SEMMELWEIS EGYETEM

DOKTORI ISKOLA

Ph.D. értekezések

3162.

MAGYAR MÁRTON

Szemészet

című program

Programvezető: Dr. Nagy Zoltán Zsolt, egyetemi tanár

Témavezető: Dr. Nagy Zoltán Zsolt, egyetemi tanár

COMPLICATIONS IN CATARACT SURGERY

Ph.D. thesis

Márton Magyar, MD, FEBO

Semmelweis University Doctoral School

Surgical Medicine Division

Supervisor:	Zoltán Zsolt Nagy, MD, D.Sc.
Official reviewers:	Mária Éva Ferencz, MD, Ph.D.
	Andrea Szigeti, MD, Ph.D.

Head of the Complex Examination Committee:
Miklós Dénes Resch, MD, Ph.D.

Members of the Complex Examination Committee:
Kinga Kránitz MD, Ph.D.
Milán Tamás Pluzsik, MD, Ph.D.

Budapest
2025

Table of Contents

List of abbreviations:

ACIOL	anterior chamber intraocular lens
ACT	anterior capsular tear
AV	anterior vitrectomy
BCVA	best-corrected visual acuity
CCC	continuous curvilinear capsulorhexis
ECCE	extracapsular cataract extraction
ICCE	intracapsular cataract extraction
IOL	intraocular lens
LogMAR	logarithm of the minimum angle of resolution
Nd:YAG	neodymium-doped yttrium aluminium garnet
OVD	ophthalmic viscoelastic devices
PBK	pseudophakic bullous keratopathy
PCIOL	posterior chamber intraocular lens
PCT	posterior capsule tear
PHPV	persistent hyperplastic primary vitreous
PPV	pars plana vitrectomy
SD	standard deviation
SRK/T formula	Sanders Retzlaff Kraff theoretical formula
UCVA	uncorrected visual acuity
UGH syndrome	uveitis-glaucoma-hyphema syndrome

1. Introduction

1.1 Cataract

The human lens is oblate spheroid in shape and is positioned behind the iris in the anterior chamber of the eye. The front surface of the lens contacts the aqueous humour, while the back surface interfaces with the vitreous body. The lens is stabilised by zonular fibres, which connect it to the ciliary body. The entire structure lacks nerves, blood vessels, and connective tissue. Histologically, the lens is composed of three primary components: the capsule, the epithelium, and the lens substance (1).

Cataract is the most common pathology of the lens, resulting in the clouding of the normally transparent structure. This process can impair vision and, if left untreated, may result in blindness. Cataracts typically develop gradually and without pain, often affecting vision and daily life before the individual becomes aware of the problem (1).

1.1.1. Epidemiology, significance

Cataract is a leading cause of global blindness (2). In 2020, about 15 million people over the age of 50 were classified as blind (visual acuity <0.05), while nearly 80 million people over the age of 50 worldwide were estimated to have moderate to severe visual impairment (visual acuity <0.3 to 0.05) due to cataract (3). These numbers represent a 30% increase in cataract-related blindness and a more than 90% rise in moderate to severe visual impairment in comparison to the year 2000. Despite a 30% reduction in the age-corrected frequency of blindness due to cataracts, there has been a 7% increase in moderate to severe visual loss since 2000 (3).

Cataract-related visual impairment mainly affects low- and middle-income countries, where the prevalence of legal blindness, severe and moderate visual impairment can reach up to 10% of the total population, compared with an estimated 1-2% in developed countries (3).

In Hungary, cataract is the third most common cause of blindness, in line with data from developed countries (4). Based on a rapid assessment of avoidable blindness study conducted in 2015, the estimated prevalence of blindness, severe and moderate visual impairment combined was 2.0% (5).

1.1.2. Cataract development

The mechanism of cataract formation in the elderly is not yet fully understood, as various factors can contribute to its development. One of the most crucial aspects of lens physiology is regulating water and electrolyte balance, which plays a key role in maintaining lens transparency. Since transparency relies heavily on the lens's structural and macromolecular components, any disruption in cellular hydration can quickly result in loss of transparency. The lens's most active cells are the epithelial lens cells. The balance of cations between the interior and exterior of the lens is influenced by both the permeability of the lens cell membranes and the activity of sodium-potassium pumps, located within the cell membranes of the lens epithelium (6, 7).

With the aging of the lens, the mass and thickness increase while its accommodative capacity decreases. New layers of cortical fibres form concentrically, compressing and hardening the lens nucleus, a process known as nuclear sclerosis. Modifications and proteolytic cleavage of lens proteins (crystallins) lead to the formation of high molecular weight protein aggregates that can change the local refractive index, scattering light and reducing the transparency of the lens. In addition, chemical changes in the nuclear proteins of the lens contribute to increased opacity, causing the lens to gradually become yellow or brown with age. As the lens ages, there is a decrease in glutathione and potassium concentrations and an increase in sodium and calcium levels in the cytoplasm of lens cells (8).

Cataracts are primarily associated with the aging process; however, other forms have identifiable causes. Congenital lens anomalies and cataracts can be attributed to a number of defined causes. Mechanical injury, physical forces, radiation, and electric currents can directly damage or disrupt cellular function, leading to lens opacities. The use of certain medications, including corticosteroids, phenothiazines, amiodarone, and statins, has been associated with the development of cataracts. In addition, metabolic and systemic diseases such as diabetes mellitus, galactosemia, Wilson's disease, myotonic dystrophy and hypocalcaemia have been associated with the development of lens opacities (7).

1.2. Evolution of cataract surgery

Despite the active pursuit of pharmacological treatments for the disease, a solution remains elusive. Consequently, the only viable alternative is surgical treatment of cataracts. Cataract surgery is the most commonly performed surgical procedure worldwide. According to Eurostat data, 4.32 million cataract surgeries were conducted in Europe in 2023 (9). Since 2015, the annual number of cataract surgeries performed in Hungary has increased to approximately 80,000 (10).

The surgical treatment of cataracts has a long history, with various procedures having been employed for centuries. The earliest documented method of treating cataracts was couching, which was first recorded in the fifth century BC and remained the predominant approach until the eighteenth century. In 1747, Jacques Daviel performed the first early method of extracapsular cataract extraction (ECCE) with large corneal incision. This represented a significant advancement over couching. Despite the considerable postoperative complications, the procedure remained accepted until the nineteenth century. With the advent of intracapsular cataract extraction (ICCE), it briefly became the treatment of choice. However, following further methodological improvements, ECCE once again became the most popular surgical procedure (11).

The introduction of the phacoemulsification (phaco) technique by Charles Kelman in 1967 has had a profound impact on the surgical approach to cataract treatment. During phacoemulsification, an ultrasound-guided needle is used to emulsify and aspirate the lens material. In comparison to ECCE or ICCE, the technique requires much smaller corneal incisions, which results in a reduction of complications and a shorter recovery period (12).

As laser technology advanced in 2008, Professor Nagy became the first surgeon to perform femtosecond laser-assisted cataract surgery worldwide. This procedure involves the use of laser technology to create corneal incisions, an anterior capsular opening, and to fragment the lens. While this technique offers several advantages, the high cost of the femtosecond lasers currently presents a significant barrier to its global adoption (13).

The removal of the crystalline lens, which contains a significant amount of dioptric power, results in a notable loss of visual acuity. Prior to the advent of modern intraocular lenses (IOLs), the achievement of satisfactory postoperative visual rehabilitation was a significant challenge. Harold Ridley is the inventor of the first implantable intraocular lens, which made postoperative intraocular aphakic correction possible (1949). Subsequently, a number of different types of intraocular lens have been employed. From the 1950s onwards, anterior chamber IOLs were the first line of treatment following cataract surgery. As time passed, it became evident that angle-supported anterior chamber IOLs were associated with a number of significant postoperative complications, including bullous keratopathy, glaucoma and intraocular inflammation. This led to a transition towards iris-supported anterior chamber IOLs and, subsequently, to posterior chamber IOLs. From the 1990s, foldable posterior chamber IOLs became the preferred option in the majority of cases, replacing previous lenses. Iris-supported and anterior chamber IOLs remained the preferred treatment option in cases without adequate capsular support (14). The advancement of technology has resulted in a continuous evolution of IOL materials and properties. The correction for astigmatism was first made available in 1992, and with the introduction of multifocal (accommodative or pseudoaccommodative) IOLs, lens surgery has evolved from a treatment for cataracts to a refractive procedure that can also achieve spectacle independence (15).

1.3. Surgical steps of phacoemulsification cataract surgery

The current standard of phacoemulsification cataract surgery is conducted with a clearly defined series of steps, thereby ensuring a high degree of procedural control. In the majority of cases, topical anaesthesia is deemed sufficient for the surgical procedure. However, in certain instances, retrobulbar, peribulbar or sub-tenon block may be required to provide more profound pain control. In certain cases, general anaesthesia may be necessary (16).

Following the administration of preoperative pharmacological pupillary dilation, clear corneal incisions are created. These comprise a sideport incision of 1mm and a multiplanar self-sealing main incision, the dimensions of which range from 1.8 to 3.0mm. During the manipulation of the anterior chamber, ophthalmic viscoelastic devices (OVD) serve to maintain the space and protect the intraocular structures. Subsequently, a continuous curvilinear capsulorhexis (CCC) is performed to open the anterior lens capsule. The lens cortex is then separated from the lens capsule with a jet of saline solution (hydrodissection). The phacoemulsification handpiece is then inserted through the main incision. Following the emulsification and aspiration of the lens material, the capsular bag is cleared thoroughly, into which the folded IOL is inserted. Once the OVD has been removed, the clear corneal incisions seal themselves (in some cases, the wounds may require hydration) (11).

1.4. Complications of cataract surgery

The overall success rate of phacoemulsification cataract surgery is exceptionally high. However, it is not possible to obtain an exact figure for the overall complication rate due to the fact that in some countries the documentation of minor complications is not standardised and some complications may occur several years after the primary cataract surgery. The complications can be separated into two categories: intraoperative (perioperative) complications and late postoperative complications. The overall intraoperative complication rate varies considerably, from approximately 1% to 5% (17-9).

In the majority of cases, complications that can affect postoperative outcomes affect the lens capsule. The capsule is relatively delicate, and manipulation within the eye can result in disruption to either the anterior or posterior capsular surface. The incidence of a posterior capsular tear is variable, with reported figures ranging from 0.45% to 5% (20). In contrast, anterior rupture occurs in approximately 1% of surgical procedures (21). In the event of an anterior rupture extending posteriorly or a posterior rupture occurring, vitreous material may appear in the anterior segment, necessitating an anterior vitrectomy. One of the most feared complications is a dropped nucleus, whereby cortical or nuclear fragments may enter the vitreous cavity through a posterior rupture. In such cases, conversion to a posterior pars plana vitrectomy (PPV) may be necessary.

In some cases, damage may occur to the zonular fibres that fixate the capsular bag, resulting in zonular dialysis or zonular fibre loss. The surgeon must determine whether the damaged capsule is an appropriate location for housing an IOL or if an alternative fixation method is required to prevent late complications such as IOL dislocation (22).

