can be due to insufficient production of tears or poor quality of tear film. The composition of the tear film includes three layers: oil, water, and mucus. However, each component is responsible for the nourishment and maintenance of the eye surface. Therefore, the symptoms develop if the tears evaporate too rapidly or do not spread evenly over the cornea (Phadatare *et al.*, 2016) ^[17]. The severity of dry eyes can be subdivided into two types, i.e., aqueous deficient or tear deficiency and hyper-evaporation (Shanti *et al.*, 2020) ^[18].

2.4.1 Symptoms of Dry Eyes

Eyes with dry and gritty feelings indicate dry eyes in the patients. Whereas the additional symptoms include redness, scratching or burning sensations, light sensitivity, watery eyes, stringy mucus near the eye, and blurry or unclear vision (Boyd, 2022 a) ^[16]. However, the severity of dry eyes gradually increases from mild symptoms of watery eyes followed by moderate symptoms of epithelial erosion to severe symptoms of a corneal ulcer or opacity of the eye lens (Golden *et al.*, 2022) ^[19].

2.4.2 Causes of Dry Eyes

Reduced tear production, excessive evaporation of tears, and abnormalities in the tear film layer, especially the mucus layer of the tear layer, are significant causes of dry eyes (Aragona *et al.*, 2021) ^[2]. However, dry eyes with poor tear production from tear glands is commonly found in older patients or patients with autoimmune diseases such as Sjögren syndrome and rheumatoid arthritis (Phadatare *et al.*, 2016) ^[17]. The eyes may dry in evaporative dry eyes due to the greater tear evaporation commonly observed in reduced blinking and eyelid abnormalities. Along with these, certain environmental factors can contribute to dryness of the eyes, which includes exposure to a dry climate, air pollution, excessive use of contact lenses, and prolonged use of screen time (staring at computer screens/ smartphones). These may further initiates the reduced blinking and increased evaporation of tears (Anonymous, 2022 c; Shanti *et al.*, 2020) ^[3, 18].

2.4.3 Treatment of Dry Eyes

Tear production with various medical and environmental conditions tends to diminish with age (Boyd, 2022 a) ^[16]. While the symptoms develop when the average amount of tear production reduces, or tears evaporate too quickly from the eyes. This condition can be initially treated by the use of a tear substitute or the use of polymers such as hyaluronic acid have been suggested, which further can enhance tear film stability (Golden *et al.*, 2022) ^[19]. Tear substitutes help to control the inflammation process, improve tear film, improve clearance by tear fluid whereas decrease the concentration of pro-inflammatory molecules in the eye. Another possible way to treat dry eye disease is to control and reduce ocular surface inflammation. Corticosteroids and other molecules, such as omega-3 fatty acids, can aid in controlling inflammation

(Aragona *et al.*, 2021) ^[2].

2.5 Glaucoma

Glaucoma is a condition with multiple eye diseases that cause irreversible vision loss, and blindness is induced by neural cell death leading to high pressure in the eye. It is a condition referred to as the "silent thief of sight" as it progresses slowly with no noticeable symptoms (Shahida & Qadir, 2020) ^[20]. Even though there is a lack of a cure for glaucoma, early detection, and treatment can naturally reverse visual loss. Glaucoma is one of the second most significant causes of blindness worldwide and can occur at any stage of life. Glaucoma is often also considered a group of optic neuropathies often characterized by degeneration of retinal ganglion cells and optic nerve axons, which affect the levels of IOP (Storgaard *et al.*, 2021) ^[21]. Open-angle Glaucoma and angle-closure glaucoma are the different types prevalent in the population. Among these, open-angle glaucoma is the most common form of glaucoma, which occurs due to the slow damage of optic nerve. However, the patient may develop blind spots in peripheral vision as the disease progresses with time. Angle-closure glaucoma is an unusual form of glaucoma and may cause vision loss within a day of its onset (Stein *et al.*, 2021) ^[22]. This type of glaucoma happens when the drainage angle is blocked, or the distance between the iris and the cornea is narrowed. The angle narrows gradually accelerates to blockage and accumulation of fluid in the eye, further increasing eye pressure (Boyd, 2022 c; Anonymous, 2022 c) ^[23, 3].

