OULUN AMMATTIKORKEAKOULU

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Clinical Guideline for Optometrists – Pre-cataract Surgery Assessment

An Innovation Project

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ABSTRACT

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Purpose
The purpose of this thesis was to create a clinical assessment guideline for optometrists for managing pre-surgery cataract patients in Finland and to create an easily understandable theoretic background about the basics of the human lens crystalline and the cataract.

Methods
This thesis is a literature review analysis-based innovation project to produce a guideline for Finnish optometrists for pre-cataract surgery assessment. The thesis was written from January 2022 to December 2022. The first phase was to conduct a literature review of the key elements involving the lens crystalline, cataract and eye examination. The second phase was to create the guideline by choosing the suitable and adequate procedures for an eye examination and patient assessment in optometric practice in an optical store. This selection of the content was based on existing valid international and national guidelines, evidence-based literature and the current law considering the optometrist's work.

Results
As a result of this thesis, the main issues about the lens crystalline, cataract and management of the cataract are compiled in a literature review based on a literature search. The pre-cataract surgery assessment guideline for Finnish optometrists includes patient history/anamnesis, ocular examination, and management of the cataract. The importance of thorough anamnesis and biomicroscopy skills became on focus in the ocular examination and in the clinical assessment of the cataractous patient.

Conclusions
This thesis provides information about the lens crystalline and the cataract, and the guideline can be used as a quick guide to assessing cataractous patients. In the future, the need for eye healthcare services will increase. People are ageing, and ophthalmologists are needed more to manage eye diseases, not to make routine follow-up examinations. Finnish optometrists must be ready to fulfil this growing demand for healthcare professionals.

Keywords:
cataract, ageing of the lens, optometrist, comprehensive eye examination, assessment of the cataract, prescription, management of the cataract

CONTENTS

1 INTRODUCTION

Cataract formation is one of the ageing changes in the eye. The optometrist is often the first healthcare professional to meet a patient with blurred vision and suspect a cataract. Currently, in Finland, the cataract pre-surgery follow-up is mainly made by ophthalmologists, although early-stage cataract requires no treatment. This is due to current legislation from 1994, whereby optometrists are not allowed to prescribe glasses if the patient has, or the optometrist suspects, eye disease. In Finland, optometrists don't have the right to write official referrals to patients to get treatment in public healthcare, but the referral must be written by a general practitioner or an ophthalmologist.

The population is ageing, and the need for healthcare is increasing. Optometrists can take a more significant role in cataract follow-up examinations. As a result, ophthalmologists' resources can be directed to those patients who need to be treated.

The practice of examining patients with cataract is very variable among Finnish optometrists. One way of dealing with patients with any opacities in the lens crystalline is to refer the patient immediately to an ophthalmologist without further examination. Meanwhile, some other optometrist performs a thorough eye examination and, with the cooperation of the ophthalmologist, is allowed to prescribe new glasses and to do follow-up examinations when needed. When opacification has proceeded, and good visual acuity is not achieved with eyeglasses, the optometrist refers the patient to an ophthalmologist. Some optometrists work in public or private clinics, with their own guidelines for performing a pre-examination before cataract surgery.

The current education of optometrists in Finland covers the clinical examination of the patient's eyes, and optometrists are obligated to evaluate the health of the patient's eyes. The former education for opticians was not so concentrated on clinical skills. Still, some opticians are working in Finland without the right to use diagnostic eye drops. In the "Hyvä optometristin tutkimuskäytäntö -ohjeistus", the guideline for the optometrist's comprehensive eye examination, the examination of the anterior and the posterior parts of the eye, and the use of mydriatic drops when needed, are listed. These examinations are excluded from opticians.

This thesis will clarify the optometrist's role when meeting cataract patients, and by following this guideline, the varying practices will be unified. The guideline works as a quick check-up guide to optometrists about how to perform an eye examination on cataract patients and as a reminder of which structures to examine and when it is time to refer the patient to an ophthalmologist to consider the cataract surgery. Valid legislation must be followed when using this guideline, and every optometrist is responsible for their own decisions and procedures.

2 THEORETICAL BACKGROUND

This theoretical background consists of three parts: The lens crystalline, the cataract, and the management of the cataract.

Opacities formed inside the lens of the eye are called a cataract, and ageing is the leading risk factor for cataract formation. It was estimated in 2020 that globally there are 33.6 million cases of blindness among people aged 50 years and older, and cataract is the leading cause, with 15.2 million cases. (Bourne et al., 2021) In addition to ageing, type 2 diabetes is a substantial risk factor for cataract formation. As the type 2 diabetes prevalence increases, cataract-related visual impairment will increase. (Drinkwater et al., 2019)

World Health Organization, WHO, estimated in 2021 that globally there are one billion cases of vision impairment that could have been prevented, and 94 million individuals of those have moderate or severe impairment in vision for distance or blindness due to cataract. The severe effects of cataract are common in low- and middle-income countries, where the only effective treatment, cataract surgery, is not available for everyone. Vision impairment significantly impacts the quality of an individual`s life, but it is also an enormous economic burden to society. As cataract is often a problem for older people, untreated, the consequences may be such as a higher risk for falling and fractures and a likelihood of needing nursing or care homes earlier. ("Blindness and vision impairment," 2021)

There is no preventive treatment for cataract, although research has been made about nutritional factors to delay or prevent cataract formation. (Braakhuis et al., 2019) The only way to treat the cataract and restore the vision of the cataract patient is cataract surgery. As people age, the need for cataract surgeries increases; thus, the healthcare resources need to be adequate. Even though the cost of cataract surgery is expensive, the cost of cataract is more expensive if untreated. People with poor vision cannot work, and they need care. (Asbell et al., 2005)

In Finland, cataract rarely causes permanent vision loss. It is estimated that over 30% of over 65 years old have a vision-impairing cataract in one or both eyes, and yearly around 50 000-60 000 cataract surgeries are made in public or private healthcare. ("Cataracts. Current Care Guidelines Abstract.," 2019; "Kaihi (aikuiset): Käypä hoito -suositus," 2019)

2.1 The Lens Crystalline

The lens crystalline (lens) is a biconvex, transparent structure positioned within the posterior chamber, in front of the vitreous body just behind the iris. The lens doesn't consist connective tissue or nerves. (Remington and Goodwin, 2021, p. 97; Yanoff and Duker, 2019, p. 325) Due to its location, the lens is the second refractive element in the eye after the cornea. The main purpose of the lens is to create a sharp image on the retina by increasing or decreasing the refractive power when focusing objects at different distances. Zonular fibers attach the lens to the ciliary body, and this structure, together with an elastic lens capsule, enables a change in the shape of the lens and, thus, a change in refractive power. The increase in refractive power of the lens occurs when focusing near, and this is called accommodation. In an unaccommodated lens, the refractive power is approximately 20D, and maximum accommodation increases this power by about 14D. The maximum accommodation power of the lens is reached in childhood, and it decreases with age, approaching zero after 50 years. (Remington and Goodwin, 2021, p. 97, 102) The lens has the highest protein content of the human body tissues. (Pescosolido et al., 2016) The lens consists of 30-35% of proteins and 65-70% of water, and the water content is higher in the cortex than in the nucleus. (Remington and Goodwin, 2021, p. 104)

2.1.1 The Lens Structure

In the adult eye, the diameter of the lens is approximately 10mm, and the axial length is about 4mm. The lens growth continues through life, and it becomes rounder. (Forrester et al., 2021, p. 32) The largest circumference of the lens, called the equator, is located at the junction of the anterior and posterior parts of the lens. The lens zonules attach to the lens capsule near the equator. (Remington and Goodwin, 2021, pp. 97–98) The lens is usually transparent due to the structure, shape, arrangement and biochemistry of lens cells and fibres. Before birth, the lens receives nourishment via tunica vasculosa lentis, a vascular net derived from the hyaloid artery, which typically disappears late in foetal development. A typical adult lens is avascular and receives its nourishment from the aqueous and vitreous humour. (Donaldson et al., 2017, p. 4; Forrester et al., 2021, p. 32) The mean weight of the lens in the second year of life is 149mg. After that, the lens grows approximately 1.38mg/year, ending at approximately 250mg weight or more. (Bassnett and Šikić, 2017, p. 184)

The lens consists of three structures: The capsule, the lens epithelium, and the lens fibres. Lens epithelium is found only on the anterior surface of the lens. The epithelium of the posterior part of the lens is used during embryological development to form the primary lens fibres. The embryonic nucleus is formed of these primary lens fibres, and all following secondary lens fibres are located outside this core. The nucleus of an adult lens is considered to include all the lens fibres formed before birth and the lens fibres formed between birth and sexual maturation. The lens cortex consists of the fibres formed after sexual maturation. (Remington and Goodwin, 2021, pp. 97–100)

