RESTORING SIGHT: EXPLORING CATARACTS AS THE LEADING TREATABLE CAUSE OF BLINDNESS: A NARRATIVE REVIEW

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ABSTRACT

Cataracts are the leading cause of treatable blindness worldwide, affecting millions of individuals. According to the World Health Organization, cataracts account for nearly half of all global blindness making them the leading cause of treatable and preventable blindness. This narrative review aims to explore the global prevalence, modifiable and non-modifiable risk factors, and symptoms of cataracts, as well as the transformative power of cataract surgery. Additionally, it discusses the impact of cataract surgery on visual outcomes and quality of life. The review synthesizes current literature on the global burden of cataracts, highlighting its prevalence across different regions. It examines various non-modifiable risk factors such as age, gender, race/ethnicity, and myopia, as well as modifiable risk factors such as smoking, alcohol consumption, nutrition and ultraviolet radiation exposure in relation to cataract development. It also explores and draws comparisons between the available techniques of cataract surgery such as phacoemulsification, extracapsular cataract extraction, and manual small incision cataract surgery. Understanding the challenges and advancements in cataract management is crucial for healthcare professionals and policymakers striving to address the global burden of blindness. With advancements in surgical techniques and access to quality healthcare, especially in developing countries, millions of individuals globally can be cured of blindness - restoring their sight. By raising awareness about cataracts, their identifiable symptoms and modifiable risk factors, as well as promoting timely interventions, we can work towards eliminating preventable blindness and empowering individuals to regain their vision, leading to a brighter future for all.

Keywords: Blindness, cataract, cataract extraction, quality of life, vision disorder

INTRODUCTION

Blindness, a global public health concern, affects millions of people worldwide, profoundly impacting their quality of life and hindering their ability to perform daily activities, work, and engage with their communities (1). However, amidst this darkness, there is a glimmer of hope: cataracts, the leading treatable cause of blindness (2). Cataracts, characterized by the clouding of the eye's natural lens, can be effectively addressed through surgical intervention, allowing individuals to regain their vision and restore their independence (1). This review article aims to explore the significance of cataracts as a treatable cause of blindness, delving into its global prevalence, risk factors, symptoms, and the transformative power of cataract surgery in restoring vision.

Cataracts have emerged as a major global health issue, affecting people of all ages, races, and socioeconomic backgrounds (3). According to the World Health Organization, the leading contributors to vision impairment and blindness are primarily uncorrected refractive errors and cataracts, with cataracts accounting for approximately 46.53% of global blindness making them the leading cause of treatable blindness (4). While there has been a general decline in prevalence, it is currently estimated that more than 10 million individuals globally suffer from blindness caused by cataracts, and over 35 million people experience moderate to severe vision impairment (5). This alarming statistic highlights the urgent need to address cataracts as a public health priority and underscores the potential impact of interventions on a global scale (2).
By examining the current state of knowledge and advancements in treatment options, this narrative review seeks to shed light on the impact of cataract interventions, highlighting the potential to alleviate visual impairment and improve the lives of individuals affected by this pervasive condition. In recent decades, significant progress has been made in understanding the epidemiology, risk factors, and development of cataracts, as well as the connection between cataracts and certain systemic diseases (5). Through a greater understanding of the global prevalence, risk factors, symptoms, and advancements in treatment options, healthcare professionals, policymakers, and communities can work collaboratively to prioritize early detection, timely interventions, and improved access to cataract surgical services (5). Ultimately, this collective effort can contribute to reducing the burden of blindness and empowering individuals to lead more fulfilling lives, restoring not only their vision but also their hopes and dreams for the future (5).