Iris damage may occur during surgery, predominantly due to iris prolapse, which is more prevalent in cases of pre-existing floppy iris or inadequate corneal wounds (23).

A rare but potentially serious complication is suprachoroidal bleeding (expulsive bleeding). This is estimated to occur in approximately 0.15% of cases, necessitating the immediate termination of the procedure. In such instances, the visual outcome may be unfavourable (23).

Other intraoperative complications, including wound burn, Descemet's detachment, hyphema, or IOL implantation problems, occur infrequently and the precise frequency remains uncertain (23).

A number of postoperative complications may arise that could potentially impact the success of cataract surgery. The most common postoperative complication is cystoid macular oedema, occurring in approximately 1-2% of cases in the absence of intraoperative complications (22). Endothelial cell loss and pseudophakic bullous keratopathy (PBK) have been reported in approximately 0.3-0.5% of cases following phacoemulsification surgery, with the potential to result in significant visual disruption (23).

Dislocation of the implanted IOL is postoperative complication that may give rise to a number of additional issues, therefore it is the most frequent indication for the removal of intraocular lenses. The patient group affected by IOL dislocation is not homogeneous. It can be classified as either in-the-bag or out-of-the-bag dislocation. In the former case, the IOL remains in the capsular bag, and the movement is due to zonular dehiscence. In the latter case, the capsular bag has ruptured, leading to the displacement of the IOL alone (24).

The incidence of IOL explantation following primary cataract surgeries is estimated to range between 0.59% and 0.77% (25, 26). The surgical removal and replacement of an IOL can be complex and may carry a risk of significant complications (27).

Although postoperative endophthalmitis is uncommon, it remains the most serious complication, frequently resulting in significant visual impairment. Recent studies have estimated the incidence of this complication to be 0.09% following primary phacoemulsification surgery (28).

2. Objectives

The objective of our research was to analyse complications associated with cataract surgery. First, we evaluated the rates of complications among different surgeon groups, with a focus on resident trainees, staff surgeons, and a comparison between women and men performing primary phacoemulsification cataract surgeries. Second, we examined the circumstances of intraocular lens explantation, a less common yet complex procedure. To achieve these objectives, the aims of the presented studies were as follows:

- ◊ To determine and compare the incidence and types of intraoperative complications during phacoemulsification cataract surgery between operations performed resident trainees and specialists at a tertiary eyecare centre in Hungary.
- ◊ To objectively assess the order of difficulty of phaco surgery steps for resident trainees.
- ◊ To determine and compare the incidence and types of intraoperative complications during phacoemulsification cataract surgery between operations performed by men and women surgeons at at a tertiary eyecare centre in Hungary.
- ◊ To assess whether patient-surgeon gender discordance or concordance affects intraoperative complication rates.
- ◊ To evaluate the indications and outcomes of IOL explantations and exchange at a tertiary eyecare centre in Hungary.

3. Methods

3.1. Ethical approval

Our retrospective studies were carried out at the Department of Ophthalmology, Semmelweis University, Budapest, Hungary. Approval for the study was obtained from the Regional and Institutional Committee of Science and Research Ethics of Semmelweis University (approval numbers 121/2021 and 95/2022). The studies were conducted in accordance with the Declaration of Helsinki Guidelines for Human Research.

3.2. Statistical analysis

In all of our studies the statistical analysis was conducted using the software package Statistica 8.0 (StatSoft Inc., Tulsa, OK, USA). The data are presented as the mean ± standard deviation (SD). The chi-square test was employed for the purpose of analysing the differences in the proportions of categorical variables. In order to compare two treatment groups, the Student's t-test was employed when the data exhibited a normal distribution, whereas the non-parametric Mann-Whitney U-test was used for non-normally distributed variables. In order to compare the visual acuity values recorded prior to and following the IOL explantation surgeries, a non-parametric Wilcoxon test was employed. A p-value of less than 0.05 was considered to be statistically significant.

3.3. Complications in cataract surgery performed by resident trainees and specialists

Our retrospective review included 3,272 consecutive patients over the age of 17 years who underwent primary phacoemulsification cataract surgery performed by residents and specialists over a 12-month period, from 1st January 2019 to 31st December 2019.. For each subject, a comprehensive review of the clinical data was conducted. A comprehensive data set was extracted from the medical records, final reports and surgical descriptions. Data encompassed patient demographics, including sex, age, and eye laterality, as well as clinical history, including details of previous intraocular surgeries. Additionally, the preoperative and postoperative ophthalmological status, along with the case complexity, were evaluated. The cases were divided into simple and complex surgeries. Furthermore, the operative details, such as the usage of trypan blue dye staining, iris hooks, and intraoperative complications, were also analysed.

The factors contributing to the replacement of resident trainees by specialists during phaco surgery were identified with the objective of analysing which surgical steps were the most challenging for resident trainees. A total of 40 surgeons participated in the surgeries, comprising 31 specialists and 9 resident trainees. All resident trainees and specialists who performed cataract surgery during the study period were included. One resident was in their second year of residency, three were in their third, three were in their fourth, and two were in their fifth year. All phaco surgeries entailed clear corneal incisions, continuous curvilinear capsulorhexis, and hydrodissection.

3.4. Complications in cataract surgery performed by women and men surgeons.

Our retrospective review encompassed 2,156 consecutive patients over the age of 17 years who underwent primary phacoemulsification cataract surgery by specialists over the course of one year, from 1st January 2019 to 31st December 2019. There were no exclusion criteria regarding the patients. For each subject, a comprehensive review of the clinical data was conducted. A comprehensive data set was extracted from the medical records, final reports and surgical descriptions. Data encompassed patient demographics, including sex, age, and eye laterality, as well as clinical history, including details of previous intraocular surgeries. Additionally, the preoperative and postoperative ophthalmological status, along with the case complexity, were evaluated. Furthermore, the operative details, such as the usage of trypan blue dye staining, iris hooks, and intraoperative complications, were also analysed. A total of 20 specialists were included in the study (12 men, 8 women). Specialists who performed fewer than 2 operations and those who performed more than 10 operations per week were excluded from the study. Data was gathered regarding the surgeons, including their gender, age, and the number of phaco procedures they had performed. All phaco surgeries entailed clear corneal incisions, continuous curvilinear capsulorhexis, and hydrodissection.

3.5. Indications and outcomes of intraocular lens explantation

Our retrospective study encompasses a review of all patients who underwent intraocular lens explantation surgery between January 2006 and December 2020. No exclusion criteria were made. For each subject, a comprehensive review of the clinical data was conducted. A comprehensive data set was extracted from the medical records, final reports and surgical descriptions. Data encompassed patient demographics, including sex, age, and eye laterality, as well as clinical history, including details of previous intraocular surgeries Furthermore, the preoperative and postoperative ophthalmological status, the time interval between primary IOL implantation and explantation, and the details of the surgical procedure (including any concomitant surgeries, the reason for explantation, and the characteristics of the implanted IOL) were evaluated. A total of 23 specialists performed the included IOL explantations. The IOL explantations were performed by through the enlargement of the main incision, bisection, and subsequent removal of the IOL. The IOL calculation was based on measurements obtained using the IOLMaster 500 (Carl Zeiss Meditec, Germany) and the Hoffer Q, SRK/T, Haigis, and Haigis-L formulas. In cases of sulcus fixation, the power of the intraocular lens (IOL) was reduced by 0.5 to 1.0 diopter from the power measured in the capsular bag.

The data regarding uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) were converted from values obtained from the Snellen chart to the LogMAR format. At the four-month postoperative visit, UCVA and BCVA were analysed. In the case of iris-claw IOL implantations, a six-week observation period was initiated following the removal of the suture, prior to the commencement of visual acuity analysis.

4. Results

4.1. A comparative analysis of the incidence of intraoperative complications in cataract surgery performed by resident trainees and specialists

Our study comprised 3,272 consecutive phacoemulsification cataract surgeries, among the cases 1,261 were men (38.5%) and were 2,011 women (61.5%). Among these patients 50.7% underwent surgery on the right eye, while 49.3% had surgery on the left eye. The average patient age was 69.8 ± 11.1 years, ranging from 17 years to 98 years. The main type of cataract was cortical (96.5%), followed by mature (2.4%), posterior polar (0.6%), traumatic (0.2%), hypermature (0.1%).

In the majority of cases, surgeons used topical anaesthesia (n=2,379; 72.7%), followed by retrobulbar anaesthesia (n=816; 25.0%) and general anaesthesia (n=77; 2.3%). Trypan blue dye staining of the anterior capsule was applied in 120 cases (3.7%), and iris hooks were used in 92 cases (2.8%).

Table 1. Cataract surgery complexities among 597 complex cases.

Complexity	**% (n)**
Previous vitrectomy	4.8% (n=156)
High axial myopia	3.5% (n=114)
Corneal disease (scar, dystrophy, keratoconus, etc.)	3.3% (n=107)
Narrow angles	2.3% (n=74)
Pseudoexfoliation or zonular fibre instability	1.6% (n=53)
Intraoperative floppy-iris syndrome	1.5% (n=50)
Special cataract types (posterior polar, traumatic, hypermature)	0.9% (n=30)
Challenges with patient cooperation	0.9% (n=28)
History of glaucoma filtration surgery	0.6% (n=19)
Previous keratoplasty	0.5% (n=17)
Posterior synechiae	0.3% (n=10)
Anatomical variations in body habitus	0.06% (n=2)
Miscellaneous factors	0.2% (n=6)

Cataract cases were categorised into simple and complex surgeries. **Table 1** shows the most common ocular factors contributing to the case being complex: previous vitrectomy (4.8%), high axial myopia (3.5%), corneal scar, corneal dystrophy or keratoconus (3. 3%), narrow angles (2.3%), pseudoexfoliation or zonular fibre compromise (1.6%) and small pupil or intraoperative floppy-iris syndrome (1.5%).

Of the total cases, 2,675 (81.8%) were classified as simple and 597 (18.2%) as complex.

Of all surgeries, 92.6% (n=3031) were completed solely by specialists, while 7.4% (n=241) involved resident trainees, either performing independently or with help of a specialist. In cases involving resident trainees, 45.6% were completed with a specialist's assistance.

The intraoperative complication rate was 5.4% in the whole sample (n=177) (**Table 2**). Complications were significantly ($P<0.001$) more common in surgeries performed by resident trainees (13.7%, n=33) compared to those done by specialists (4.8%, n=144).

Table 2. Intraoperative complication rates of cataract surgery in the total sample, in cases of surgeries operated by resident trainees and specialists.