The lens epithelium is a single layer of cuboidal epithelial cells, and these cells are more columnar at the equator. Mitosis of the epithelial cells is maximal in the area anterior to the equator, called the germinative zone. (Forrester et al., 2021, p. 34) The anterior epithelium of the lens controls the nutrients, ions, and water movement in and out of the lens by aquaporins and ion pumps. The lens epithelium is involved in the production of an antioxidant called glutathione, and metabolites, which filter UV light. (Remington and Goodwin, 2021, p. 104) When the epithelial cells elongate, the apical part is located deeper than the other more anteriorly positioned lens cells. Elongated epithelial cells are differentiated as lens fibres. The older lens fibres are pushed deeper into the lens by new lens fibres, and the cell nucleus is migrated anteriorly. (Forrester et al., 2021, p. 34) Inside the lens, the anaerobic glycolysis is the energy source for cellular metabolism and replication. Aerobic glycolysis is limited to the surficial, newer fibres or the epithelium that still has mitochondria. (Remington and Goodwin, 2021, p. 104)

The deeper and older lens fibres are anucleate, and this loss of cellular organelles, together with the anteroposterior orientation, allows light transmission. (Forrester et al., 2021, p. 235) The central nucleus of the lens is harder than the outer cortex. Lens fibres extend the entire length of the lens, and they meet at the posterior and anterior sutures. The length of an outer fibre can be up to 1cm from suture to suture in the adult lens. (Remington and Goodwin, 2021, pp. 97–98) Recent studies confirm the conception that the lens epithelium has the lifelong capacity for self-renewal. The defining property of stem cells is self-renewal, so many researchers are convinced that the lens epithelium contains a number of adult stem cells. (Bassnett and Šikić, 2017, p. 187)

Between the lens fibres, there is minimal intercellular space. A vast network of gap junctions along the lateral fibre membranes enables the movement of nutrients and ions within the lens. (Forrester et al., 2021, p. 34) The deeper fibres are far from aqueous and vitreous humour, so transport between the fibres via gap junctions is essential. The lens has more gap junctions than other cells, and some channel proteins are only found in the lens. (Remington and Goodwin, 2021, p. 104) The lens has a complex transport system which maintains the optical properties of the lens by transporting solutes: metabolic waste and nutrients. This microcirculation between the cells is driven by hydrostatic pressure and an ionic current flowing into the lens at the poles and outwards at the equator. Recent studies have also shown that the tension of lens zonules affects the microcirculation via the change in hydrostatic pressure. (Giannone et al., 2021)

The lens epithelium and lens fibres produce thickened, smooth basement membrane called the lens capsule. This elastic capsule envelops the lens completely, and the lens zonules are attached to the capsule. (Forrester et al., 2021, p. 34) The lens capsule is mainly collagen, and the elastic property is due to the lamellar arrangement of the fibres. The capsule prevents large molecules from entering the lens but allows nutrients and antioxidants to enter. The capsule also serves as a reservoir for molecules and growth factors that regulate lens processes. (Remington and Goodwin, 2021, pp. 97–98, 103–104)

2.1.2 Lens Transparency

Visible light passes well through the lens, as well as through the cornea and aqueous humour. The cornea absorbs wavelengths below 300nm, and the lens filters all the light wavelengths below 300nm and the majority below 360nm. (Forrester et al., 2021, p. 234)

The lens transparency is due to several factors. The loss of vasculature during foetal development and the loss of cell organelles during the differentiation of epithelial cells to lens fibres is essential to lens transparency. The lens fibre cells are densely packed and geometrically ordered to minimise light scattering and maintain transparency. Within the lens, the highly organised microcirculation system effectively transports nutrients and wastes, thus maintaining lens transparency. (Donaldson et al., 2017, pp. 4–8) As mentioned earlier, the lens epithelium has an essential role in maintaining the fluid and electrolyte balance of the lens by ion-pump mechanisms. Any disturbance in the function of the lens epithelium will have major effects on lens clarity. (Forrester et al., 2021, p. 234)

The main cellular proteins of the lens are water-soluble crystallins, which cause the high refractive index of the lens. At the nucleus, the refractive index is 1.41 and at the periphery 1.38. The crystallins are packed densely and in high concentrations that resemble glass or a dense liquid. The crystallins have a highly ordered structure, and a cytoskeletal network of microtubules and filaments provides this structure and stability. Some of these cytoskeletal proteins are lens specific. The light scatter from one molecule is related to the scatter from the adjacent molecule, and they cancel each other out, so the light transmission is secured. There are three types of crystallins in mammals, α, β and γ and their subtypes. The α crystallins maintain lens transparency by preventing other crystallins and proteins from disrupting the structure of the crystalline packing. When crystallins undergo chemical changes and form aggregates, their density changes, and they become water-insoluble. When these aggregates grow enough, they cause light scatter. (Forrester et al., 2021, pp. 234–238; Remington and Goodwin, 2021, pp. 97, 99, 104)

2.1.3 Ageing In the Lens

The lens undergoes changes with age. Lens capsule becomes more brittle, thicker, and less elastic. The lens shape is unable to change, and this leads to presbyopia, a loss in accommodative ability. The thickness of the lens increases through its lifetime, and the curvature of the anterior surface steepens, causing a decrease in anterior chamber depth. (Donaldson et al., 2017, pp. 15–16)

The light transmission by the lens decreases with age. A disturbance in the ordered packing of the lens crystallins and especially the decrease in the number of α crystallins cause changes within the lens, such as vacuole formation, increased water accumulation and lens protein aggregate. The structure of the cytoskeleton also changes. (Forrester et al., 2021, pp. 243–245; Remington and Goodwin, 2021, p. 105)

By age, the lens´s level of ultraviolet radiation filters decreases, causing more ultraviolet radiation damage. In the lens, the epithelium is the first tissue to face ultraviolet radiation, making it prone to damage from unstable free radicals caused by ultraviolet radiation and cellular metabolic processes. Changes in the lens epithelium may lead to permanent changes throughout the lens. Lens fibres also absorb ultraviolet radiation, which leads to oxidative damage. Oxidative stress occurs when the rate of free radical formation is greater than their degradation rate. Oxidative stress may cause changes in the structure and function of gap junction proteins, cause protein accumulation, DNA damage and modify lens crystallins. All these changes promote cataract development. (Remington and Goodwin, 2021, p. 105) Though the ageing of the lens and the cataract formation are often considered synonymous, there is a difference in the amount of oxidation on lens proteins. In an aged lens without a cataract, the oxidation is much less than in a cataractous lens. (Forrester et al., 2021, p. 243)

Fibre membrane permeability increases with age, and the ion balance in the lens is disrupted. There is also a disturbance in water flow. Aquaporins change significantly, and the water and glutathione flow is more restricted at the cortex-nucleus border. Glutathione is found in high concentration within the lens and aqueous humour and is an agent that detoxifies free radicals. It has a role in maintaining membrane transport mechanisms. The deeper fibres of the lens are dependent on the diffusion of glutathione from superficial fibres. Ascorbic acid is another substance whose concentration is relatively high in aqueous humour, and it has a role in protecting lens epithelium from oxidative stress. (Remington and Goodwin, 2021, p. 105) Ageing causes degradation in ascorbic acid, which predisposes the lens to oxidative damage. (Pescosolido et al., 2016)

2.2 The Cataract

Age-related cataract is the most common form of cataracts, but cataract may also be related to trauma, systemic diseases, or congenital. A secondary cataract may develop as a result of other ocular diseases or medication use. (Remington and Goodwin, 2021, pp. 105–108) Cataract involves people of both gender and all races, and the prevalence of cataract increases with age, notably after age 60. Some occupations predispose to cataract, e.g., outdoor workers. (Hashemi et al., 2020; Modenese and Gobba, 2018) The cataract is almost always bilateral, but the progression may be asymmetrical. (Saari, 2011, p. 216)

2.2.1 Risk Factors

The main risk factor for cataract, particularly nuclear and cortical cataract, is ageing. Although the name "age-related cataract" is used, cataract is often caused by many factors in addition to ageing. As mentioned earlier, the cataract may also be congenital. Genetic factors have an essential role in the severity of nuclear cataract and in the development of cortical cataract. Women have to some extent, a greater risk for cataract formation than men. (Asbell et al., 2005)

Nutritional and metabolic deficiencies and systemic diseases have an impact on developing cataract. Particularly diabetes mellitus is associated with cortical and subcapsular cataract, and patients with diabetes mellitus tend to need cataract surgery at an earlier age. (Asbell et al., 2005; Mathew et al., 2012; Remington and Goodwin, 2021, pp. 107–108) According to a cross-sectional study made in Greece in 2018-2019, hypertension might have an even more significant role as a single risk factor in cataract formation than diabetes mellitus. Therefore, the importance of the early detection of hypertension is also an issue to consider while thinking about slowing down cataract progression. (Mylona et al., 2019) High body mass index (BMI) is related to an increased risk of posterior subcapsular cataract and cortical cataract. Some dermatological disorders, like atopic dermatitis and eczema, are also associated with cataract formation. (Yanoff and Duker, 2019, pp. 332–333)

Exposure to UV radiation causes cortical cataract. Other radiation damage, e.g., radiation therapy for cancer treatment, might be one factor in promoting posterior subcapsular cataract and cortical cataract. The use of systemic corticosteroids has been related to posterior subcapsular cataract, but the use of inhaled corticosteroids as a risk factor has not been fully demonstrated. (Asbell et al., 2005; Mathew et al., 2012; Remington and Goodwin, 2021, pp. 107–108)