Global Prevalence

The World Health Organization estimates that approximately 2.2 billion individuals worldwide are affected by either near or distant vision problems (4, 6). Alarming, almost half of these cases, totaling around 1 billion people with vision impairment that remain untreated to this day, could have easily been prevented (4, 6). This group of roughly one billion people can be divided into individuals with near vision impairment as a result of unevaluated presbyopia (826 million), and individuals with preventable blindness (202 million) (4, 6). The group of 202 million individuals with preventable blindness can further be broken down and presented as cataracts (46.53%, 94 million), followed by unaddressed refractive errors (43.76%, 88.4 million), age-related macular degeneration (3.96%, 8 million), glaucoma (3.81%, 7.7 million), and diabetic retinopathy (1.93%, 3.9 million) (4, 6). There are therefore 94 million individuals globally who are blind due to cataracts, that do not have to remain blind, because their cataract-related blindness can be cured through a simple ten-minute surgery (7).

Regional disparities exist in the prevalence of vision impairment as well, low- and middle-income regions have about four times higher rates of distance vision impairment compared to high-income regions (6). More than 90% of individuals in low- and middle-income nations who experience visual impairment caused by cataracts face obstacles in accessing cataract surgery, a relatively straightforward and affordable treatment (8). These barriers include limited awareness of available services, a scarcity of eye care facilities, and the burden of high user fees and transportation costs (8). The prevalence of cataract-related blindness in adults aged 50 years and older has been collected and presented by the Vision Loss Expert Group of the Global Burden of Disease Study as seven separate super regions (6). These super regions as well as their prevalence of cataract-related blindness in adults aged 50 years and older is listed as follows in ascending order (6):

- High-Income Countries, Western Europe & North America (17.50%),
- Central Europe, Eastern Europe & Central Asia (22.40%),
- North Africa & Middle East (33.60%),
- Latin America & Caribbean (35.40%),
- Sub-Saharan Africa (39.80%),
- South-East Asia, East Asia & Oceania (48.30%),
- South Asia (63.10%).

High-income countries such as the United States, Norway and Ireland enjoy the lowest prevalence of cataract-related blindness in adults aged 50 years and older at 17.5%, whereas countries in South Asia such as India, Bangladesh and Pakistan suffer from the highest rates of cataract-related blindness at 63.1% (6). Factors such as aging populations, limited access to eye care services, and socioeconomic disparities contribute to the higher prevalence of cataract-related blindness in these low- and middle-income regions (8). Moreover, the global prevalence of cataracts is expected to rise due to increasing life expectancies and changes in lifestyle factors (8). Understanding the magnitude of the problem and identifying strategies to address the global burden of cataracts are essential for achieving the goal of restoring sight and improving the quality of life for individuals affected by this treatable condition.

Pathophysiology and Classification

Cataracts, a prevalent age-related vision disorder, involve the progressive clouding of the eye’s natural lens, leading to impaired vision and potential blindness if left untreated (9). The pathophysiology of cataracts is characterized by the accumulation of protein deposits and oxidative damage within the lens, resulting in its opacity (10). These changes disrupt the lens' transparency and refractive properties, leading to visual disturbances like blurred vision, glare sensitivity, and decreased color perception (10). Cataracts are broadly classified based on their location within the lens: anterior subcapsular cataracts (ASCs), posterior subcapsular cataracts (PSCs), cortical cataracts (CCs), and nuclear cataracts (NCs) (11). ASCs form just beneath the front surface of the lens and may cause significant vision problems, especially with near vision tasks (10). PSCs form just beneath the posterior lens capsule, often causing visual difficulties in bright light conditions (10). CCs develop in the outer edges of the lens, and their growth towards the center interferes with light passage (10). Lastly, NCs occur in the central nucleus of the lens, progressively impacting distance vision and causing a yellowing of vision (10). More than one type of cataract may be present in one patient (10). Prompt diagnosis and appropriate management remain crucial to restore clear vision and enhance the quality of life for affected individuals (10). Figure 1 demonstrates a diagrammatic representation of the eye’s lens, and the expected locations of the four aforementioned cataracts (11).
Symptoms