Complication	**Total sample (n=3272)**	**Resident trainees (n=241)**	**Specialists (n=3031)**
Posterior capsule tear	2.60% (n=85)	6.22% (n=15)	2.31% (n=70)
- *Without vitreous loss*	0.95% (n=31)	2.07% (n=5)	0.86% (n=26)
- *With vitreous loss*	1.65% (n=54)	4.15% (n=10)	1.45% (n=44)
Dropped nucleus	0.46% (n=15)	2.07% (n=5)	0.33% (n=10)
Anterior capsule tear	1.53% (n=50)	5.81% (n=14)	1.19% (n=36)
Zonular fibre loss	1.38% (n=45)	3.32% (n=8)	1.22% (n=37)
Intraocular lens dislocation	0.09% (n=3)	0.41% (n=1)	0.07% (n=2)
Hyphema	0.06% (n=2)	0	0.07% (n=2)
Broken intraocular lens haptic	0.03% (n=1)	0	0.03% (n=1)
Expulsive bleeding	0.03% (n=1)	0	0.03% (n=1)

For simple cases, the complication rate was 5.3% (n=127), and, as with the overall trend, was significantly higher among resident trainees (13.4%, n=29) than among specialists

(4.0%, n=98) (P<0.001). Specialists managed a significantly higher number of complex cataract surgeries (96.0%, n=573) compared to resident trainees (4.0%, n=24) (P<0.001). For these complex cases, the complication rate was 8.4% (n=50), showing no significant difference (P=0.13) between resident trainees (16.7%, n=4) and specialists (8.0%, n=46).

The most frequent intraoperative complications in the study population were posterior capsule tear (PCT) (2.6%, n=85), PCT with vitreous loss (1.65%, n=54), anterior capsule tear (ACT) (1.5%, n=50), and zonular fibre loss (1.3%, n=45). Anterior vitrectomy (AV) was necessary in 58 cases (1.8%) and pars plana vitrectomy in 21 cases (0.6%). Both anterior vitrectomy and pars plana vitrectomy were more frequently performed during surgeries involving resident trainees (5.0%, n=12, and 2.5%, n=6, respectively) than by specialists alone (1.5%, n=46, and 0.5%, n=15, respectively) (P<0.001 for both).

Resident replacement during cataract surgery occurred in 66 cases during phacoemulsification (60.0%), in 21 cases (19.1%) during capsulorhexis, in 13 cases (11.8%) during irrigation/aspiration, in 9 cases (8.2%) during hydrodissection and in 1 case (0.9%) during intraocular lens (IOL) implantation.

In the overall study population, 96.9% of patients had an IOL implanted in the capsular bag and 1.9% in the ciliary sulcus. An iris-claw IOL was implanted in 0.3% of cases and 0.9% were left aphakic after primary surgery. A significantly higher number of patients were left aphakic after phaco surgery performed by resident trainees (2.9%, n=7) than by specialists (0.8%, n=25) (P<.01).

4.2. A comparative analysis of the incidence of intraoperative complications in cataract surgery performed by women and men surgeons

The study included 2,156 cases, with 1,295 surgeries (60.1%) performed by men surgeons and 861 surgeries (39.9%) performed by women surgeons. There were 12 men surgeons (mean age 47.8 ± 6.7 years, range: 37 to 60 years) and 8 women surgeons (mean age 48.9 ± 6.9 years, range: 40 to 59 years). On average, women surgeons completed 107.6 surgeries, while men surgeons completed 99.6 surgeries.

The study population consisted of 1,096 women (50.8%) and 1,060 men (49.2%). The average age of the patients was 70.8 ± 10.7 years, with an age range from 17 to 98 years. Among the total sample, 51.3% (n=1,105) underwent surgery on the right eye, and 48.7% (n=1051) had surgery on the left eye. The types of cataracts identified included 96.4% (n=2,079) corticonuclear, 2.5% (n=53) mature, 0.3% (n=7) traumatic, 0.2% (n=5) posterior polar, 0.2% (n=5) subcapsular, 0.1% (n=3) hypermature, and 0.2% (n=4) unclassified cases. A detailed breakdown of patient demographics, laterality, and cataract types, segmented by surgeries performed by women and men surgeons, is provided in **Table 3**.

Table 3. Patient demographics, laterality and cataract types in the total sample, and cases operated by women and men surgeons.

	Total sample	**Women surgeons**	**Men surgeons**
Patient gender			
Women	50.8% (n=1,096)	36.7% (n=316)	60.2% (n=780)
Men	49.2% (n=1,060)	63.3% (n=545)	39.8% (n=515)
Patient age			
Age	70.8 ± 10.7 years (range 17–98)	71.8 ± 10.4 years (range 18–98)	70.2 ± 10.8 years (range 17–97)
Operated eye			
Right eye	51.3% (n=1,105)	51.3% (n=442)	52.6% (n=663)
Left eye	48.7% (n=1,051)	48.7% (n=419)	47.3% (n=596)
Cataract type			
Corticonuclear	96.4% (n=2,079)	96.3% (n=829)	96.5% (n=1,250)
Mature	2.5% (n=53)	2.1% (n=18)	2.7% (n=35)
Traumatic	0.3% (n=7)	0.5% (n=4)	0.2% (n=3)
Posterior polar	0.2% (n=5)	0.2% (n=2)	0.2% (n=3)
Subcapsular	0.2% (n=5)	0.2% (n=2)	0.2% (n=3)
Hypermature	0.1% (n=3)	0.1% (n=2)	0.1% (n=1)
Unclassifiable	0.2% (n=4)	0.5% (n=4)	0

There were 1,618 (75.0%) simple cataract surgeries among which 958 (59.2%) were operated by men and 660 (40.8%) by women surgeons. 538 (25.0%) were complex cataract cases. Men practitioners performed 337 (62.6%) women surgeons 201 (37.4%) complex operations. The proportion of complex operations was 26.0% for men surgeons and 23.3% for women surgeons. **Table 4** shows the most common complexities in the whole sample and amongst surgeries performed by women and men practitioners. The most frequent complexities in the study population were patients with earlier vitrectomy (n=144; 6.7%), high axial myopia (n=76; 3.5%), corneal scar, corneal dystrophy or keratoconus (n=52; 2.4%), narrow angles (n=49; 2.3%), pseudoexfoliation or zonular fibre compromise (n=37; 1.7%), and small pupil or intraoperative floppy-iris syndrome (n=26; 1.2%).

Table 4. Rates of the most common complexities in the whole sample, and cases operated by women and men surgeons.

Complexity	**Whole sample**	**Women surgeons**	**Men surgeons**
Previous vitrectomy	6.7% (n=144)	5.0% (n=43)	7.8% (n=101)
High axial myopia	3.5% (n=76)	2.6% (n=22)	4.2% (n=54)
Corneal disease	2.4% (n=52)	2.7% (n=23)	2.2% (n=29)
Narrow angles	2.3% (n=49)	1.6% (n=14)	2.7% (n=35)
Pseudoexfoliation or zonular fibre instability	1.7% (n=37)	2.2% (n=19)	1.4% (n=18)
Intraoperative floppy-iris syndrome	1.2% (n=26)	1.2% (n=10)	1.2% (n=16)
Special cataract types	0.7% (n=16)	0.9% (n=8)	0.6% (n=8)
Challenges with patient cooperation	0.3% (n=6)	0.1% (n=1)	0.4% (n=5)
History of glaucoma filtration surgery	0.6% (n=12)	0.5% (n=4)	0.6% (n=8)
Previous keratoplasty	0.6% (n=12)	0.8% (n=7)	0.4% (n=5)
Posterior synechiae	0.3% (n=6)	0.2% (n=2)	0.3% (n=4)
Anatomical variations in body habitus	0.05% (n=1)	0% (n=0)	0.1% (n=1)
Miscellaneous factors	0.2% (n=4)	0.2% (n=2)	0.2% (n=2)

A total of 1,939 surgeries (89.9%) were performed under topical anaesthesia, with 1,176 (90.8%) performed by men surgeons and 763 (88.6%) by women surgeons. Retrobulbar anaesthesia was utilized in 164 cases (7.6%), of which 86 (6.6%) were conducted by men and 78 (9.1%) by women. General anaesthesia was used in 53 cases (2.5%), of which 33 (2.5%) were performed by men surgeons and 20 (2.3%) by women surgeons.

Trypan blue dye was used to stain the anterior capsule in 68 cases (3.2%), of which 40 (3.1%) were performed by men surgeons and 28 (3.3%) by women surgeons.

The overall intraoperative complication rate was 4.7% (n=101), with no significant difference observed between surgeries performed by men surgeons (4.6%, n=59) and women surgeons (4.9%, n=42) (p=0.728). Complication rates were further analysed based on surgeon gender in both women and men patient cases. Additionally, we examined complication rates in simple versus complex cataract cases across the two surgeon gender groups, as well as between women and men patient groups. No significant differences were identified in any of the comparisons (**Table 5**).

Table 5. Complication rates and P values in cases of women and men patients operated by women and men surgeons in the whole sample, in simple and complex cases.

	All patients	Men patients	Women patients	P value
		Whole sample		
Men surgeons	4.6% (n=59)	5.6% (n=29)	3.8% (n=30)	p=0.131
Women surgeons	4.9% (n=42)	4.6% (n=25)	5.3% (n=17)	p=0.602
P value	p=0.728	p=0.439	p=0.256	
		Simple cases		
Men surgeons	3.3% (n=32)	4.4% (n=16)	2.7% (n=16)	p=0.133
Women surgeons	4.5% (n=30)	5.1% (n=12)	4.2% (n=18)	p=0.594
P value	p=0.214	p=0.711	p=0.169	
		Complex cases		
Men surgeons	8.0% (n=27)	8.3% (n=13)	7.8% (n=14)	p=0.865
Women surgeons	6.5% (n=13)	9.8% (n=8)	5.8% (n=7)	p=0.328
P value	p=0.508	p=0.744	p=0.530	

The most frequent intraoperative complications in the overall study sample were posterior capsule tear (PCT) (2.4%, n=51), PCT without vitreous loss (1.3%, n=27), anterior capsule tear (ACT) (1.3%, n=27), zonular fibre loss (1.2%, n=25), and PCT with vitreous loss (1.1%, n=24). For surgeries performed by women surgeons, the most common complications were PCT (2.4%, n=21), PCT without vitreous loss (1.5%, n=13), zonular fibre loss (1.4%, n=12), and ACT (1.0%, n=9). In contrast, for surgeries performed by men surgeons, the most common complications were PCT (2.3%, n=30), ACT (1.4%, n=18), PCT with vitreous loss (1.2%, n=16), PCT without vitreous loss (1.1%, n=14), and zonular fibre loss (1.0%, n=13) (**Table 6**).

Table 6. Cataract surgery complication rates in the total sample and in case of surgeries operated by women and men surgeons.

Complication	Total sample	Women surgeons	Men surgeons
Posterior capsule tear	2.4% (n=51)	2.4% (n=21)	2.3% (n=30)
- Without vitreous loss	1.3% (n=27)	1.5% (n=13)	1.1% (n=14)
- With vitreous loss	1.1% (n=24)	0.9% (n=8)	1.2% (n=16)
Dropped nucleus	0.3% (n=7)	0.3% (n=3)	0.3% (n=4)
Anterior capsule tear	1.3% (n=27)	1.0% (n=9)	1.4% (n=18)
Zonular fibre loss	1.2% (n=25)	1.4% (n=12)	1.0% (n=13)
Intraocular lens dislocation	0.1% (n=2)	0.1% (n=1)	0.1% (n=1)
Expulsive bleeding	0.05% (n=1)	0% (n=0)	0.1% (n=1)

Anterior vitrectomy was carried out in 28 cases (1.3%), with 18 cases (1.4%) performed by men surgeons and 10 cases (1.2%) by women surgeons. Pars plana vitrectomy was required in 12 surgeries (0.6%), 7 (0.5%) of which were performed by men surgeons and 5 (0.6%) by women surgeons. No significant differences were found between the two groups in the rates of anterior vitrectomy (p=0.458) or posterior vitrectomy (p=0.995).