Smoking has been linked mainly to nuclear cataract. People who smoke have three times greater risk of developing a nuclear cataract, and quitting smoking reduces the risk. Smoking reduces the endogenous antioxidants, and tobacco contains heavy metals which cause toxicity when accumulating in the lens. Smokers are often more likely to use excessive alcohol and likely to have a poor diet, which also increases the risk of cataract formation, even though the study reports concerning alcohol use and cataract formation are mixed. (Yanoff and Duker, 2019, p. 332)

Trauma may be penetrating or blunt trauma. Electric shock, a result of lightning or accident, is a rare cause of cataract. Also, infrared radiation in occupations where extreme heat is present increases the risk for cataract. The duration and intensity of the uveitis affect the development of the opacities. Opacities start as a polychromatic lustre at the posterior pole of the lens, ending in posterior and anterior opacities if inflammation persists. (Mathew et al., 2012; Salmon, 2020, pp. 308–311; Yanoff and Duker, 2019, pp. 332–333) High myopia is related to posterior subcapsular cataracts and nuclear sclerosis at the early stage. Small anterior subcapsular or capsular opacities, glaukomflecken, within the pupillary area may be caused by acute congestive angle closure. (Salmon, 2020, p. 310)

2.2.2 Age-related Cataracts

The location of opacity can classify age-related cataracts. In nuclear cataract, opacity is located in the lens nucleus. The lens cortex has opacities in the cortical cataract, and in the posterior subcapsular cataract, opacities are located just beneath the posterior capsule. All these three types of cataracts can be present alone, or they can be present simultaneously. (Asbell et al., 2005; Remington and Goodwin, 2021, pp. 105–107)

The decrease of glutathione exposes lens fibres to oxidative damage, which is associated with nuclear cataract. Due to oxidative damage, the proteins in the lens nucleus aggregate, and the normal arrangement of the lens fibres changes. This change leads to opacification. A nuclear cataract is graded by the colour and opalescence of the lens nucleus. The colour changes in nuclear cataracts vary from light yellow to dark brown, rarely black, depending on how advanced the cataract is. In slit lamp examination, nuclear sclerosis is best seen with an oblique beam. A fine red reflex with retroillumination is seen, but a subtle distinction between the nucleus and cortex is seen in close observation. In refractive power, a myopic shift is usually measured due to an increased refractive index of the nucleus. (Remington and Goodwin, 2021, p. 107; Salmon, 2020, p. 308)

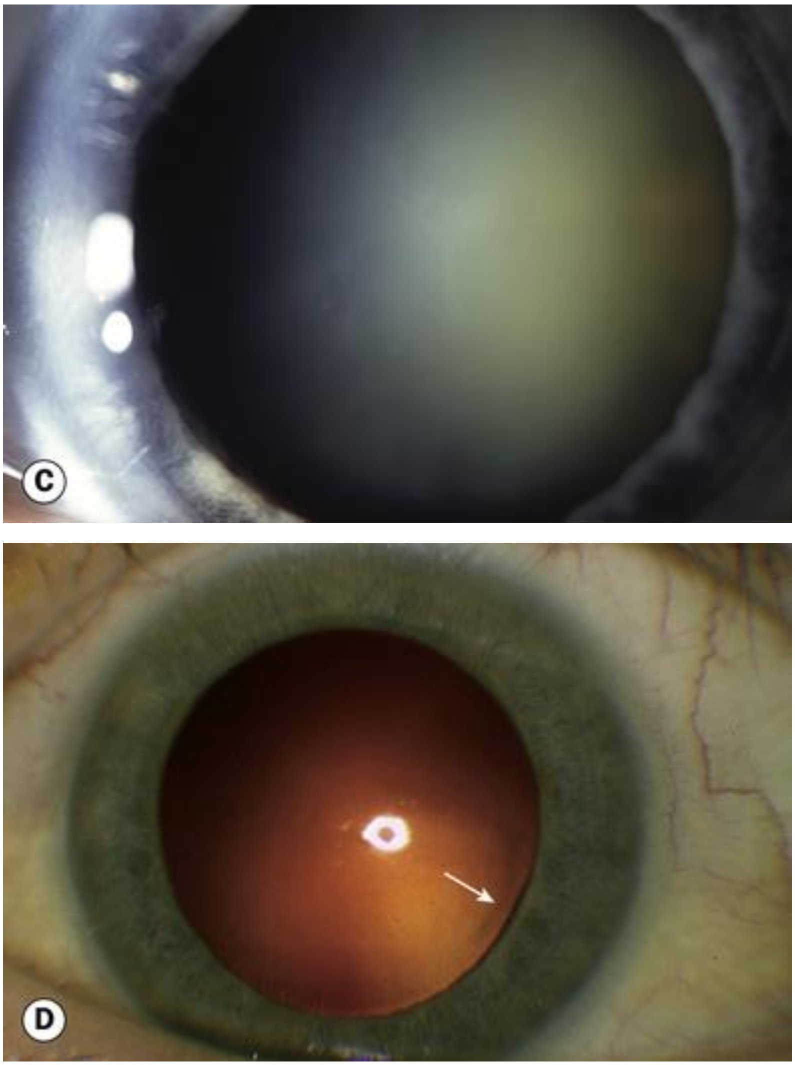

Figure 1 (C) Nuclear sclerosis (D) Nuclear sclerosis in retroillumination, the demarcation between nucleus and cortex (arrow). Reprinted with permission. (Salmon, 2020, p. 309)

In cortical cataract, opacities appear first as clefts and vacuoles between lens fibres. Later wedge-shaped or radial spoke-like opacifications are seen in slit lamp examination with retroillumination or direct illumination. (Salmon, 2020, pp. 308–309) A cortical cataract is associated with an astigmatic shift due to the uneven accumulation of fluids causing changes in the refractive index within the lens cortex. (Donaldson et al., 2017, p. 18) Membrane permeability increases, and cell mechanisms are not able to maintain homeostasis. The increased concentration of ions drives fluid accumulation inside the cells. Opacities start from the equatorial zone and reach the optical axis when affecting the vision. Initially, changes are often seen in the inferonasal quadrant. (Remington and Goodwin, 2021, p. 107)

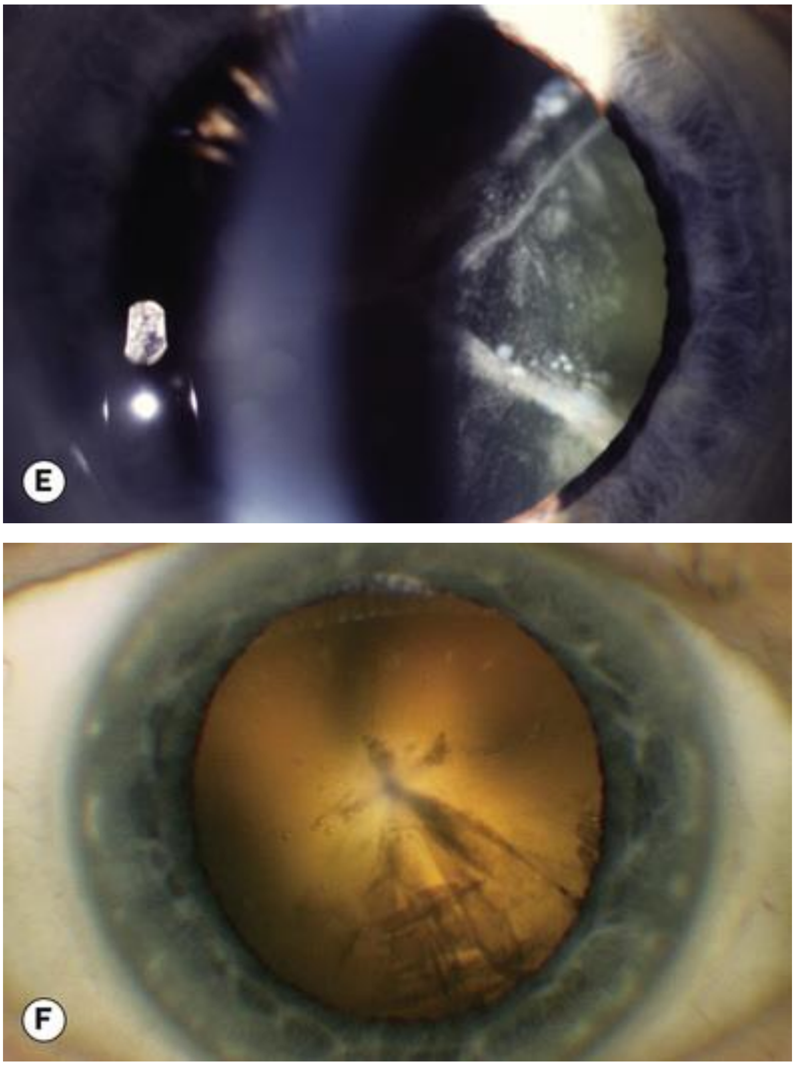

Figure 2 (E) Cortical cataract (F) Cortical spokes on retroillumination. Reprinted with permission. (Salmon, 2020, p. 309)

A posterior subcapsular cataract is formed when epithelial cells migrate from the equatorial area and accumulate at the posterior pole under the lens capsule. This accumulation appears as a granular or plaque-like formation with an oblique slit lamp beam. On retroillumination, these opacities appear black and vacuolated. (Remington and Goodwin, 2021, p. 107; Salmon, 2020, p. 308)