The symptoms of cataracts can vary depending on the stage and severity of the condition (12). In the early stages, individuals may experience gradual blurring or hazy vision, as if looking through a smudged window (13). As cataracts progress, vision may become increasingly impaired, leading to difficulty in reading, driving, or recognizing faces (13). Sensitivity to light and glare, particularly at night or in bright sunlight, is also common (12). Colors may appear faded or yellowed, and the overall clarity of vision is diminished (12). Some individuals may have frequent changes in their eyeglass prescription without significant improvement in vision (13). Additionally, cataracts can cause double vision in one eye or a halo effect around lights (13). It is important to note that cataracts do not cause pain, redness, or discharge from the eye (12). Recognizing these symptoms and seeking early medical intervention can greatly improve the chances of successful treatment and restoration of visual function (12). The diagnosis of cataracts is typically determined through a slit-lamp examination performed after the dilation of the pupils (12). This examination enables the classification of the opacity patterns based on their anatomical distribution, which can assist in guiding any further investigations related to the underlying causes (12). The Lens Opacities Classification System III is a commonly employed subjective grading system that is widely utilized to evaluate the severity of cataracts (14).

Risk Factors

Understanding the risk factors associated with cataracts is crucial for effective prevention and management strategies (5). Series of both non-modifiable as well as modifiable risk factors that contribute to the development of cataracts have been identified (5).

Non-modifiable Risk Factors

Several non-modifiable risk factors have been identified in association with cataract development (5). Age is the most significant non-modifiable risk factor, as the incidence and severity of cataracts increase substantially with advancing age (5). According to the findings of the Beaver Dam Eye Study, a population-based cohort examining the incidence of age-related diseases of the eye in around five thousand participants, there was a noticeable rise in the incidence of PSCs, CCs, and NCs with advancing age (15). The study revealed a significant increase in the overall occurrence of NCs, which escalated from 2.9% in individuals between the ages of 43 and 54, to a striking 40% in those aged 75 or above (15). Similar patterns of cumulative incidence were observed with age for CCs and PSCs (15). The incidence of CCs exhibited a notable rise from 1.9% in those aged between 43 and 54 to 21.8% in those aged 75 and above, while PSCs increased from 1.4% to 7.3% (15). Similar findings were observed in the Blue Mountains Eye Study in Australia, confirming an increase in incidence as well as severity of cataracts with advancing age (16). Another non-modifiable risk factor is gender, particularly the decline in estrogen levels during menopause, which has been suggested to contribute to cataract formation (5). There is a hypothesis suggesting that estrogen might possess a safeguarding influence on the development of cataracts (17). It is well known that estrogen has protective effects against cardiovascular as well as neurodegenerative diseases (18). Lower levels of cataract surgery incidence were observed in women with a larger accumulation of reproductive years, and therefore exposure to estrogen, indicating a protective effect of estrogen against cataract formation (19). The Barbados Eye Study consisting of 4,709 participants over five years compared the prevalence of cataracts between men and women among five separate age groups; 40-49, 50-59, 60-69, 70-79, and those above the age of 80 (20). The average age of menopause onset globally is estimated to be 48.8 years as of 2022 (21). The Barbados Eye Study included an age group of 40-49 which provides information on the prevalence of cataracts in women prior to or during the beginning of menopause, where the effects of estrogen deprivation have not yet made themselves apparent (20). In the age group of 40-49, the prevalence of cataracts is reported to be 4.2% in women and 4.3% in men [relative risk (RR) 0.98, 95% confidence interval (CI) 0.58-1.65], indicating that pre-menopausal women or women that recently had menopause onset have a lower prevalence of cataracts than men (20). However, moving to the
experiments conducted on animals have revealed a link to an increased risk of cataract development and quitting smoking has been shown to decrease the risk over time (5). Researchers from the Beaver Dam Eye Study discovered a significant association between smoking and a heightened occurrence of NCs (26). Notably, this association persisted even after adjusting for age and sex (26). The Korea National Health and Nutrition Examination Survey, a cross-sectional study conducted on more than fifteen thousand participants, yielded similar outcomes, demonstrating that smoking was linked to a heightened risk of NCs among both men and women (27). Cannabis smoking has also been linked to an increased incidence of cataract development, with cannabis users developing cataracts 5 years earlier than individuals that did not smoke cannabis (28). It is not surprising to find a connection between cannabis smoking and the emergence of cataracts (28). Tobacco smoke and cannabis smoke are similar in that they both contain a plethora of organic and inorganic chemical compounds (28). Cannabis tar exhibits chemical similarities to the tar found in tobacco smoke, and more than fifty known carcinogens, such as nitrosamines and reactive aldehydes have been identified in cannabis smoke (28).