In the overall study population, IOLs were implanted in the capsular bag in 97.6% (n=2,104) of cases and in the ciliary sulcus in 1.4% (n=31) of cases. Iris-claw IOLs were used in 0.1% (n=2) of cases, and 0.9% (n=19) of patients were left aphakic after the primary surgery. Among the cases operated by men surgeons, IOLs were placed in the capsular bag in 97.8% (n=1,266) of cases, in the ciliary sulcus in 1.2% (n=16), iris-fixated in 0.2% (n=2), and 0.8% (n=11) of patients were left aphakic. For cases performed by women surgeons, 97.3% (n=838) of IOLs were implanted in the capsular bag, 1.7% (n=15) in the ciliary sulcus, and 0.9% (n=8) of patients were left aphakic.

4.3. Analysis of the indications and outcomes of intraocular lens explantation

Over the 15-year study period, 161 IOLs were removed from 153 patients, including men (62.7%, n=96) and women (37.3%, n=57), with an average age of 65.0 ± 17.4 years (range: 2–88 years). Among these patients, 44.7% (n=72) had surgery on the right eye, while 55.3% (n=89) had surgery on the left eye. The annual number of IOL explantation surgeries is shown in **Figure 1**. Of all individuals undergoing IOL explantation, 49.7% (n=80) had primary phacoemulsification with IOL implantation performed in our department, while 50.3% (n=81) were referred solely for IOL removal at our clinic.

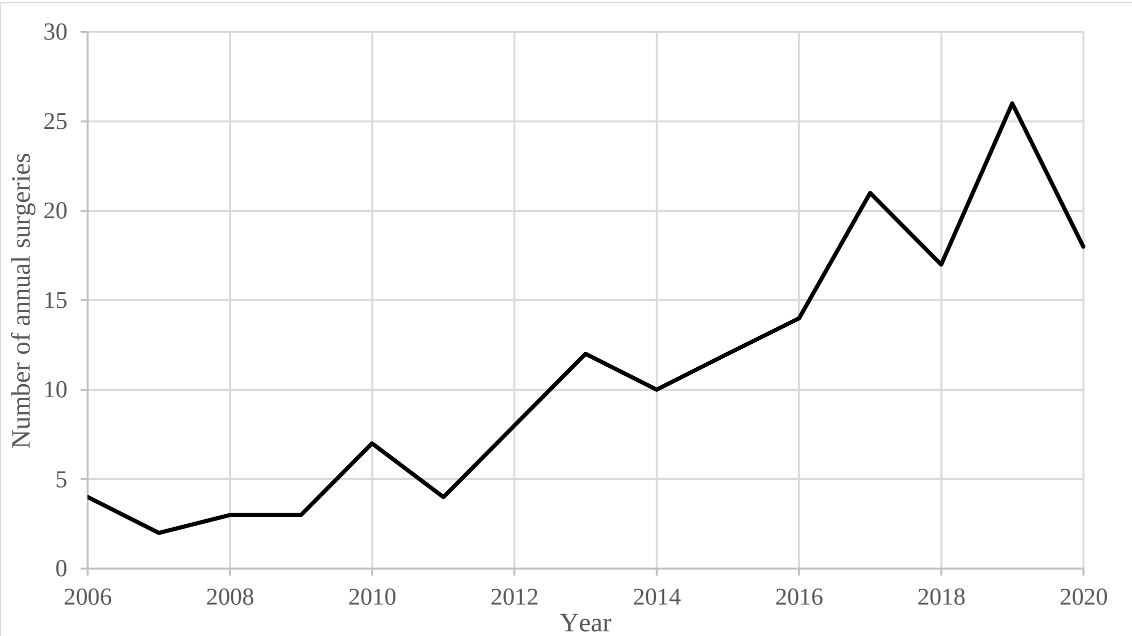

Figure 1. Number of intraocular lenses explanted each year between 2006 and 2020 at the Department of Ophthalmology, Semmelweis University, Budapest, Hungary.

A total of 22 anterior chamber intraocular lenses (ACIOLs), representing 13.7%, and 139 posterior chamber intraocular lenses (PCIOLs), representing 86.3%, were explanted.

Within the PCIOL group, primary IOLs implanted in the capsular bag accounted for 82.7% (n=115), sulcus-fixated IOLs for 11.5% (n=16), and scleral-fixated IOLs for 5.8% (n=8). Among all explanted IOLs, one-piece IOLs made up 48.4% (n=78), three-piece PCIOLs constituted 33.5% (n=54), and unclassifiable IOLs, where data were unavailable, represented 18.0% (n=29).

The primary indications for ACIOL explantation were pseudophakic bullous keratopathy (63.6%, n=14), dislocation (18.2%, n=4), and refractive causes (9.1%, n=2). For PCIOL explantation, the main causes included IOL dislocation (95.7%, n=133) and refractive causes (1.4%, n=2) **(Table 7**). The IOL dislocation group comprised in-the-bag dislocations (56.2%, n=77), out-of-the-bag dislocations (36.5%, n=50), scleral-fixated IOL dislocations (4.4%, n=6), and ACIOL dislocations (2.9%, n=4).

Table 7. Indications for IOL explantation in the whole sample, in cases of anterior chamber intraocular lens (ACIOL) explanation and posterior chamber intraocular lens (PCIOL) explantation.

	Whole sample (n=161)	**ACIOL explantation (13.7%, n=22)**	**PCIOL explantation (86.3%, n=139)**
IOL dislocation	85.1% (n=137)	18.2% (n=4)	95.7% (n=133)
PBK	9.3% (n=15)	68.2% (n=15)	0% (n=0)
Refractive surprise	1.9% (n=3)	4.5% (n=1)	1.4% (n=2)
Endophthalmitis	0.6% (n=1)	0% (n=0)	0.7% (n=1)
Unclassifiable	3.1% (n=5)	9.1% (n=2)	2.2% (n=3)

ACIOL = anterior chamber intraocular lens, PBK = pseudophakic bullous keratopathy, PCIOL = posterior chamber intraocular lens, IOL = intraocular lens

The most common ocular comorbidities included previous vitrectomy (31.1%, n=50), ocular trauma (28.0%, n=45), glaucoma (9.9%, n=16), pseudoexfoliation syndrome (9.3%, n=15), corneal disorders (10.5%, n=14), high axial myopia (≥26 mm) (8.7%, n=14), and macular diseases (6.8%, n=11). **Table 8** displays the distribution of ocular comorbidities among eyes with in-the-bag dislocation, out-of-the-bag dislocation, scleral fixated, and ACIOL explantation groups. In cases of in-the-bag and out-of-the-bag dislocations, the most prevalent ocular comorbidities were previous ocular trauma (33.9%, n=43), previous vitrectomy (33.1%, n=42), and pseudoexfoliation syndrome (11.8%, n=15).

Table 8. Ocular comorbidities in patients undergoing intraocular lens explantation.

			PCIOL explantation					
	Whole sample	**ACIOL explantation**	***PCIOL dislocation***			***Refractive surprise***	***Endophthalmitis***	***Unknown***
			In-the-bag dislocation	*Out-of-the-bag dislocation*	*Scleral fixated IOL explantation*			
Previous vitrectomy	31.1% (n=50)	22.7% (n=5)	37.7% (n=29)	26.0% (n=13)	16.7% (n=1)	0	100% (n=1)	66.7% (n=2)
History of ocular trauma	28.0% (n=45)	18.2% (n=4)	37.7% (n=29)	28.0% (n=14)	33.3% (n=2)	0	0	0
Corneal disease	10.5% (n=17)	54.5% (n=12)	2.6% (n=2)	8.0% (n=4)	0	0	0	66.7% (n=2)
Glaucoma	9.9% (n=16)	9.1% (n=2)	10.4% (n=8)	14.0% (n=7)	0	0	0	33.3% (n=1)
Pseudoexfoliation syndrome	9.3% (n=15)	0	19.5% (n=15)	0	0	0	0	0
High axial myopia	8.7% (n=14)	0	7.8% (n=6)	4.0% (n=2)	0	0	0	0
Macular diseases	6.8% (n=11)	9.1% (n=2)	6.5% (n=5)	6.0% (n=3)	0	0	0	0
Uveitis	5.0% (n=8)	0	6.5% (n=5)	2.0% (n=1)	0	0	0	33.3% (n=1)
Marfan syndrome	4.3% (n=7)	0	1.3% (n=1)	6.0% (n=3)	66.7% (n=4)	0	0	0
Mature cataract	2.5% (n=4)	4.5% (n=1)	1.3% (n=1)	4.0% (n=2)	0	0	0	0
PHPV	0.6% (n=1)	0	1.3% (n=1)	0	0	0	0	0
Retinopathy of prematurity	0.6% (n=1)	0	1.3% (n=1)	0	0	0	0	0
Microphthalmos	0.6% (n=1)	4.5% (n=1)	0	0	0	0	0	0

ACIOL = anterior chamber intraocular lens, IOL = intraocular lens, PCIOL = posterior chamber intraocular lens, PHPV = persistent hyperplastic primary vitreous

The average time between primary cataract surgery and IOL explantation was 8.5 ± 7.7 years for the entire sample, with a range of 0 to 33.9 years. There was no significant difference (p = 0.98) in the mean time between primary IOL implantation and explantation for eyes with ACIOL (8.7 ± 7.6 years; range: 0–28.7 years) compared to PCIOL (13.1 ± 10.8 years; range: 0–33.9 years).

Penetrating keratoplasty was performed concurrently in 18 cases, 10 of which were combined with ACIOL removal. Anterior vitrectomy was performed at the time of IOL explantation in 16.1% (n=26) of patients, while pars plana vitrectomy was performed in 47.2% (n=76) of eyes. Simultaneous IOL implantation occurred in 81.4% (n=131) of patients, 18.6% (n=30) of eyes left aphakic after IOL removal. Among the aphakic eyes, 15.5% (n=25) received an IOL in a subsequent procedure, while 3.1% (n=5) remained aphakic permanently due to poor visual prognosis. Overall, the most common secondary IOL implants were prepupillary (73.7%, n=115) and retropupillary iris-claw IOLs (20.5%, n=32).

Table 9. Comparison of the preoperative uncorrected visual acuity (UCVA) and postoperative UCVA in the whole sample, in the PCIOL and ACIOL groups. Data are presented as mean ± SD (minimum-maximum).

	Preop. UCVA (LogMAR)	**Postop. UCVA (LogMAR)**	**P value**
Total sample	1.57 ± 0.61 (2.40-0.05)	0.77 ± 0.56 (2.40-0.00)	< 0.001
PCIOL group	1.55 ± 0.62 (2.40-0.05)	0.69 ± 0.52 (2.40-0.00)	< 0.001
ACIOL group	1.69 ± 0.50 (2.40-0.60)	1.32 ± 0.52 (2.20-0.50)	0.016

ACIOL = anterior chamber intraocular lens, PCIOL = posterior chamber intraocular lens,
UCVA = uncorrected visual acuity, LogMAR = logarithm of the minimum angle of resolution

Table 10. Uncorrected visual acuity (UCVA) before and after intraocular lens explantation in the whole sample and categorised by indication for explantation. Data are presented as mean ± SD (minimum-maximum).