2.5.1 Symptoms of Glaucoma

Glaucoma is asymptomatic and gradual changes occur until it is in later stages. Usually, there are no specific symptoms for the condition, but some common ones are loss of side (peripheral) vision, severe headache, severe eye pain, and gradual blurred vision. Symptoms of glaucoma may vary on the type and stages of the condition (Boyd, 2022 c) ^[23]. Open-angle glaucoma is asymptomatic at early stages, but gradual loss of peripheral vision is noticed along patchy blind spots. Later on, the central vision of patient can be affected, further causes permanent loss of vision (Storgaard *et al.*, 2021) ^[21].

2.5.2 Causes of Glaucoma

The exact root cause of glaucoma is still unknown, but it is indeed associated with increased intra-ocular pressure or high eye pressure followed by inadequate blood supply. The optimum eye pressure is maintained by fluid, named aqueous humour, and disturbance in fluid production, drainage may initiate elevated pressure (Storgaard *et al.*, 2021) ^[21]. Due to structural abnormalities, problems with the drainage system of eye (also known as drainage age) may impede the outflow of fluid and can lead to elevated IOP of an eye. Genetic factors and age factors may also risk the development of glaucoma (Stein *et al.*, 2021) ^[22]. The existence of medical conditions such as diabetes or high blood pressure, eye abnormalities due to severe eye trauma, or the presence of thinner cornea or inflamed eye or more sensitive optic nerves are certain factors that can indicate increased risk for developing glaucoma (Shahida & Qadir, 2020) ^[20].

2.5.3 Treatment of Glaucoma

There is no specific treatment for the glaucoma condition. The treatment is possible, where there is a way to lower eye

pressure, and it falls into three basic categories of laser treatment, incisional ceremony, and proper administration of medicines.

Laser treatment has been proven beneficial for glaucoma treatment as the treatment method can reduce the IOP of the eye (Stein *et al.*, 2021). However, under the supervision of an ophthalmologist, medicated eye drops are often opted for as the first line of treatment for glaucoma. While, the drops can reduce aqueous humour production or drainage to lower IOP. Oral medication is prescribed under the condition that eye drops are insufficient but should be taken under the supervision to avoid any systemic side effects (Storgaard *et al.*, 2021) [21]. Among surgical procedures, trabeculectomy is preferred chiefly for glaucoma filtration procedures in open-angle glaucoma. Whereas for angle-closure glaucoma, the iridotomy opts to reduce eye pressure. These surgical procedures improve the aqueous humour flow and relieve eye pressure (Stein *et al.*, 2021; Boyd, 2022 c) [22, 23].

3. Conclusion

Eyes are the essential sensory organ for connectivity to the world. Due to the change in the working protocol, prolonged screen time, change in lifestyle, nutritional insufficiency, polluted environment, stressed condition, allergic reactions, and excessive use of topical ocular drugs further tends to the occurrence of eye diseases. Thoroughly understanding the various types of optical degenerative disorders, available management strategies, healthcare professionals can provide timely interventions and support to affected individuals. Early detection and regular eye examinations are crucial for identifying degenerative ailments in their initial stages, allowing for the implementation of appropriate treatment plans. While, optical degenerative diseases present significant challenges, ongoing research and advancements provide hope for improved diagnosis, treatment, and prevention of these conditions. Investing in scientific research, raising awareness, and advocating for individuals with optical degenerative diseases, can work towards a future where vision loss is minimized and affected individuals can lead fulfilling lives.

In conclusion, understanding optic degenerative diseases, their impact, and available management strategies is crucial in providing adequate care and support to individuals with these conditions. Through continued research and collaborative efforts, can strive better outcomes, improved quality of life, and a hopeful tomorrow for those affected by optical degenerative diseases. As wisely expressed by Dr. Kimberly Reed, Optometrist and Ocular Nutrition Society Board Member, "Vision is influenced by our lifestyle and commonly declines as we age. The goal is to build optimal eye health early and maintain it throughout adult life.

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