Lower-income and education level have also been identified as modifiable risk factors, possibly due to limited access to healthcare and lower health literacy (5). Higher incidences of cataracts are observed in those with lower household incomes as well as lower education levels (27).

Excessive alcohol consumption has been associated with an elevated risk of cataracts, emphasizing the importance of moderation, however the data is not yet conclusive (5). The researchers conducting the Blue Mountain Eye Study found that exceeding a daily consumption of two alcoholic drinks was linked to a higher probability of requiring cataract surgery (29). Notably, they also observed that refraining from alcohol was similarly connected to an increased likelihood of needing cataract surgery, in comparison to consuming one to two drinks per day—indicating that mild alcohol consumption may have a protective effect over cataract development, whereas excessive alcohol consumption may be a causative factor (29). However, a meta-analysis study including nearly one hundred twenty thousand subjects found there to be no association whatsoever between alcohol consumption and the risk for cataract development, indicating that further investigation is warranted (30).

Proper nutrition including a healthy diet made up of vegetables and fruits, as well as multivitamin supplementation may help protect against cataract formation (5). The Antioxidants in Prevention of Cataracts Study, a five-year placebo-controlled clinical trial, concluded that the supplementation of antioxidants such as beta carotene, vitamin C, and vitamin E did not have an impact on the progression of cataracts (31). Another study found that while nutritional supplementation with vitamin C, lutein and zeaxanthin might provide benefits for specific populations such as individuals with inadequate nutrition or heavy smokers, its impact on cataract progression in the absence of proper nutrition, as well as further study is warranted (5).

Lastly, myopia has been associated with an increased risk of cataracts, although the exact mechanisms underlying this relationship require further investigation (5). In a meta-analysis study, twelve population-based studies involving nearly forty thousand participants were analyzed, and the findings indicated a positive correlation between myopia and the growing prevalence of NCs and PSCs (24). While conflicting data exist on this matter, some studies suggest that the presence of myopia does not seem to predispose individuals to cataracts (25). Instead, it is proposed that the increase in cataract development may lead to refractive changes resulting in myopia (25).

Modifiable Risk Factors

While certain risk factors for cataracts are beyond individual control, there are several modifiable factors that individuals can actively address to reduce their risk (5). Smoking has consistently been linked to an increased risk of cataract development, and quitting smoking has been shown to decrease the risk over time (5). Researchers from the Beaver Dam Eye Study discovered a significant association between smoking and a heightened occurrence of NCs (26). Notably, this association persisted even after adjusting for age and sex (26). The Korea National Health and Nutrition Examination Survey, a cross-sectional study conducted on more than fifteen thousand participants, yielded similar outcomes, demonstrating that smoking was linked to a heightened risk of NCs among both men and women (27). Cannabis smoking has also been linked to an increased incidence of cataract development, with cannabis users developing cataracts 5 years earlier than individuals that did not smoke cannabis (28). It is not surprising to find a connection between cannabis smoking and the emergence of cataracts (28). Tobacco smoke and cannabis smoke are similar in that they both contain a plethora of organic and inorganic chemical compounds (28). Cannabis tar exhibits chemical similarities to the tar found in tobacco smoke, and more than fifty known carcinogens, such as nitrosamines and reactive aldehydes have been identified in cannabis smoke (28).