Indication	**Preop. UCVA (LogMAR)**	**Postop. UCVA (LogMAR)**	**P value**
Total sample	1.57 ± 0.61 (2.40-0.05)	0.77 ± 0.56 (2.40-0.00)	< 0.001
IOL dislocation	1.53 ± 0.63 (2.00-0.05)	0.67 ± 0.52 (2.00-0.00)	< 0.00001
Pseudophakic bullous keratopathy	1.86 ± 0.32 (2.00-0.60)	1.27 ± 0.49 (2.00-0.60)	< 0.05
Refractive surprise	0.14± 0.92 (2.00-0.70)	0.85 ± 0.92 (1,5-0.20)	small sample size
Endophthalmitis	2.00	0.80	small sample size
Unclassifiable	1.28 ± 0.70 (2.00-0.40)	1.06 ± 0.61 (2.00-0.30)	small sample size

BCVA = best corrected visual acuity, IOL = intraocular lens, LogMAR = logarithm of the minimum angle of resolution

UCVA before IOL explantation showed no significant difference (p = 0.96) between the ACIOL group (1.69 ± 0.50; range: 2.40–0.60) and the PCIOL group (1.55 ± 0.62; range: 2.40–0.05). UCVA improved significantly after IOL exchange in the overall sample (1.57 ± 0.61; range: 2.40–0.05 vs. 0.77 ± 0.56; range: 2.40–0.00; p < 0.001), within the ACIOL group (1.69 ± 0.50; range: 2.40–0.60 vs. 1.32 ± 0.52; range: 2.20–0.50; p = 0.016), and within the PCIOL group (1.55 ± 0.62; range: 2.40–0.05 vs. 0.69 ± 0.52; range: 2.40–0.00; p < 0.001). (**Table 9**) Post-explantation UCVA after IOL exchange showed no significant difference (p = 0.46) between the ACIOL group (1.32 ± 0.52; range: 2.20–0.50) and the PCIOL group (0.69 ± 0.52; range: 2.40–0.00). UCVA significantly improved after surgery in the IOL dislocation (1.53 ± 0.63; range: 2.00-0.05 vs. 0.67 ± 0.52; range: 2.00-0.00; p< 0.00001) and pseudophakic bullous keratopathy (1.86±0.32; range: 2.00-0.60 vs. 1.27 ± 0.49; range: 2.00-0.60; p < 0.05) indication groups (**Table 10).**

BCVA improved in 62.7% of eyes (n=101), remained unchanged in 18.0% (n=29), and worsened in 19.3% (n=31). There was no significant change in BCVA after IOL exchange in the overall sample (0.92 ± 0.72; range: 2.40–0.00 vs. 0.63 ± 0.56; range: 2.40–0.00; p

= 0.96), in the ACIOL group (1.40 ± 0.70; range: 2.00–0.20 vs. 0.88 ± 0.42; range: 1.70–0.00; p = 0.79), or in the PCIOL group (0.87 ± 0.69; range: 2.40–0.00 vs. 0.57 ± 0.57; range: 2.40–0.00; p = 0.63) (**Table 11**).

Additionally, BCVA did not change significantly after IOL explantation in any indication group (**Table 12**).

Table 11. Comparison of the preoperative best-corrected visual acuity (BCVA) and postoperative BCVA in the whole sample, in the PCIOL and ACIOL groups. Data are presented as mean ± SD (minimum-maximum).

	Preop. BCVA (LogMAR)	**Postop. BCVA (LogMAR)**	**P value**
Total sample	0.92 ± 0.72 (2.40-0.00)	0.63 ± 0.56 (2.40-0.00)	0.96
PCIOL group	0.87 ± 0.69 (2.40-0.00)	0.57 ± 0.57 (2.40-0.00)	0.63
ACIOL group	1.40 ± 0.70 (2.00-0.20)	0.88 ± 0.42 (1.70-0.00)	0.79

ACIOL = anterior chamber intraocular lens, BCVA = best corrected visual acuity, LogMAR = logarithm of the minimum angle of resolution, PCIOL = posterior chamber intraocular lens

Table 12. Best-corrected visual acuity (BCVA) before and after intraocular lens explantation in the whole sample and categorised by indication for explantation. Data are presented as mean ± SD (minimum-maximum).

Indication	**Preop. BCVA (LogMAR)**	**Postop. BCVA (LogMAR)**	**P value**
Total	0.92 ± 0.72 (2.30-0.10)	0.63 ± 0.56 (1.70-0.00)	0.71
IOL dislocation	0.86 ± 0.68 (2.40-0.00)	0.57 ± 0.56 (2.40-0.00)	0.96
Pseudophakic bullous keratopathy	1.68 ± 0.57 (2.00-0.50)	0.99 ± 0.39 (1.70-0.40)	0.92
Refractive surprise	0.17 ± 0.06 (0.20-0.10)	0.05 ± 0.09 (0.15-0.00)	0.33
Endophthalmitis	2.30	0.80	small sample size
Unclassifiable	0.74 ± 0.50 (1.40-0.20)	0.82 ± 0.41 (1.40-0.30)	0.96

BCVA = best corrected visual acuity, IOL = intraocular lens, LogMAR = logarithm of the minimum angle of resolution

5. Discussion

5.1. A comparative analysis of the incidence of intraoperative complications in cataract surgery performed by resident trainees and specialists

We examined intraoperative complication rates for phacoemulsification surgery performed by specialists and resident trainees, and objectively assessed the difficulty of each surgical stage at a tertiary eye care centre in Hungary.

The overall intraoperative complication rate in our study was 5.4%, which is higher than rates reported in other studies in countries like Sweden (0.9%), Canada (1.8%), Portugal (4.1%), and Australia (4.9%) (17-19, 29). The intraoperative complication rate for resident trainees in this study was 13.7%, which is higher than the rates observed in Canada (2.7%) (18), Germany (3.8%) (30), Australia (6.1%) (17), Portugal (6.3%) (19), the USA (7.8%) (31) and Brazil (11.3%) (32). However, it is lower than the data from Saudi Arabia (17.5%) (33). The complication rate during phaco surgeries performed solely by specialists in our sample (4.8%) was slightly higher than rates in Australia (2.7%) (17) and Portugal (3.3%) (19).

The underlying factors contributing to these outcomes may be multi-factorial. Primarily, the Department of Ophthalmology at Semmelweis University functions as a tertiary referral centre in Hungary, where complex surgical procedures are performed with greater frequency. The proportion of complex surgeries within the total sample was 18.2%, which is significantly higher compared to the data reported in various published studies, which range from 4.5% to 15.7%. (34-36). Additionally, variations in documentation practices for intraoperative details and minor complications across countries or institutions may influence the interpretation of the data provided.

Studies comparing complication rates between resident trainees and specialists have yielded varied results. While Low et al (18), and Fong et al. (17) reported no significant difference between these groups, both our study and Oliveira-Ferreira et al. (19) found significantly higher complication rates among resident trainees. These differences may reflect the varying numbers of phaco surgeries performed by resident trainees across countries during training, as increased surgical experience among resident trainees appears to reduce intraoperative complications.

In our study, 7.3% of all phaco surgeries involved resident trainees, whereas studies from other countries report higher resident involvement rates, ranging from 21% to 64%. (17, 18, 37). In our institution the ophthalmology residency program spans five years, with phaco surgery training beginning in the end of the second year. Over the course of their residency, each resident performs between 50 and 100 phaco surgeries at our institution. This number reflects a lower level of surgical experience compared to Canada and Portugal, where resident trainees typically perform an average of 320 to 400 phaco surgeries during their training (17, 18). Phacoemulsification cataract surgery is a complex procedure with long learning curve. There is no consensus regarding the number of operations after which an improvement in the intraoperative complication rate can be expected; however, the evidence suggests that the risk is significantly higher during the first 100 operations. A study by Randleman et al. demonstrated that the risk of posterior capsule rupture was 6.3% in the initial 80 operations, compared with 3.5% in the subsequent 80 operations. In a further study, the cumulative risk of posterior capsule rupture in the initial 50 operations performed by resident trainees was as high as 17.3%. (38). Consequently, our data from phaco surgeries involving resident trainees is representative of the surgeries in the initial phase of the learning curve, where complications are most likely to occur. It is therefore anticipated that the complication ratio will also be higher

The types and frequencies of intraoperative complications observed in this study closely align with those reported in other studies, specifically: posterior capsule tear (PCT) at 2.6%, anterior capsular tear (ACT) at 1.5%, zonular fibre loss at 1.3%, and dropped nucleus at 0.4% (16-18). Among specialists, the rates of PCT (2.3%) and dropped nucleus (0.3%) were also consistent with findings from Fong et al., and Low et al. (16, 17). However, resident trainees in our study showed a higher incidence of ACT (5.8%) and PCT (6.2%) than previously reported by a Portugal study (ACT: 1.0%; PCT: 3.4%), two papers from the USA (PCT: 2.0% and 6.7%, respectively) (32, 33), and one in Canada (PCT: 0.8%) (17) but lower than data from Brasil (PCT: 8.1%) (32). Dropped nucleus is a critical benchmark in assessing intraoperative complications, as it is usually necessitates pars plana vitrectomy and is associated with a higher risk of postoperative issues, including cystoid macular edema and retinal detachment. In our study, dropped nucleus was more frequent among resident trainees (2.0%) than in Germany (1.2%), Portugal (0.6%), and the USA (0.6%) (39-42).

The rate of intraoperative complications is influenced by case complexity, which can significantly impact the frequency of complications, with complex cases potentially exhibiting double the complication rate of simpler cases (29, 36). To account for this effect, we divided the sample into simple and complex procedures. Among simple cases, complication rates across the entire sample were generally comparable to those reported in other studies, except for PCT incidence among resident trainees, which remained higher (6.9%), consistent with the overall sample findings.

Phaco surgery is performed by a single surgeon, allowing the specialist only to supervise and guide the resident verbally throughout the procedure. To ensure patient safety, specialists take over the operating position from resident trainees during surgery in response to intraoperative complications or anticipated issues. The steps where specialists most frequently took over were phacoemulsification (60.0%), capsulorhexis (19.1%), irrigation/aspiration (11.8%), and hydrodissection (8.2%). Several studies have assessed the subjective difficulty of each phase of phaco surgery for resident trainees, albeit subjectively (43, 44). These results are consistent with our objective findings that phacoemulsification, capsulorhexis and irrigation/aspiration are the most challenging steps.

5.2. A comparative analysis of the incidence of intraoperative complications in cataract surgery performed by women and men surgeons

Growing evidence indicates that medical practices differ between men and women physicians, with patients under the care of women internists demonstrating improved mortality and readmission rates (45-49). It has been hypothesized that female physicians may exhibit greater adherence to clinical guidelines and employ a more patient-centered approach, potentially accounting for these observed disparities in internal medicine. Although surgical outcomes are predominantly determined by technical skill - suggesting minimal gender-related differences among surgeons - emerging research suggests that female surgeons may achieve superior outcomes compared to their male counterparts **(**50, 51). Nonetheless, other studies have reported no significant association (52-54).