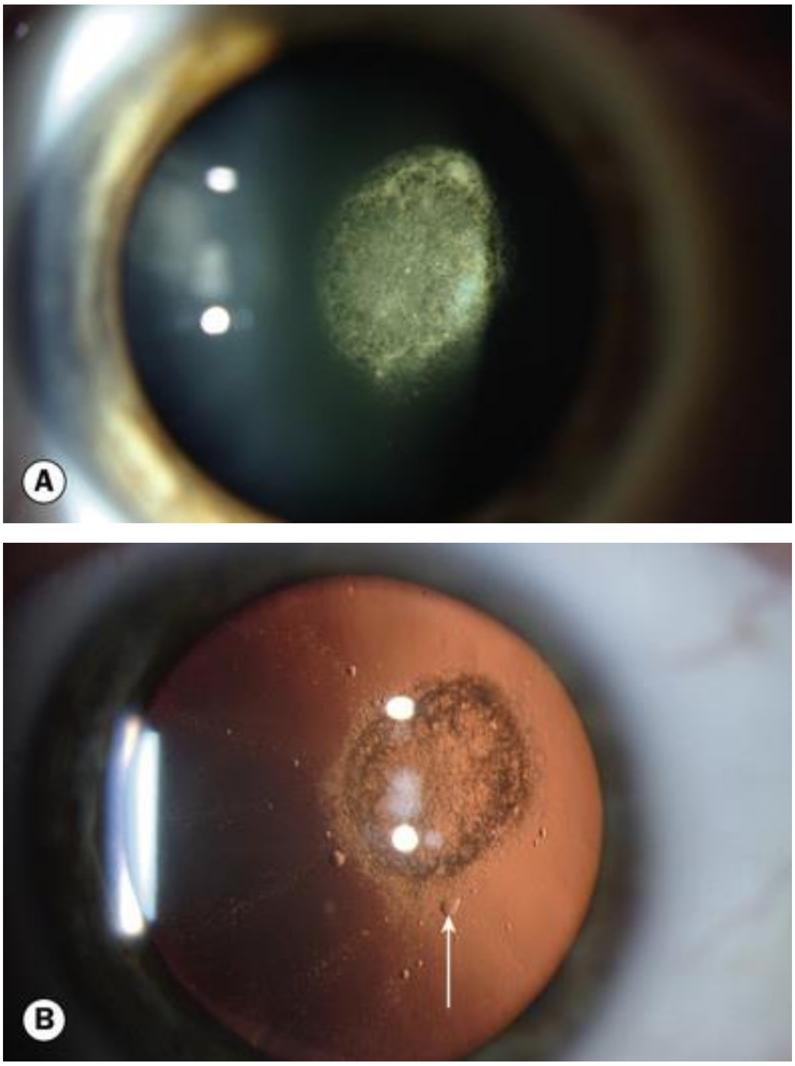

Figure 3 (A) Posterior subcapsular (B) Posterior subcapsular on retroillumination. Reprinted with permission. (Salmon, 2020, p. 309)

2.2.3 Diabetes-Related Cataract

Diabetes mellitus is a chronic systemic disease and a significant risk factor for cataract, especially cataract formation at a younger age. It has been reported that cataract is twice as prevalent in diabetic people over age 65 and three to four times more prevalent in diabetic people under the age of 65. As the number of type 1 and type 2 diabetes increases worldwide, the incidence of diabetic cataract increases. (Kiziltoprak et al., 2019)

The main mechanism for diabetic cataract formation is related to the excess glucose in the aqueous humour. The excess glucose entering the lens from the aqueous humour is metabolised and converted to sorbitol. All generated sorbitol cannot be reused, and sorbitol does not pass through the fibre membranes, so the concentration of sorbitol increases within the lens fibres. This increase of sorbitol causes the water to accumulate into the fibres, fibres swell, and the lens loses its transparency. (Remington and Goodwin, 2021, p. 107)

The osmotic stress caused by swelling of the lens fibres is another mechanism for rapid cataract formation in, especially, type 1 diabetic patients. The lens of the diabetic patient is also more prone to oxidative stress due to decreased antioxidant capacity. In addition, there are also theories about autoimmune processes and apoptosis of the lens epithelial cells in the formation of diabetic cataract. (Kiziltoprak et al., 2019)

With diabetic patients, the age-related cataract develops earlier and more rapidly compared to nondiabetic patients and is the most common type of cataract. A snowflake cataract with snowflake-like cortical opacities is typical for young patients with type 1 diabetes. It may appear in a few days and resolve spontaneously. (Kiziltoprak et al., 2019; Salmon, 2020, p. 308)

2.2.4 Symptoms And Effects on Vision

Patients with early-stage nuclear cataract do not necessarily notice any significant vision changes, and visual acuity may remain high when measured using high-contrast Snellen acuity charts. If a cataract keeps progressing without treatment, it becomes opaque and very dense, and the visual acuity may be light perception only. (Yanoff and Duker, 2019, p. 338)

As the nuclear cataract progress, a myopic shift is usually measured, and spectacles need to be updated. The patient may be able to read without previously needed reading glasses due to this myopic shift. Visual acuity decreases, especially for far. (Asbell et al., 2005) Colour discrimination becomes difficult because the lens becomes more absorbent at the blue end of the spectrum. Typically, patients notice this change in colour vision only after cataract surgery when the vision has normalised. Cortical spoke cataract might produce some astigmatism because of uneven changes in the refractive index of the lens. (Yanoff and Duker, 2019, p. 339)

A cortical cataract affects vision when opacities reach the optical axis or involve the whole cortex, and the lens becomes white. Pupil size often affects symptoms; when dilated, the opacities lying more periphery reduce vision. Glare is the most common symptom in cortical cataract as well as in posterior subcapsular cataract. Even minor opacities cause glare because of the forward scatter of the light. Patients often complain of reduced vision in bright sunlight or being blinded more easily by the headlights of approaching cars while driving at night. In posterior subcapsular cataract, opacities are centrally located, and symptoms increase by miosis, e.g., in bright light or when focusing near. (Asbell et al., 2005; Salmon, 2020, p. 308; Yanoff and Duker, 2019, p. 339)

Contrast sensitivity is reduced due to cataracts, and the patient may have difficulties reading texts with low contrast or recognising people or facial expressions in low illumination. (Saari, 2011, p. 216) Though all cataracts reduce contrast sensitivity, the posterior subcapsular cataract has the most significant impact. Water clefts together with cortical spoke cataract may cause monocular diplopia. Dense opacities may also affect the visual fields. (Yanoff and Duker, 2019, p. 339)

2.2.5 Grading of the Cataract

Cataracts are graded by the severity of the opacification, and during the decades, several grading scales have been created. Most widely used, The Lens Opacities Classification System III (LOCS III) was introduced in 1993, and it was an updated version of previous LOCS I and LOCS II systems (Figure 1). LOCS III grading scale consists of six slit-lamp images for grading nuclear colour (NC) and nuclear opalescence (NO) and five retroillumination images for grading cortical cataract (C) and posterior subcapsular cataract (P). (Chylack et al., 1993)

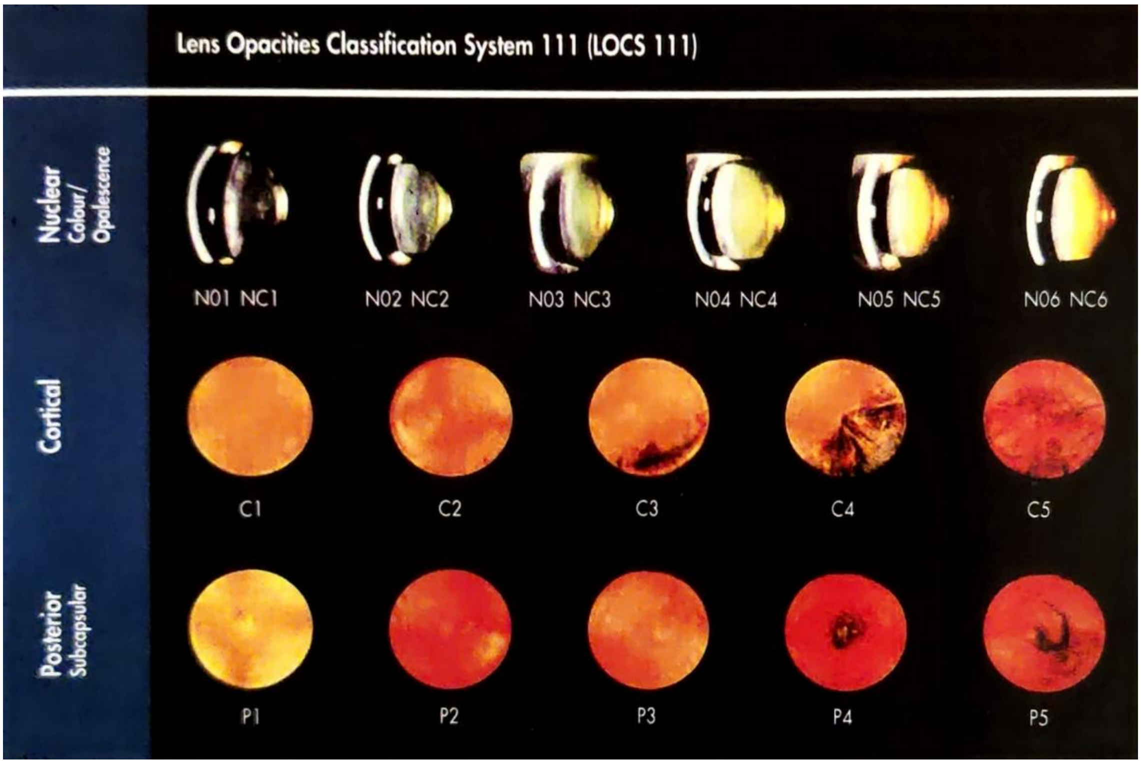

Figure 4 Lens Opacities Classification System III Simulation Chart (Yanoff and Duker, 2019, p. 339)