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重大部分的患者是不太可能的（32）。尽管对于营养与青光眼的各自影响有不同的意见，但有人认为，青光眼可能影响对眼睛保护的需求和避免阳光直射（5）。它是认为，氧化应激通常由紫外线辐射暴露导致，而紫外线辐射会导致青光眼的发展（34）。

最后，紫外线（UV）辐射暴露对青光眼的形成有影响，同时具有人工和天然因素的青光眼发展被证实存在这种影响，强调了对眼睛保护的需求以避免阳光直射（5）。研究显示，UV-B辐射是导致青光眼的主因（35）。一项研究超过八百名在切萨皮克湾工作的人，观察到高水平的紫外线B辐射暴露显著提高了CCs的风险（35）。这发现是，水手的平均年紫外线B辐射暴露在上四分位数有显著的提高（35）。更近的研究进一步证实了这个发现，通过证明更年期的CCs较高的人中暴露紫外线B辐射较高的人。紫外线B辐射暴露在上四分位数的人，紫外线B辐射的平均年紫外线B辐射暴露在上四分位数在最低四分位数（35）。这些发现是，通过证明更高比例的CCs在个体中工作于户外工作（34）。

青光眼是一种多因素性眼疾，由可改因素和不可改因素影响（5）。虽然年龄、性别、种族/族裔和近视是不可改因素，个人可以采取积极措施来改变改因素，如吸烟、收入、教育、饮酒、营养和紫外线辐射暴露（16, 19, 22, 24, 26, 27, 29, 35）。公共卫生努力应该关注提高对这些风险因素的认识，例如健康的习惯，以减少这些因素对眼睛的危害，实施预防措施来减少青光眼的负担和保存视力在世界的群体。

治疗和青光眼的强改变力

青光眼手术革命是治疗青光眼的方法，它已经成为最具改变力的治疗措施之一（36）。移除被云状的晶状体及其替代品与一个无创的内眼植入物的结合，被证明在恢复视力和改善视觉功能方面是有效的（36）。该程序通常在门诊病人基础上进行，并有很高的成功率（36）。一种之前被认为需要住院和长时间视力恢复的程序，现在被改良成一个快速的日间程序，归功于在技术上的进步（36）。先进的技术，如超声乳化，使用超声波使晶体破碎成小块（46）。这些碎片被轻轻吸出眼睛（46）。如果手术成功，患者可以体验到更好的视力和恢复日常生活和活动的能力（52）。预期的术后恢复结果因个体的因素和期望的结果而定（50）。超声乳化手术的平均成本可以低至25.55美元，这取决于IOL的选择（50）。平均的手术成本会因医院、医生的资历和手术类型而有所不同（49）。超声乳化手术通常被广泛使用，被认为是发达国家的首选手术方法（45）。

Phacoemulsification

超声乳化手术，其名称来源于希腊语，是现代手术技术，用于移除青光眼，将晶体乳化（46）。它是目前最常用的青光眼手术方法，使用超声波设备将云状的晶体打碎成小块（46）。这些碎片被轻轻吸出眼睛（46）。一旦移除青光眼，人工IOL被植入以恢复清晰的视力（48）。超声乳化在全世界范围内得到广泛应用，并被认为是标准的青光眼手术方法（49）。平均的超声乳化手术成本可以低至25.55美元，这取决于IOL的选择（50）。平均的手术成本会因医院、医生的资历和手术类型而有所不同（49）。超声乳化手术的预期结果通常是积极的（52）。患者可以体验到改善的视力和清晰度，以及移除青光眼的手术（52）。该程序被用于迅速恢复时间，减轻不适，减少手术风险，以及与较老的手术技术，如已知的青光眼手术，相比较。许多患者报告了更好的生活质量，能够进行日常活动，以及改善视力，当手术成功（54）。
while leaving the posterior capsule intact (43). It is commonly used in developing regions where resources for advanced techniques like phacoemulsification may be limited (49). The average cost of ECCE can range anywhere from 16.25 USD per eye in developing countries such as India, up to 1,500 USD per eye in developed countries such as the United States (50). The expected outcomes include improved vision but with a longer recovery time and a slightly higher risk of complications compared to more modern techniques like phacoemulsification or laser-assisted surgeries (49).