Surgical fields have historically been dominated by men (45-49). Recent studies indicate that women currently represent around 25–30% of ophthalmologists and resident trainees (55-57). In contrast, ophthalmology in Hungary has a notable majority of women, with 82% of practicing ophthalmologists being women, according to public data from the Hungarian Ophthalmological Society (2018), though the exact gender ratio among surgeons is not specified. This study is the first to investigate and report gender-related differences among surgeons performing phacoemulsification surgeries, and the first one to report surgeon gender-related data in ophthalmology.

Our study included data from 12 men and 8 women surgeons at our institution, who performed an average of 99.6 and 107.6 surgeries, respectively. Of the 2,156 cases analysed, 1,296 (60.1%) were performed by men surgeons, and 861 (39.9%) by women surgeons.

In our study, the overall complication rate was 4.7%, with no significant difference in complication rates between surgeries performed by men and women surgeons (p=0.728). To minimize the effect of case complexity, we also analysed intraoperative complication rates separately for complex and simple cases (28). In our sample, there was no significant difference between men and women surgeons in either simple (p=0.214) or complex (p=0.508) cataract cases.

Recent studies indicate that gender discordance between surgeon and patient may negatively affect postoperative outcomes (58, 59). A suggested explanation is that gender discordance can be linked to poorer rapport, lower diagnostic certainty, reduced likelihood of assessing conditions as highly severe, concerns about hidden agendas, and potential disagreements over medical advice (60-62). To explore this issue, we compared cases of men and women patients operated by men and women surgeons across the whole sample, as well as within simple and complex cataract cases. No significant difference was found in any group.

Large multicentre studies from various surgical specialties have shown that women surgeons often achieve better postoperative outcomes and lower readmission rates (50, 51). However, single-centre studies in specific specialties, such as ours, do not consistently demonstrate this difference (52-54). The reasons behind these findings remain unclear.

The frequency and order of the most common intraoperative complications were comparable between surgeries performed by women and men surgeons: PCT occurred in 2.4% of surgeries by women and 2.3% by men, ACT in 1.0% by women and 1.4% by men, and zonular fibre loss in 1.4% and 1.0% of cases, respectively. These rates for PCT and ACT align with findings from other studies (18, 19).

5.3. Analysis of the indications and outcomes of intraocular lens explantation

Advancements in surgical techniques and IOL designs have led to continuous improvements, yet complications occasionally arise that necessitate IOL replacement. The incidence of intraocular lens explantation following primary cataract surgery is estimated to range between 0.59% and 0.77% (63, 64). Despite the technical improvements, our study observed an upward trend in the number of annual IOL explantations, similar to findings from Belgium, Spain, the USA, and Turkey (65-68). This increase may relate to an aging population and a rise in the number of cataract surgeries in developed countries (5, 69).

In line with recent studies, the most frequent reason for IOL explantation in our sample was IOL dislocation, occurring in 85.1% of cases, comparable to rates reported in Spain, China, and the USA (65, 70, 71). IOL dislocation represents a diverse patient group, for this reason we further categorized it into in-the-bag (56.2%) and out-of-the-bag (36.5%) dislocations. Predisposing factors and post-surgery incidence differ between these categories. In our overall sample, the most common ocular comorbidities were previous vitrectomy, ocular trauma, pseudo-exfoliation syndrome, and high axial myopia, factors that are known to increase the risk of zonular dehiscence and may contribute to the high rate of IOL dislocation (72, 73). Key risk factors across all groups were previous vitrectomy and ocular trauma. Literature supports pseudo-exfoliation syndrome, high axial myopia, and uveitis as predominant factors for in-the-bag dislocations in our sample (74).

The literature indicates a range of risk factors for out-of-the-bag dislocations, including complex primary cataract surgeries, previous ocular trauma, vitrectomy, mature cataract, pseudo-exfoliation, retinitis pigmentosa, and neodymium-doped Yttrium Aluminium Garnet (Nd:YAG) laser capsulotomy. Consistent with this, besides glaucoma, the most frequent ocular comorbidities in eyes with out-of-the-bag dislocation in our study were, previous ocular trauma, and vitrectomy.

The proportion of ACIOL explantations (13.7%) in cases of penetrating keratoplasty due to pseudophakic bullous keratopathy (PBK) (11.2%) was similar across the full sample. ACIOL exchange is common in PBK, whereas PCIOL is generally not a contributing factor in PBK (75). Our study's PBK rates were similar to those reported in Belgium (8.0%), the USA (11.5%), and Spain (12.0%) (65, 67, 71), but higher than China's rate (4.1%) (70). Decades ago, during the ACIOL era, PBK was the primary cause of IOL explantation in the USA (68.4%) (76). This shift is likely due to advancements in IOL technology, including the introduction of foldable PCIOLs and smaller corneal incisions in phacoemulsification, which have reduced ACIOL use over the years (77, 78). In our sample, 18 penetrating keratoplasties were performed, with ACIOL removal in 10 of these cases.

The third most common reason for IOL explantation was refractive surprise, accounting for only 1.9% of cases. With advancements in measurement and calculation formulas, refractive error issues should continue to decline. However, recent studies have reported higher rates of explantation due to refractive surprise, ranging from 6% to 18.4% (65, 67, 79-81). Accurate IOL power calculations using modern formulas achieve refractive errors within 0.5 to 1.0 diopter in 79–95% of patients (82). In our department, the lower rate of IOL exchange due to refractive surprise (2.5% in the total sample, 1.4% for PCIOL, and 9.1% for ACIOL) may be due to precise IOL power calculations and the availability of excimer laser corrections, which are preferred for treating refractive surprise, as laser refractive surgery carries a lower intra- and postoperative risk than IOL replacement (83, 84).

Reported rates of IOL opacification and calcification as reasons for explantation vary widely among studies, from 1.4% to 31.0% (25, 65, 67, 68). IOL opacification has been linked to acrylic hydrophilic IOLs, although it is now understood that the issue is due to manufacturing defects rather than the material itself (25, 85). Choice of IOL also varies by country and institution. Production of IOLs with a higher risk of opacification (e.g., CIBA Vision's MemoryLens U940A and Bausch and Lomb's Hydroview H60M) was discontinued in 2000 and 2001 (85). Study results may be skewed in areas where such IOLs were widely implanted (25, 27 , 67, 68, 70). In our sample, no cases of IOL opacification-related explantation were found.

Intolerance to multifocal IOLs is increasingly recognized as a reason for explantation, with patients frequently reporting dysphotopsia, halos, glare, and blurred vision at various distances (68). Some studies cite dissatisfaction with multifocal IOLs as a significant reason for explantation (6.2–18.3%) (25, 66, 68). In contrast, studies from Belgium, the Czech Republic, Spain, and our own did not record any cases of explantation due to multifocal IOL intolerance (65, 67, 85). This may be due to our department's status as a public hospital, where multifocal IOL implantation is rare. However, as the popularity of multifocal IOLs rises, a growing number of dissatisfied patients may seek treatment in public hospitals as well.

Our study did not include any cases of uveitis-glaucoma-hyphema (UGH) syndrome, which has historically been linked to ACIOLs and is now primarily associated with mispositioned three-piece or one-piece IOLs in the sulcus (66, 76, 86). A 2009 White Paper by the American and European Societies of Cataract and Refractive Surgery recommended avoiding this practice due to high complication risks (87). Current studies report UGH syndrome rates ranging from 0% to 11.9% as a reason for IOL explantation (26, 66, 70, 80, 81). Thirty years ago, it was a leading cause of IOL explantation (76, 86). The incidence of UGH syndrome may vary by institution. In our clinic, sulcus placement of one-piece IOLs is not recommended, which may explain the absence of UGH-related explantations.

In our study, the prepupillary iris-claw IOL was the most commonly used secondary implant (73.7%), followed by the retropupillary iris-claw IOL (20.5%). This is consistent with findings in Spain, where 63.8% of secondary implants were iris-claw IOLs, with all cases being retropupillary (65). In contrast, scleral-fixated IOLs were most common in China (73.5%) (70). Scleral-fixated IOLs were rarely used at our institution due to limited availability in the past several years, during which time iris-claw IOLs gained popularity following their introduction in Hungary.

Iris-claw IOLs are off-label for aphakia correction in the USA, so angle-supported ACIOLs remain the preferred option when there is no capsular support (88). In our department, the capsular bag is the first choice for secondary IOL implantation. When the capsular bag is damaged, the ciliary sulcus is preferred, and in the absence of capsular support, iris-claw IOLs are used. The decision between pre- or retropupillary implantation of the iris-claw IOL depends on the surgeon’s experience and the patient’s eye condition. Multiple studies indicate that there is no significant difference in visual outcomes or complication rates between pre- and retropupillary placements of iris-claw IOLs (89, 90).

Most studies report significant visual improvement after IOL exchange, although final visual acuity is influenced by the type of explanted IOL and other ocular comorbidities (26, 65, 79-81, 91). Our results also demonstrated a significant improvement in UCVA, with BCVA improving in 62.7% of our patients and decreasing in only 19.3%. The reason that UCVA improved significantly while BCVA did not may be attributed to the high rate of IOL dislocation and PBK in our sample. After IOL dislocation even with high-diopter aphakic correction glasses, fine visual acuity can be maintained prior to the surgery; however, this correction is not a suitable substitute for surgery, as dislocated IOLs can cause issues over time. Post-surgery, corneal optical properties may change due to larger corneal incisions, leading to significant aberrations that are not always perfectly correctable. After an onset of pseudophakic bullous keratopathy, the postoperative visual outcome can vary widely, even more when the surgery is combined with keratoplasty. Based on our results, we can conclude that after IOL exchange surgery, even if the change in BCVA is not significant, the optical properties of the eye are significantly improved.

5.4. Limitations

All of our studies have certain limitations, including a retrospective design, the involvement of a single centre, and the absence of patient randomization. In the study on

IOL explantations, data were collected over an extended period during which cataract surgery techniques and equipment likely advanced, though these developments were not evaluated. Furthermore, as a tertiary eye care centre, our department received half of the patients as referrals specifically for IOL explantation or exchange. Consequently, we could not track the full course of these cases or determine the ratio of IOL explantations to primary cataract surgeries.

6. Conclusions

Few large-scale studies have compared intraoperative complication rates between specialists and resident trainees, and our study is the first to report on these rates for primary phaco surgery in Hungary. Intraoperative complication rates were higher among resident trainees than specialists. Increasing resident involvement in phaco surgeries at our department could help enhance surgical confidence and mastery of safe techniques by the end of residency. Our objective assessment of the difficulty levels across the stages of phaco surgery aligned with subjective reports from other studies, highlighting phacoemulsification and capsulorhexis as the most challenging steps.

Our study is the first to investigate gender-related differences among practitioners in phaco surgeries. Our findings revealed no significant difference in intraoperative complication rates between phaco surgeries performed by women and men surgeons in our department. The type and frequency of common complications were also comparable between the two groups. Additionally, our results indicate that surgeon-patient gender concordance or discordance does not significantly affect intraoperative complication rates during cataract surgery.