BCN 10 grading scale was introduced in 2017, and the Description of the Simple Pre-operative Nuclear Classification System (SPONCS) was introduced in 2020 (Figure 2). BCN 10 (Figure 3) is based on nuclear opacity and has ten reference pictures. SPONCS is based on nuclear colour only and does not use reference photos. WHO made its own grading system, A Simplified Cataract Grading System, in 2002. It is based on nuclear opalescence and on a comparison of standardised photos. (Barraquer et al., 2017; Mandelblum et al., 2020)

Table 1 Description of the Simple Pre-operative Nuclear Classification System (SPONCS). Adapted, with CC BY 4.0 license from Mandelblum et al., 2020

Grade	Description	Nucleus Colour	Posterior Cortex Colour
0	Clear lens	Clear	Clear
1	Subcapsular cataract with clear nucleus	Clear	Clear
2	Mild hardness	Green	Green
2+		Green	Yellow
3	Moderate hardness	Yellow	Yellow
3+		Yellow	Red/Brown
4	Advanced hardness	Red/Brown	Red/Brown
4+		Red/Brown	White
5	Hyperma-ture/Morgagnian (liq-uefaction of the cor-tex and sinking of the nucleus to the bottom of the capsular bag)	Black/White	Black/White

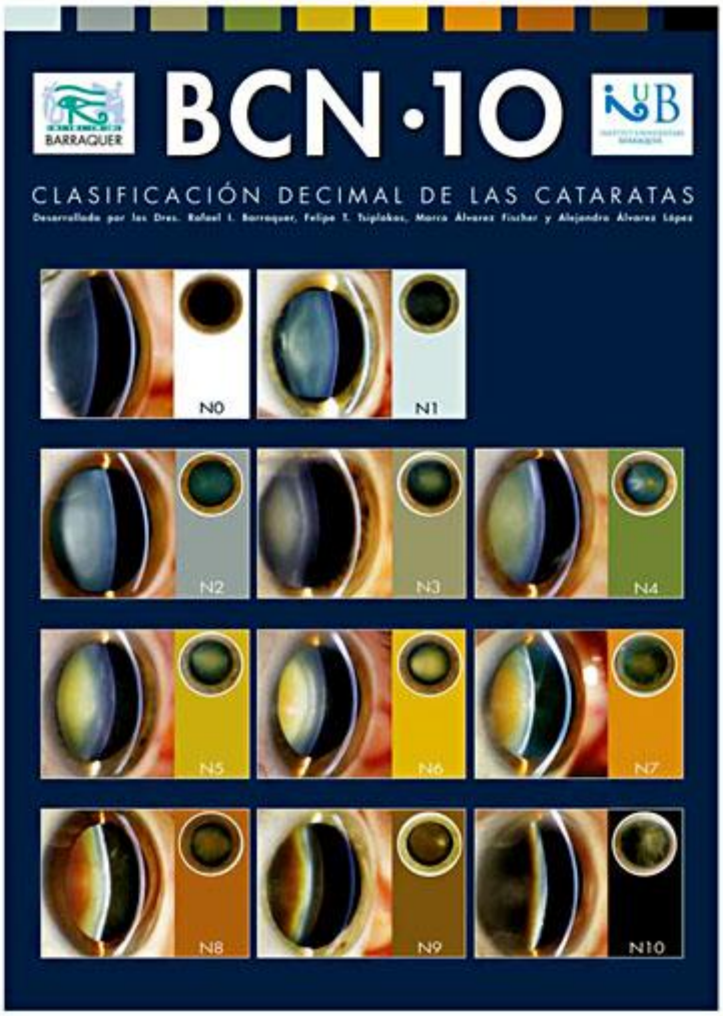

Figure 5 BCN 10 grading scale. N0 referring clear lens, and N10 referring a completely opaque lens. Reprinted under CC BY NC ND license. (Barraquer et al., 2017)

2.3 Management of Age- and Diabetes-Related Cataract

There is no preventive treatment for cataract. Although there have been studies, e.g., about anti-oxidant supplements to prevent cataract formation, evidence for that has not been found. When a patient complains about blurred vision, and a cataract is suspected, a comprehensive eye examination must be performed. This includes refraction, measuring intraocular pressure, slit lamp examination and fundus examination with dilated pupil. It is essential to find out that there are no other ocular diseases, such as macular degeneration, glaucoma or diabetic retinopathy, or only refractive error that impairs the vision. When the visual functions of the patient are significantly reduced, and other reasons for visual problems are excluded, elective cataract surgery is the way to improve the vision. (Asbell et al., 2005; Mathew et al., 2012)

In cataract surgery, an intraocular lens (IOL) implant is installed in the eye. (Yanoff and Duker, 2019, p. 327) Surgery is performed under local anaesthesia, with topical and anaesthetics as injections inside the anterior chamber. General anaesthesia may be required with some patients, such as patients with head tremors or who are very anxious. The power of the needed IOL is calculated beforehand, and emmetropia is usually the desired postoperative refraction. ("Cataracts. Current Care Guidelines Abstract.," 2019; "Kaihi (aikuiset): Käypä hoito -suositus," 2019; Salmon, 2020, pp. 316–319)

As cataract surgery is always an optional operation, the patient must be well informed about the pros and cons of the surgery. There are risks in every operation, but the visual outcome after cataract surgery is usually good, and most of the possible complications are effectively treated. In some cases, a second operation is needed. (Salmon, 2020, p. 316)

2.3.1 Systemic Preoperative Assessment

Before cataract surgery, the patient is referred for medical examination and standard laboratory tests. The current medications and systemic diseases of the patient must be recorded. Systemic alpha-blockers, such as medication for enlarged prostate, are associated with floppy iris syndrome. Immunosuppressants and anticoagulant therapy may also affect the surgery. Allergies for iodine, latex, or local anaesthetics may cause complications during the operation. (Asbell et al., 2005; Salmon, 2020, pp. 311–316)

2.3.2 Ocular Preoperative Assessment

Monocular visual acuity for both eyes, corrected if needed, and the cataract patient's current refractive status and intraocular pressure must be measured during the eye examination. Intraocular lens selection is based on the pre-operative refractive error of the patient. The keratometry readings must also be noted, especially if a toric intraocular lens is planned. ("Cataracts. Current Care Guidelines Abstract.," 2019; "Kaihi (aikuiset): Käypä hoito -suositus," 2019; Salmon, 2020, p. 315)

Cover test and pupillary responses should be tested. Amblyopia may be present in the case of heterotropia, and diplopia may be caused due to improved vision by cataract surgery. On the other hand, cataract surgery may straighten the eye if the deviation is due to poor vision caused by the cataract. A cataract does not cause an afferent pupillary defect. If this is present, further examinations must be done. A poorly dilating pupil, a shallow anterior chamber as well as pseudoexfoliation syndrome and previous anterior uveitis may cause difficulties in cataract surgery. Therefore, these conditions must be noted. Inflammations, infections, and abnormalities in ocular adnexa must be taken care of because of the risk of endophthalmitis. ("Cataracts. Current Care Guidelines Abstract.," 2019; "Kaihi (aikuiset): Käypä hoito -suositus," 2019; Salmon, 2020, p. 315) Formal perimetry testing should be done if some defect is noted in confrontation fields testing. (Optometric Clinical Practice Guideline: Care of the Adult Patient with Cataract, 2004, p. 14)

Examination of corneal endothelium reveals if the cornea has decreased number of endothelial cells, as in Fuchs dystrophy or cornea guttata. In this case, the patient has a higher risk for post-operative decompensation. Dry eye disease should be well treated before cataract surgery. Patients with dry eye disease may have an increased risk for infections, and the effects of dry eye disease on the cornea and tear film layer may lead to inaccurate pre-operative assessments. (Naderi et al., 2020; Salmon, 2020, p. 315)

Careful examination of the lens reveals the location of the cataract and the stage of the cataract. The lens should be examined with the pupils dilatated so that the periphery of the lens is also seen properly. In advanced nuclear cataract, opacities are extremely hard, affecting the choice of surgical method. More detailed information about how different cataract types are seen with a slit lamp microscope is presented in chapter 2.2.2. (Salmon, 2020, p. 315)

Fundus examination reveals pathologies, like age-related macular degeneration, which may impact the outcome after cataract surgery. If the traditional fundus examination is difficult or impossible to perform through the opacified lens, ultrasonography may be required. (Salmon, 2020, p. 315) Optical coherence tomography, OCT, is also an effective and non-invasive tool to assess and detect macular abnormalities through the opacified lens. (Alizadeh et al., 2021)