**Intracapsular Cataract Extraction**

Intracapsular cataract extraction (ICCE) is a surgical technique used to remove a cataract where both the cloudy lens and the surrounding lens capsule are removed together (55). This older technique is now rarely performed due to advancements in cataract surgery (55). Modern techniques like phacoemulsification have largely replaced the use of ICCE as the procedure is associated with higher risks and complications (56).

**Laser-assisted Cataract Surgery**

Laser-assisted cataract surgery (LACS) is a modern technique where a femtosecond laser is used to assist in various steps of cataract removal, including creating precise incisions, opening the lens capsule, and fragmenting the cataract for removal (57). LACS is commonly used in developed countries where advanced technology is available such as the United States, with the average cost of surgery being 4,365 USD per eye (51). Expected outcomes often include improved visual acuity, faster recovery, reduced risk of complications, and the potential for enhanced precision in creating incisions and positioning the IOL (57-59). This breakthrough technology has shown potential in enhancing cataract surgery outcomes when compared to all other existing surgical methods, leading to its recognition as a significant advancement in the field of cataract surgery (51).

**Manual Small Incision Cataract Surgery**

Manual small incision cataract surgery (MSICS) is a surgical technique used to remove a cataract through a small incision, typically around 6 to 7 millimeters in size (60). The surgeon manually removes the cataract and implants an IOL to restore vision (60). MSICS has undergone significant improvements in recent decades, resulting in comparable outcomes to phacoemulsification in specific situations (61). This type of surgery is commonly used in developing countries where access to advanced technology like phacoemulsification or laser-assisted surgeries may be limited (62). The cost-effectiveness and efficiency of MSICS make it a crucial approach in the global effort to combat cataract-related blindness (61). The average cost of MSICS can range anywhere from 17.03 USD per eye in developing countries such as India, up to 600 USD per eye in developed countries (50). Expected outcomes include improved vision, but the recovery time may be slightly longer compared to more advanced techniques, and there is a slightly higher risk of postoperative complications such as astigmatism when compared to phacoemulsification (63). However, MSICS is still considered an effective and cost-efficient alternative for cataract surgery in resource-constrained settings (61-63).

The choice of cataract surgery technique is influenced by several factors including cost of surgery, access to advanced technology, and surgeon preference (36-38). While newer techniques like phacoemulsification and LACS offer advantages such as faster recovery, reduced risk of complications, and precise outcomes, traditional methods like ECCE or MSICS still have a role in specific situations, particularly in resource-constrained settings (49, 52, 57, 63). Understanding the individual patient's needs, available resources, and surgical expertise is crucial in determining the most suitable approach, ensuring optimal outcomes and patient satisfaction in cataract surgery (45).

**CONCLUSION**

In conclusion, this brief narrative review article has provided a concise yet comprehensive overview of the significance of cataracts as the primary treatable cause of blindness and the various interventions available for restoring sight. Through an exploration of the global prevalence, risk factors, symptoms, and treatment options, we have gained valuable insights into the potential of cataract surgery and its impact on improving visual impairment worldwide. With advancements in surgical techniques and access to quality healthcare, especially in developing countries, millions of individuals globally can be cured of blindness - restoring their vision. By raising awareness about cataracts, its identifiable symptoms and modifiable risk factors, as well as promoting timely interventions, we can work towards eliminating preventable blindness and empowering individuals to regain their sight, leading to a brighter future for all.

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