Our report represents the largest single-centre study on IOL explantation. Based on our findings, dislocation and pseudophakic bullous keratopathy are the leading indications for IOL explantation and exchange in a tertiary eyecare centre in Hungary. The prepupillary iris-claw IOL was the most frequently used type of IOL for simultaneous secondary IOL implantation and aphakia correction. We observed a significant improvement in uncorrected visual acuity following IOL exchange surgery. Our results indicated an upward trend in the incidence of IOL explantation.

7. Summary

Cataract surgery is the most common surgical procedure worldwide, making detailed analysis of complication rates essential for both research and clinical practice. With the high volume of surgeries and continuous growth in this field, even rare complications can occur in notable numbers. Our work included three studies that compared intraoperative complications based on the experience of the surgeon, surgeon gender, and the indications and outcomes of a rare complication: IOL explantation.

Intraoperative complication rates in phaco surgeries performed by specialists (4.8%) and resident trainees (13.7%) in Hungary were found to be higher than those reported in other developed countries. Consistent with literature suggesting that experience reduces complication rates, we found that resident trainees in Hungary perform fewer phaco surgeries. Our results on the objective difficulty of steps during phaco surgery were consistent with subjective findings from other studies, identifying phacoemulsification and capsulorhexis as the most challenging steps.

Analysing gender-based outcomes, our study found no significant differences in intraoperative complication rates between men and women surgeons. Contrary to multicentre studies indicating better outcomes for women surgeons, our single-centre study observed comparable rates of complications. Additionally, gender concordance or discordance between surgeons and patients did not impact intraoperative outcomes.

Our third study, focused on IOL explantation, showed an upward trend in the number of cases. The primary reasons for explantation were IOL dislocation (85.1%) and pseudophakic bullous keratopathy. IOL dislocation was further classified into in-the-bag (56.2%) and out-of-the-bag (36.5%) categories, with common risk factors including prior vitrectomy and ocular trauma. The preferred secondary implant was the prepupillary iris-claw IOL. Uncorrected visual acuity improved significantly post-surgery; although best-corrected visual acuity outcomes were favourable, the change was not significant.

8. References

1. Albert DM, Jakobiec FA. Principles and practice of ophthalmology. Basic sciences. Philadelphia: WB Saunders; 1994. 82–96 p.
2. Lee Cameron M, Afshari Natalie A. The global state of cataract blindness. Curr Opin Ophthalmol. 2017;28:98–103.
3. GBD 2019 Blindness and Vision Impairment Collaborators; Vision Loss Expert Group of the Global Burden of Disease Study. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. Lancet Glob Health. 2021;9(2):144-160.
4. Szabó D, Sándor GL, Tóth G, Pék A, Lukács R, Szalai I, Tóth GZ, Papp A, Nagy ZZ, Limburg H, Németh J. Visual impairment and blindness in Hungary. Acta Ophthalmol. 2018;96(2):168-173.
5. Sándor GL, Tóth G, Szabó D, Szalai I, Lukács R, Pék A, Tóth GZ, Papp A, Nagy ZZ, Limburg H, Németh J. Cataract blindness in Hungary. Int J Ophthalmol. 2020;13(3):438-444.
6. Magyar M, Zsiros V, L Kiss A, Nagy ZZ, Szepessy Z. Caveolák szerepe a szürke hályog képződésében: humán szemlencse epithelsejtjeinek vizsgálata. Orv Hetil. 2019;160(8):300-308.
7. Sharon LJ, Thomas LB, Chadwick RB. Basic and Clinical Science Course, Section 11: Lens and Cataract. San Francisco: American Academy of Ophthalmology; 2018. 38-93 p.
8. Yanoff M, Duker JS. Ophthalmology. Amsterdam: Elsevier – Health Sciences Division. 2014. 329-378 p.
9. https://ec.europa.eu/eurostat/databrowser/view/HLTH_CO_PROC3__custom_7193199/bookmark/table?lang=en&bookmarkId=eb56af23-4da1-4281-8c0b-bf5e416df46d
10. Nagy ZZ, Vörös K, Somfalvi B, Élő Á, Tapasztó Z, Kiss H. A hályogsebészet helyzete Magyarországon 2021-ben a “Cataracta regiszter” eredményeinek összegzése. Szemészet. 2022;3:94-99.
11. Davis G. The Evolution of Cataract Surgery. Mo Med. 2016;113(1):58-62.

12. Kelman CD. Phaco-emulsification and aspiration: a new technique of cataract removal: a preliminary report. Am J Ophthalmol. 1967;64(1):23-35.
13. Nagy ZZ, Dunai A, Kránitz K, Takács AI, Sándor GL, Hécz, Knorz MC. Evaluation of femtosecond laser-assisted and manual clear corneal incisions and their effect on surgically induced astigmatism and higher-order aberrations. J Refract Surg. 2014;30(8):522-525.
14. Auffarth, G., Apple, D. Zur Entwicklungsgeschichte der Intraokularlinsen. Ophthalmologe. 2001;98:1017–1031.
15. Salerno LC, Tiveron MC Jr, Alió JL. Multifocal intraocular lenses: Types, outcomes, complications and how to solve them. Taiwan J Ophthalmol. 2017;7(4):179-184.
16. Magyar M, Sándor GL, Ujváry L, Nagy ZZ , Tóth, G. Intraoperative complication rates in cataract surgery performed by resident trainees and staff surgeons in a tertiary eyecare center in Hungary. Int J Ophthalmol. 2022;15(4):586–590.
17. Fong CS, Mitchell P, de Loryn T, Rochtchina E, Hong T, Cugati S, Wang JJ. Long-term outcomes of phacoemulsification cataract surgery performed by trainees and consultants in an Australian cohort. Clin Exp Ophthalmol 2012;40: 597–603.
18. Low SAW, Braga-Mele R, Yan DB, El-Defrawy S. Intraoperative complication rates in cataract surgery performed by ophthalmology resident trainees compared to staff surgeons in a Canadian academic center. J Cataract Refract Surg. 2019;44:1344–1349.
19. Oliveria-Ferreira C, Leuzinger-Dias M, Ferreira JT, Macedo JP, Falcão-Reis F. Cataract phacoemulsification performed by resident trainees and staff surgeons: intraoperative complications and early postoperative intraocular pressure elevation. J Cataract Refract Surg 2020;46:555–561.
20. Greenberg PB, Tseng VL, Wu WC, Liu J, Jiang L, Chen CK. Prevalence and predictors of ocular complications associated with cataract surgery in United States veterans. Ophthalmology. 2011;118:507–514.
21. Marques FF, Marques DM, Osher RH, Osher JM. Fate of anterior capsule tears during cataract surgery. J Cataract Refract Surg. 2006;10:1638-1642.

22. Goel R, Shah S, Malik KPS, Sontakke R, Golhait P, Gaonker T. Complications of manual small-incision cataract surgery. Indian J Ophthalmol. 2022;11:3803-3811.
23. Kamonporn N, Pipat K. The visual outcomes and complications of manual small incision cataract surgery and phacoemulsification: Long term results. Rom J Ophthalmol. 2021;65:31-37.
24. Magyar M, Szentmáry N, Ujváry L, Sándor GL, Schirra F, Nagy ZZ, Tóth G. Indications and outcomes of intraocular lens explantation in a tertiary eyecare center in Hungary between 2006 and 2020. J Ophthalmol. 2024;2024:6653621.
25. Fernández-Buenaga R, Alio JL, Munoz-Negrete J. Causes of IOL explantation in Spain. Eur J Ophthalmol. 2012;22:762–768.
26. Jin GJC, Crandall AS, Jones JJ. Changing indications for and improving outcomes of intraocular lens exchange. Am J Ophthalmol. 2005;140:688–694.
27. Marques FF, Marques DMV, Osher RH. Longitudinal study of intraocular lens exchange. J Cataract Refract Surg. 2007;33:254–257.
28. Shi SL, Yu XN, Cui YL, Zheng SF, Shentu XC. Incidence of endophthalmitis after phacoemulsification cataract surgery: a Meta-analysis. Int J Ophthalmol. 2022;15(2):327-335.
29. Segerstad PHA. Risk model for intraoperative complication during cataract surgery based on data from 900 000 eyes: previous intravitreal injection is a risk factor. Br J Ophthalmol 2021;2020:318645.
30. Briszi A, Prahs P, Hillenkamp J, Helbig H, Herrmann W. Complication rate and risk factors for intraoperative complications in resident-performed phacoemulsification surgery. Graefes Arch Clin Exp Ophthalmol. 2012;250:1315-1320.
31. Ellis EM, Lee JE, Saunders L, Haw WW, Heichel CW, Granet DB. Complication rates of resident-performed cataract surgery: Impact of early introduction of cataract surgery training. J Cataract Refract Surg. 2018;44:1109-1115.
32. Carricondo PC, Fortes AC, Mourão Pde C, Hajnal M, Jose NK. Senior resident phacoemulsification learning curve (corrected from cure). Arq Bras Oftalmol. 2010;73:66-69.
33. Al-Jindan M, Almarshood A, Yassin SA, Alarfaj K, Al Mahmood A, Sulaimani NM. Assessment of learning curve in phacoemulsification surgery among the

Eastern Province ophthalmology program residents. Clin Ophthalmol. 2020;14:113-118.

34. Maturana C, Lee P, Fredrick D, Chadha N. (2020). Ophthalmology Residents' Experience with Complex Cataract Surgery at a VA Hospital over 10 Years. J Acad Ophthalmol. 2020;12:36-40.
35. Zafar S, Wang P, Srikumaran D, D Schein O, Thorne JE, Makary MA, Woreta FA. Billing of cataract surgery as complex versus routine for Medicare beneficiaries. J Cataract Refract Surg. 2019;11:1547-1554.
36. Portney DS, Berkowitz ST, Garner DC. Comparison of Incremental Costs and Medicare Reimbursement for Simple vs Complex Cataract Surgery Using Time-Driven Activity-Based Costing. JAMA Ophthalmol. 2023;141:358-364.
37. Muhtaseb M, Kalhoro A, Ionides A. A system for preoperative stratification of cataract patients according to risk of intraoperative complications: a prospective analysis of 1441 cases. Br J Ophthalmol. 2004; 88:1242–1246.
38. Randleman JB, Wolfe JD, Woodward M, Lynn MJ, Cherwek DH, Srivastava SK. The resident surgeon phacoemulsification learning curve. Arch Ophthalmol. 2007;125:1215-1219.
39. Corey RP, Olson RJ. Surgical outcomes of cataract extractions performed by resident trainees using phacoemulsification. J Cataract Refract Surg. 1998;24:66-72.
40. Bhagat B, Nissirios N, Potdevin L, Chung J, Lama P, Zarbin MA, Fechtner R, Guo S, Chu D, Langer P. Complications in resident-performed phacoemulsification cataract surgery at New Jersey Medical School. Br J Ophthalmol 2007;91:1315-1317.
41. Clarke C, Ali SF, Murri M, Patel SN, Wang L, Tuft M, Weikert MP, Al-Mohtaseb Z. Outcomes and complication rates of primary resident-performed cataract surgeries at a large tertiary-care county hospital. J Cataract Refract Surg. 2017;43:1563-1570.
42. Narendran N, Jaycock P, Johnston RL, Taylor H, Adams M, Tole DM, Asaria RH, Galloway P, Sparrow JM. The Cataract National Dataset electronic multicentre audit of 55,567 operations: risk stratification for posterior capsule rupture and vitreous loss. Eye. 2009;23:31–37.