Depending on the individual circumstances, additional testing may also be used when finding out the presence of some coexisting eye diseases, the extent of functional disability, or the potential for improvement. Testing the visual fields may give evidence for retinal detachment, an eye tumour, glaucoma, optic nerve disease, coloboma or retinitis pigmentosa. Amsler Grid is a helpful tool to assess macular health; a distorted test image reveals abnormalities on the macula, and more careful examination is needed. Colour vision testing may reveal macular or optic nerve diseases, and contrast sensitivity and glare testing may show that functional disability is worse than suspected by visual acuity measurement. Electrophysiology testing to measure the function of the visual pathway is run if suspected optic nerve or retinal disease or if there is a need to evaluate the visual function of the patient with a mature cataract. A potential acuity meter predicts the visual acuity after cataract surgery. (Optometric Clinical Practice Guideline: Care of the Adult Patient with Cataract, 2004, pp. 15–16)

Other things that may have issues during the cataract surgery are previously made eye operations, especially glaucoma-related, cervical spine problems, the posterior position of the eyes, and if the patient is poor cooperating, e.g., due to memory disorder. ("Cataracts. Current Care Guidelines Abstract.," 2019; "Kaihi (aikuiset): Käypä hoito -suositus," 2019)

2.3.3 Non-surgical Treatment Options

Sometimes cataract surgery is not an option for a patient, or the patient declines surgery. Under these circumstances, the purpose of the treatment is to make the patient vision as good as possible despite the cataract. Eventually, the cataract usually proceeds to a phase when a low vision evaluation is necessary.

The spectacle or contact lens prescription should be updated regularly to reduce the cataract symptoms. Sometimes the unequal spectacle correction or unilateral change in refraction causes difficulties due to a difference in image size. In this case, lenses with equal base curve and center thickness may reduce the problem. Contact lenses, or a combination of contact lenses and spectacles, might be a helpful solution if the patient is having cataract in one eye and having difficulties in tasks requiring good binocularity. In many cases, contact lenses minimise image size differences. Visual discomfort or diplopia may occur when unilateral or unequal refractive changes cause vertical deviation, mainly while focusing near. Prisms, decentration of the lenses, dissimilar segment types in bifocals, contact lenses or changing bifocal position may be helpful. (Optometric Clinical Practice Guideline: Care of the Adult Patient with Cataract, 2004, pp. 18–20)

Protective hats and sunglasses are recommended to reduce glare. In addition to regular sunglasses, also different kinds of filter glasses that selectively filter short wavelengths may be helpful to reduce glare and enhance contrast vision and visual acuity. The patient may also benefit from instructions about illumination; how to place and use light sources. (Optometric Clinical Practice Guideline: Care of the Adult Patient with Cataract, 2004, pp. 18–20)

Mydriatic drops are also a non-surgical way to improve vision if the cataract is centrally located. The idea is that dilating the pupil allows the patient to see better by using more peripheral parts of the lens. Side effects of mydriatic drops are the loss of accommodation and photosensitivity, so advantages and disadvantages should always be evaluated in advance. (Optometric Clinical Practice Guideline: Care of the Adult Patient with Cataract, 2004, pp. 18–20)

2.3.4 Management Pathway of the Cataract in Finland

A patient with a cataract is referred to ophthalmologists to get a diagnosis. If the patient has cataract-based difficulties in everyday life, and if the best corrected visual acuity (BCVA) in the better eye is ≤ 0.5, or BCVA is ≤ 0.3 in the worse eye, the patient is indicated for cataract surgery. In addition, these limitations may deviate if one of the following is present:

- Posterior subcapsular cataract significantly affects everyday life, for example, while driving.
- Over 2D anisometropia is present after the operation of the first eye.
- The treatment of other eye diseases is difficult due to cataract. E.g., glaucoma or diabetic retinopathy.

A referral for cataract surgery can be written by a public or private primary healthcare doctor or an ophthalmologist. In Finland, optometrists are not allowed to write referrals for cataract surgery. If the patient declines cataract surgery or the patient's quality of life has not deteriorated, the cataract surgery is contraindicated. Also, cataract surgery will not be performed if eyeglasses or other vision aids are enough for the patient or if it is unlikely to improve vision by operation. Contraindication for cataract surgery is when the surgery is not safe due to existing systemic disease or eye disease. (“Cataracts. Current Care Guidelines Abstract.,” 2019; “Kaihi (aikuiset): Käypä hoito -suositus,” 2019)

The recommendation in Finland is that a follow-up visit with an ophthalmologist is arranged approximately one month after the cataract surgery. The prescription for new eyeglasses should be done five to six weeks after the surgery. (“Cataracts. Current Care Guidelines Abstract.,” 2019; “Kaihi (aikuiset): Käypä hoito -suositus,” 2019)

The above limitations are valid in public healthcare in Finland. Patients, who are not willing to wait for visual acuity to deteriorate to get surgery in public healthcare, may contact private hospitals or clinics to have cataract surgery earlier. These hospitals and clinics have their own guidelines for cataractous patients.

3 THE PURPOSE, OBJECTIVES, AND TASKS OF THE RESEARCH DEVELOPMENT WORK AND THE DIFFERENT STAGES

3.1 Purpose of the Study Statement

The purpose of this thesis was to create a clinical assessment guideline for optometrists for managing pre-surgery cataract patients in Finland and to create an easily understandable theoretic background about the basics of the human lens crystalline and the cataract.

3.2 Statement of the Research Question

What are the main clinical components of the pre-cataract surgery assessment in an optometrist´s eye examination?

3.3 Summary Description of the Experimental Design

This thesis is a literature review analysis-based innovation project to produce a guideline for Finnish optometrists for pre-cataract surgery assessment. The first approach was to conduct a literature review of the key elements involving the lens crystalline, cataract and eye examination. The second phase was to create the guideline by choosing the suitable and adequate procedures for an eye examination and patient assessment in a regular optical store, not in the hospital environment. The choice of procedures is explained more carefully in chapter 3.5.3, and a more specific timetable is described in chapter 3.5.2, table 2. IRB approval or statistical analyses were not required for this thesis.

3.4 Study Objectives

The first aim of this study was to conduct a comprehensive literature review of the anatomy and physiology of the lens crystalline, the cataract, and the pre-surgical assessment.

The second aim of this study was to produce a clinical guideline for optometrists: Pre-cataract surgery assessment.

3.5 Methodology

This thesis is an innovation project which consists of two sections. The first section is the theoretical background, a literature review about the anatomy and physiology of the lens crystalline, the cataract and the management of the cataract. The second section of this thesis is the guideline for Finnish optometrists. The guideline is based on existing valid international and national guidelines, evidence-based literature and the current law considering the optometrist's work in Finland.

3.5.1 Project Co-operation

The pre-cataract surgical assessment guideline for optometrists was ordered by Optometrian Eettinen Neuvosto (OEN), The Finnish Ethical Council of Optometry. The intention of the OEN is to create a uniform practice for Finnish optometrists by clinical guidelines. At the moment, there are no clinical guidelines for optometrists in Finland. The agreement framework allows OEN to keep the right to change the contents of the final guideline and choose the timeframe for publishing it.

3.5.2 Timeline

The thesis project started on January 2022 with initial planning and a literature search. The writing of this thesis began on February 2022, and the thesis was finished in December 2022. The more specific timetable is presented in table 2. This thesis was part of the studies in Master of Health Care, Clinical Optometry, and sponsors or financial support was not included in this thesis.

Table 2 The timeline of the innovation project.

Innovation project	Time	Outcome
Defining the research question and possible specific aims.	January 2022	Research question and a preliminary project plan.
Making the literature search for the theoretical background and selecting the sources. Narrowing down the related topics.	January 2022	
Writing of the theoretical background.	February -May 2022	Theoretical background.
Defining and reviewing the specific aims.	June 2022	Study objectives
Planning of the guideline: • Familiarising with international and national cataract guidelines • Choosing the procedures to use in the guideline.	June 2022	Preliminary guideline plan.
Making the guideline	July – September 2022	Clinical Guideline for Optometrists – Pre-cataract Surgery Assessment, first version.
Reviewing the results of the literature search again and including a few more sources. Making the final check for the thesis.	October - December 2022	The final version of the thesis.

3.5.3 Conducting Comprehensive Literature Search and Appraisal

The literature search for the theoretical background was conducted in January 2022. In the primary literature search, Pubmed database and Google Scholar were used. Keywords for the search were cataract, age-related cataract, lens crystalline, lens opacities, grading of the cataract, diabetic cataract, and risk factors for cataract. The search was limited between 2000-2022, and only the studies in English were searched. A few older studies and articles were found while reading more recent studies.

The secondary literature search from ophthalmology books was most helpful when conducting the theoretical background. Supplementary information was found from studies and articles. A logical structure and order to write the theoretic background were to start with the lens crystalline, following the ageing changes of the lens crystalline, cataract formation and the management of the cataract. The comprehensive literature review is an essential part of the thesis to understand the guideline's background and theory.

3.5.4 Development of the Guideline

The first version of the guideline for Finnish optometrists was written between July and September 2022. The final version was finished in November 2022. The guideline is based on the literature review, existing international and national guidelines, and the knowledge of the optometrist's work in Finland. Clinical assessment procedures were selected from evidence-based literature:

International

- American Optometric Association (AOA), Care of the Adult Patient with Cataract –Optometric Clinical Practice Guideline 2004
- Moorfields Eye Hospital NHS Foundation Trust, Cataract Clinic Guidelines for Optometrists 2014
- National Institute of Health and Excellence (NICE), Cataracts in Adults: Management -Full guideline 2017

National

1. Current Care Guideline / Käypähoito suositus

2. OEN: Hyvä optometristin tutkimuskäytäntö -ohjeistus (Guideline for the optometrist's good examination practice)

The international guidelines have been selected from the countries where cataract patients are, to a great extent, handled and examined by optometrists. The national guidelines used in this thesis are the only currently existing guidelines concerning cataract or the optometrist's eye examination.

In addition to evidence-based literature, the work experience as an optometrist and knowledge of the facilities available in Finnish optical stores is used when writing the clinical guideline. The chosen procedures are selected by the knowledge of the level of education of Finnish optometrists and by the knowledge of the instruments in use in optical stores. For example, the use of equipment like Optical Coherence Tomography (OCT), ultrasonography, standardised automated perimetry (SAP) or corneal pachymetry is ruled out in this guideline because this equipment is not available for all optometrists. All the chosen procedures are explained and justified in the theoretical background. All of the procedures are part of a comprehensive eye examination according to Finnish Guideline for the optometrist's good examination practice, Hyvä optometristin tutkimuskäytäntö-ohjeistus. The procedures concerning the surgery evaluation are excluded because this evaluation is currently made in surgical clinics and hospitals, mainly by ophthalmologists. The sources used to create the guideline were very uniform regarding the procedures with cataractous patient assessment. The international guidelines explained the assessment procedures more thoroughly than the national Current Care Guideline / Käypähoito suositus. The current law considering the optometrist's work is also noted when selecting the procedures.

The first part of the guideline, patient history/anamnesis, is more detailed than optometrists presumably are used to asking in the anamnesis. The essential medications are listed in the guideline as a reminder to ask for more details about medications. The general question "Do You have any medications?" does not give enough information for the optometrist. The vision-related problems are also listed based on the knowledge about what kind of symptoms are due to cataract.

The next part of the guideline, ocular examination, conforms to the Finnish "hyvä optometristin tutkimuskäytäntö" guideline. However, the focus is more on the clinical assessment of the eye, assuming that refraction, motility, and pupillary testing are basic skills which do not need detailed instructions. The cataractous patient might have perfect high-contrast visual acuity but may still have problems with functional vision in low-contrast situations or with colour discrimination. The testing for contrast and colour vision are included in the guideline as additional tests if anamnesis indicates functional vision problems that are not explained with poor visual acuity.

The management of the cataract is the third part of the guideline. It is based on the Current Care Guideline, Käypähoito suositus, which includes the official guideline about cataract management for healthcare professionals in Finland. The guideline follows the standards of treatment in public healthcare in Finland. For example, the limitation for visual acuity before cataract surgery is indicated in public healthcare but does not count in private clinics. Finnish optometrists must keep in mind the current legislation and always cooperate with an ophthalmologist when required. With the cooperation of the ophthalmologist, the optometrist may proceed with the patient as agreed with the ophthalmologist in charge. The non-surgical options, if the patient does not want surgery or surgery is not yet indicated, are mentioned in the guideline. These options, for example, prescribing eyeglasses with prisms or special filter glasses, are assumably routine work for optometrists and are not explained in detail.

The existing guidelines did not have formal recommendations about the timeline of cataract monitoring after the cataract is diagnosed. When considering the progressive nature of the cataract and the recommendation generally used by Finnish ophthalmologists, yearly monitoring by an optometrist is chosen for this guideline.

4 IMPLEMENTATION OF THE RESEARCH DEVELOPMENT WORK

4.1 Specific Aim 1

The first aim of this study was to conduct a comprehensive literature review of the anatomy and physiology of the lens crystalline, the cataract, and the pre-surgical assessment.

4.1.1 Methods

A thorough literature search with keywords cataract, age-related cataract, lens crystalline, lens opacities, grading of the cataract, diabetic cataract, and risk factors for cataract was conducted from Pubmed and Google Scholar databases and ophthalmology books in January 2022. The Literature review is written based on this literature search.

4.1.2 Results

All the key issues about the anatomy and physiology of the human lens crystalline have been explained in the theoretical background. The theoretical background will improve the understanding of the ageing changes in the lens crystalline, and the cataract formation is explained as it is known according to current knowledge. The treatment and management procedures for cataract are introduced based on the current national and international guidelines.

The comprehensive eye examination is reviewed in theoretical background, and the different procedures are introduced logically. Also, less frequently used additional tests are mentioned for the optometrists working in clinics where additional equipment is available. The assumption is that every Finnish optometrist has the skills to perform an eye examination and to use a slit lamp microscope, so detailed instructions for every test or technique are not given.

The literature review answers why it is essential to examine the whole eye, not only to measure the visual acuity or to examine the lens crystalline, and why the patient anamnesis must be done carefully. Several systemic diseases significantly impact cataract formation and might also be risk factors concerning cataract surgery. The number of patients suffering from dry eye disease has increased, so identifying and treating dry eye is also crucial before planning cataract surgery.

4.2 Specific Aim 2

The second aim of this study was to produce a clinical guideline for optometrists: Pre-cataract surgery assessment.

4.2.1 Methods

The guideline is based on the literature review and existing valid international and national guidelines. The current law considering the optometrist's work is also noted when selecting the procedures, and clinical assessment procedures were selected from evidence-based literature.

4.2.2 Results

This guideline is developed to create a uniform procedure for Finnish optometrists working in optical stores to assess cataract patients before cataract surgery. The actual preoperative examination is performed in the hospital where the surgery occurs, and they have their own instructions.

This guideline only covers adult patients aged eighteen or over. By this guideline, optometrists are able

- ➢ to inform the patient about the visual changes and complications due to cataract.
- ➢ to recognise cataract and differentiate different forms of cataract.
- ➢ to know when it is time to refer patients to the ophthalmologist to consider cataract surgery

The use of this guideline must comply with valid legislation. Current legislation requires optometrists to consult with an ophthalmologist if the patient has ocular diseases or the optometrist suspects ocular disease, so the guideline must be followed in cooperation with an ophthalmologist. All findings must be carefully noted in patient data.

A comprehensive eye examination is required when meeting a patient with an undiagnosed or diagnosed cataract. The following steps are not all-inclusive. The individual patient symptoms, as well as professional assessment, may change the procedure.

1. Patient history / Anamnesis

- demographic data
  - name, date of birth, address, gender, race, ethnicity
- vision problems
  - What is the main complaint with vision?
  - Are problems acute or gradual onset?
  - Are problems more severe under special conditions, e.g., low or bright illumination?
- vision-related problems with
  - driving
  - locomotion
  - reading
  - working
  - recognising people´s faces
  - everyday life
- refractive history
  - previous prescription
  - previous glasses/contact lenses
  - possible myopic shift
- other ocular diseases
- previous eye surgery
- ocular trauma
- amblyopia
- general health history, especially
  - Diabetes is prone to speed up the progression of the cataract.
  - prostatic hyperplasia (medication alpha antagonists)
- medications (affecting the progression of the cataract or may have an effect on cataract surgery)
  - alpha antagonists (tamsulosin)
  - steroids (e.g., long-term use of corticosteroids for asthma, rheumatoid arteritis)

        - anticoagulant/antiplatelet medication
        - immunosuppressants

2. Ocular examination

- uncorrected and corrected best visual acuity for both eyes distance and near (use pinhole if needed)
- ocular motility
- pupillary responses
    - if RAPD is present, refer to further medical examination
- refraction and BCVA distance and near
    - additional tests for contrast and colour vision
- IOP measurement
- biomicroscopy
    - Rule out the possibility of conjunctivitis, blepharitis, trichiasis, ectropium, entropion, and lacrimal inflammations. If some of these are present, refer the patient to an ophthalmologist for treatment.
    - assessment of the cornea
        - dry eye
            - If dry eye is diagnosed, ensure that appropriate treatment is ongoing. If undiagnosed, start treatment with moisturising and lid hygiene products. Refer to an ophthalmologist if inflammation is present and medication is needed.
        - cornea guttata
        - Fuchs dystrophy
    - signs of pseudoexfoliation syndrome
    - signs of active/previous uveitis
    - assessment of the lens with pupils dilated
        - nucleus
            - colour: clear – yellow – dark brown
        - cortex
            - vacuoles
            - wedge-shaped or radial spoke-like opacifications
        - capsule

- posterior subcapsular opacifications centrally
- Use an appropriate grading scale for the assessment and check previous notes, if available, to note the progression.

- fundus assessment
  - Rule out other possible ocular diseases that might cause deterioration of visual acuity. If the patient has any abnormal fundus findings, refer to an ophthalmologist.

3. Management

The following limitations for cataract surgery are currently used in public healthcare in Finland. In addition to public hospitals, cataract surgeries are made in private clinics. Patient education about different options concerning cataract surgery is part of the optometrist's proper examination practice.

When the best corrected visual acuity of the patient´s better eye is ≤ 0.5, or the best corrected visual acuity in the better eye is > 0.5, and the best corrected visual acuity of the worse eye is ≤ 0.3 due to cataract, cataract surgery is indicated. Cataract surgery is also well-grounded if the patient has everyday living problems due to cataracts or anisometropia > 2D present. If the previously mentioned conditions are met, the patient is referred to an ophthalmologist or general practitioner, who refers the patient to a private or public hospital for a cataract surgery estimation. Treatment recommendations may change over time, so the optometrist should verify the indications for cataract surgery from the latest Current Care Guideline.

If visual acuity can be improved with glasses, new glasses or contact lenses are prescribed. Due to current legislation in Finland, the optometrist must work in cooperation with an ophthalmologist before prescribing. The follow-up visit should occur yearly or more often if the patient gets symptomatic.

The optometrist is often the first healthcare professional to meet an undiagnosed cataract patient. The word cataract may still have a scary impact on the patient, so one of the key roles of the optometrist is to provide the patient with correct information about the cataract. How will it affect the vision, and what kind of symptoms to wait for? The patient may be relieved when having the information that cataract formation is part of normal ageing changes in the eye. The optometrist should ensure the patient understands the basics of cataract formation, signs and symptoms, and the importance of timely follow-up examinations because of the cataract progression over time. The patient should be informed about the following possible ocular symptoms:

- blurred vision
- glare
- decreased vision in bright or dim light
- difficulties in colour perception
- diplopia (monocular)
- effect on visual tasks or visually guided activities (e.g., driving)

Though the patient gets a new prescription, the symptoms mentioned above may only vanish partially with new glasses. This fact needs to be well explained for the patient to avoid dissatisfaction with new glasses.

If the patient decides to decline the cataract surgery, the treatment concentrates on gaining the best or most comfortable vision despite the cataract. Consider the need for

- new eyeglasses/contact lenses
  - prisms
  - special filter lenses
  - notice possible aniseikonia
- advise for illumination
- low vision aid

4.3 Discussion

As cataract formation is due to the normal ageing of people, will the number of cataract patients increase in future. In developed countries, life expectancy is longer, and on the other hand, the prevalence of lifestyle diseases that affect cataract formation is increasing. There will be a growing demand for healthcare professionals to deal with cataract patients in the near future. According to a newssheet released on 13.5.2022 by the Finnish Association of Vision and Eyecare, Näkeminen ja silmäterveys NÄE ry, in 2040, there will be 420 000 more people over 65 years old than today. Thence the number of treatment visits for age-related ocular diseases will multiply. Public healthcare is inadequate to treat all the patients needing primary healthcare services, as well as the patients needing specialised healthcare.

After the cataract is diagnosed, the patient needs regular monitoring. Currently, in Finnish public healthcare, these follow-up visits are not organised. It is completely in the patient's responsibility how often the follow-up visits are done. It is difficult for the patient to assess vision changes, especially if the cataract formation is monocular. Therefore, the patient may suffer from poor vision-related problems in everyday life for a long time without knowing that cataract surgery may already be a possibility.

Finnish optometrists have the education to conduct a comprehensive eye examination and evaluate the health of different structures of the eye. Based on this knowledge, optometrists can examine cataract patients and decide when the patient must be referred to an ophthalmologist. Expanding the scope of the optometrist’s work also requires a structural change in the optical field. The traditional thinking of optometrists only as prescribers of eyeglasses has to change. The optometrist is a healthcare professional who needs adequate time to perform a comprehensive eye examination. Twenty minutes, the time many employees give for optometrists to conduct the eye test currently is not necessary enough in all cases.

The theoretical background of this thesis offers a compact package about the theory behind the cataract and examining the cataract patient. The examination may be inadequate if the examiner has the skills to conduct a procedure but does not understand why it is done. At the moment, there is some variation in the skills of Finnish optometrists/opticians since the novel education for optometrists is more focused on clinical skills than the previous education for opticians. Also, in some workplaces, optometrists have mainly prescribed eyeglasses and contact lenses, so a memory fresh-up for clinical examination techniques may be required. Regular continuing education is a demand for optometrists, so the level of know-how is easy to update for those who need it.

The facilities for a comprehensive eye examination for cataract patients already exist in Finnish optical stores. Compared to the expenses of special healthcare in public hospitals, the expenses for a pre-surgical cataract follow-up examination run by an optometrist are minimalistic. In the future, the need for ophthalmologists to operate on cataract and to treat other eye diseases is so great that it is only wise to target routine cataract monitoring to optometrists.

As Finnish public healthcare is undergoing structural changes, the timing is right to bring up the possibility of using optometrists as healthcare professionals before referring patients to specialised healthcare. In the future, primary healthcare personnel could refer patients with vision problems first to optometrists, and the optometrists estimate if the patient needs ophthalmologists. This way, concerning cataract, patients who only need new eyeglasses and are not yet indicated for cataract surgery would not be a burden to public healthcare. A visit with a primary healthcare doctor may not even be needed, but the nurses assessing the need for treatment could make the referral to the optometrist.

Pre-cataract surgery assessment guideline for optometrists works as a quick guide, making it easy to check what structures to examine and in which order. The procedures are chosen by the knowledge of what instruments Finnish optometrists usually have in their practice. Nowadays, optical stores have increasingly novel equipment for imaging, like OCT, retinal cameras, and corneal topographers, which can be used with cataract patients. This equipment produces detailed information but is unavailable in every optical store, so it is ruled out from this guideline. Following the guideline, optometrists will have a uniform way of examining cataract patients. Evaluation of the cataract progression is registered with the chosen grading scale, so the findings are easily compared with previous findings.

As a further innovation project, a clinical guideline for optometrists – post-cataract surgical assessment, is a subject for a future thesis as a sequel to this thesis. Also, a study about the current clinical skills of the optometrists working in a field and a study about the expenses of public eye healthcare compared to eye healthcare offered by optical stores would be helpful when increasing policymakers' knowledge about the options to produce healthcare services. Moreover, as mentioned, currently, the skills of Finnish optometrists are variable due to the recent changes in education; a separate quick guide for slit lamp techniques with tutorial videos might be a helpful tool to produce as a future innovation project.

4.4 Conclusions

What are the main things to check in a comprehensive eye examination for a cataract patient? This question was the starting point for this thesis. Checking the visual acuity and a slit lamp examination of the different parts of the lens crystalline is the first things coming to mind. When proceeding with this thesis, the importance of anamnesis and a careful slit lamp examination of the whole anterior part of the eye appeared as an essential issue. Visual acuity only tells the level of the visual acuity, nothing else, and visual acuity is only one component in evaluating the cataract patient.

Even though the cataract is a change in the lens crystalline, the status of the patient's general health and the health of the whole eye impact how to proceed with the cataract patient. Coexisting ocular diseases affect the treatment options, and some systemic diseases significantly impact cataract development and progression and cataract surgery.

Every optometrist in Finland knows how to conduct a comprehensive eye examination, but the practice varies depending on the workplace. Following the guideline, the essential examinations will be conducted and the results recorded in the patient data, and the follow-up examinations will be reliably compared with previous data.

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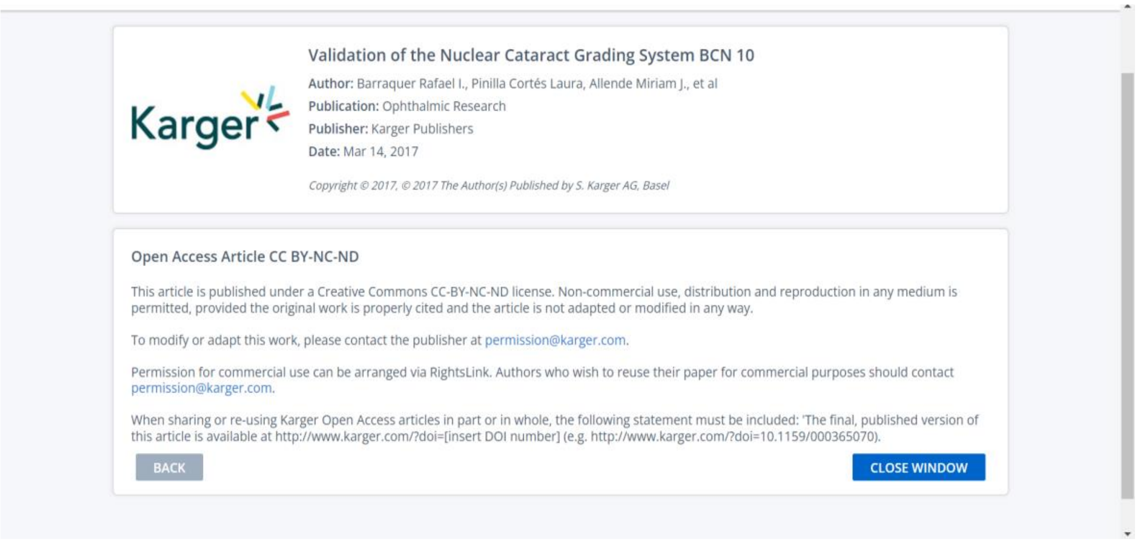

Validation of the Nuclear Cataract Grading System BCN 10

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