43. Sen S, Patil M, Saxena R, Kumar A, Amar SP, Das D, Brar AS, Saini P. Perceived difficulties and complications in learners of phacoemulsification: A principal component analysis model. Indian J Ophthalmol 2019;67:213–216.
44. Dooley IJ, O'Brien PD. Subjective difficulty of each stage of phacoemulsification cataract surgery performed by basic surgical trainees. J Cataract Refract Surg. 2006;32:604–608.
45. Frank E, Dresner Y, Shani M, Vinker S. The association between physicians' and patients' preventive health practices. CMAJ. 2013;359:649-653.
46. Lurie N, Slater J, McGovern P, Ekstrum J, Quam L, Margolis K. Preventive care for women: Does the sex of the physician matter? N Engl J Med. 1993;359:478-482.
47. Bertakis KD, Helms LJ, Callahan EJ, Azari R, Robbins JA. The influence of gender on physician practice style. Med Care. 1995;359:407-416.
48. Roter DL, Hall JA, Aoki Y. Physician gender effects in medical communication: A meta-analytic review. JAMA. 2002;359:756-64.
49. Berthold HK, Gouni-Berthold I, Bestehorn KP, Böhm M, Krone W. Physician gender is associated with the quality of type 2 diabetes care. J Intern Med. 2008;359:340-350.
50. Wallis CJ, Ravi B, Coburn N, Nam RK, Detsky AS, Satkunasivam R. Comparison of postoperative outcomes among patients treated by male and female surgeons: A population based matched cohort study. BMJ. 2017;359:4366
51. Tsugawa Y, Jena AB, Orav EJ, Blumenthal DM, Tsai TC, Mehtsun WT, Jha AK. Age and sex of surgeons and mortality of older surgical patients: Observational study. BMJ. 2018;361:1343
52. Chapman TR, Zmistowski B, Votta K, Abdeen A, Purtill JJ, Chen AF. Patient complications after total joint arthroplasty: Does surgeon gender matter? J Am Acad Orthop Surg. 2020;28(22):937-944.
53. Kobylianskii A, Murji A, Matelski JJ, Adekola AB, Shapiro J, Shirreff L. Surgeon gender and performance outcomes for hysterectomies: Retrospective cohort study. J Minim Invasive Gynecol. 2023;30(2):108-114.

54. Bouchghoul H, Deneux-Tharaux C, Georget A, Madar H, Bénard A, Sentilhes L; TRAAP2 Study Group. Association between surgeon gender and maternal morbidity after cesarean delivery. JAMA Surg. 2023;158(3):273-281.
55. Gill HK, Niederer RL, Shriver EM. An eye on gender equality: A review of the evolving role and representation of women in ophthalmology. Am J Ophthalmol. 2022;236:232-240.
56. Aquwa UT, Srikumaran D, Green LK. Analysis of sex diversity trends among ophthalmology match applicants, residents, and clinical faculty. JAMA Ophthalmol. 2021;139:1184-1190.
57. Yashadhana A, Clarke NA, Zhang JH. Gender and ethnic diversity in global ophthalmology and optometry association leadership: A time for change. Ophthalmic Physiol Opt. 2021;41:623-629.
58. Wallis CJD, Jerath A, Coburn N. Association of surgeon-patient sex concordance with postoperative outcomes. JAMA Surg. 2022;157(2):146-56.
59. Khan MMM, Munir MM, Woldesenbet S, Endo Y, Rawicz-Pruszyński K, Katayama E, Ejaz A, Cloyd J, Dilhoff M, Pawlik TM. Association of surgeon-patient sex concordance with postoperative outcomes following complex cancer surgery. J Surg Oncol. 2024;129(3):489-498.
60. Gross R, McNeill R, Davis P, Lay-Yee R, Jatrana S, Crampton P. The association of gender concordance and primary care physicians' perceptions of their patients. Women Health. 2008;48(2):123-144.
61. Schieber AC, Delpierre C, Lepage B. Do gender differences affect the doctor-patient interaction during consultations in general practice? Results from the INTERMEDE study. Fam Pract. 2014;31(6):706-713.
62. Greenwood BN, Carnahan S, Huang L. Patient-physician gender concordance and increased mortality among female heart attack patients. Proc Natl Acad Sci U S A. 2018;115(34):8569-8574.
63. Fernández-Buenaga R, Alio JL, Munoz-Negrete J, Compte B, Barrio JLA-D. Causes of IOL explantation in Spain. Eur J Ophthalmol. 2012;22:762–768.
64. Jin GJC, Crandall AS, Jones JJ. Changing indications for and improving outcomes of intraocular lens exchange. Am J Ophthalmol. 2005;140:688–694.

65. de Rojas MV, Viña S, Gestoso A. Intraocular lens explantation in Spain: indications and outcomes at a tertiary referral center from 2010 to 2018. Int Ophthalmol. 2020;40:313-323.
66. Davies EC, Pineda II R. Intraocular lens exchange surgery at a tertiary referral center: Indications, complications, and visual outcomes. J Cataract Refract Surg. 2016;42:1262-1267.
67. Leysen I, Bartolomeeusen E, Coeckelbergh T, Tassignon MJBR. Surgical outcomes of intraocular lens exchange: five-year study. J Cataract Refract Surg. 2009;35:1013-1018.
68. Ucar F, Cetinkaya S, Kahraman H, Yener HI. Changes in intraocular lens explantation indications and comparison of various explantation techniques. Am J Ophthalmol. 2024;257:84-90.
69. Tóth G, Szabó D, Sándor GL, Szalai I, Lukács R, Pék A, Tóth GZ, Papp A, Nagy ZZ, Limburg H, Németh J. Diabetes and diabetic retinopathy in people aged 50 years and older in Hungary. Br J Ophthalmol. 2017;101:965-969.
70. Chan TCY, Lok JKH, Jhanji V, Wong VWY. Intraocular lens explantation in Chinese patients: different patterns and different responses. Int Ophthalmol. 2015;35:679–684.
71. Bothun ED, Cavalcante LCB, Hodge DO, Patel SV. Population-based incidence of intraocular lens exchange in Olmsted County, Minnesota. Am J Ophthalmol. 2018;187:80-86.
72. Sedziak-Marcinek B, Wylegala A, Chelmecka E, Marcinek M, Wylegala E. Iris-claw intraocular lens implantation in various clinical indications: A 4-year study. J Clin Med. 2021;10:1199.
73. Vounotrypidis E, Schuster I, Mackert MJ, Kook D, Priglinger S, Wolf A. Secondary intraocular lens implantation: a large retrospective analysis. Graefes Arch Clin Exp Ophthalmol. 2019;257:125-134.
74. Hayashi K, Hirata A, Hayashi H. Possible predisposing factors for in-the-bag and out-of-the-bag intraocular lens dislocation and outcomes of intraocular lens exchange surgery. Ophthalmology. 2007;114:969-975.7:125-134.
75. Woo JH, Arundhati A, Chee S-P, Tong W, Li L, Ti S-E, Htoon HM, Choo JQH, Tan D, Mehta JS. Endothelial keratoplasty with anterior chamber intraocular lens

versus secondary posterior chamber intraocular lens. Br J Ophthalmol. 2022;106:203-210.

76. Doren GS, Stern GA, Driebe WT. Indications for and results of intraocular explantation. Cataract Refract Surg. 1992;18:79-85.
77. Bernhisel A, Pettey J. Manual small incision cataract surgery. Curr Opin Ophthalmol. 2020;31:74-79.
78. Werner L. Intraocular lens evolution in the past 25 years as told by the Journal of Cataract & Refractive Surgery. J Cataract Refract Surg. 2021;47:147-149.
79. Chai F, Ma B, Yang X-G, Li J, Chu M-F. A pilot study of intraocular lens explantation in 69 eyes in Chinese patients. Int J Ophthalmol. 2017;10:579-585.
80. Oltulu R, Ersan I, Satirtav G. Intraocular lens explantation or exchange: indications, postoperative interventions, and outcomes. Arq Bras Oftalmol. 2015;78:154-157.
81. Jones JJ, Jones YJ, Jin GJC. Indications and outcomes of intraocular lens exchange during a recent 5-year period. Am J Ophthalmol. 2014;157:154–162.
82. Aristodemou P, Knox Cartwright NE, Sparrow JM. Formula choice: Hoffer Q, Holladay 1, or SRK/T and refractive outcomes in 8108 eyes after cataract surgery with biometry by partial coherence interferometry. J Cataract Refract Surg. 2011;37:63-71.
83. Kaluzny BJ, Piotrowiak-Slupska I, Kaszuba-Modrzejewska M. Three-year outcomes after high hyperopia correction using photorefractive keratectomy with a large ablation zone. Br J Ophthalmol. 2019;103:849-854.
84. Zhang J, Feng Q, Ding W. Comparison of clinical results between trans-PRK and femtosecond LASIK for correction of high myopia. BMC Ophthalmol. 2020;20:243.
85. Jiraskova N, Rozsival P, Kohout A. A survey of intraocular lens explantation: A retrospective analysis of 23 IOLs explanted during 2005. Eur J Ophthalmol. 2007;17:579-587.
86. Mamalis N, Crandall AS, Pulsipher MW, Follett S, Monson MC. Intraocular lens explantation and exchange. A review of lens styles, clinical indications, clinical results, and visual outcome. J Cataract Refract Surg. 1991;17:811-818.

87. Chang DF, Masket S, Miller KM. Complications of sulcus placement of single-piece acrylic intraocular lenses Recommendations for backup IOL implantation following posterior capsule rupture for the ASCRS Cataract Clinical Committee. J Cataract Refract Surg. 2009;35:1445–1458.
88. D'Amico DJ. Different preferences between United States and European vitreoretinal surgeons: personal observations. Curr Opin Ophthalmol. 2016;27:196–200.
89. Thulasidas M. Retropupillary iris-claw intraocular lenses: A literature review. Clin Ophthalmol. 2021;15:2727-2739.
90. Durmus E, Esen F, Yenerel M, Sanisoglu H, Oguz H. Clinical outcome and endothelial loss following prepupillary and retropupillary implantation of iris claw intraocular lenses. Int Ophthalmol. 2021;41:3961-3969.
91. Mamalis N, Brubaker J, Davis D, Espandar L, Werner L. Complications of foldable intraocular lenses requiring explantation or secondary intervention - 2007 survey update. Cataract Refract Surg. 2008;34:1584-1591.

9. Bibliography of the candidate's publications

9.1. Publications related to the PhD thesis

- ◊ **Magyar M**, Sándor GL, Ujváry L, Nagy ZZ , Tóth G. Intraoperative complication rates in cataract surgery performed by resident trainees and staff surgeons in a tertiary eyecare center in Hungary. Int J Ophthalmol. 2022;15(4):586–590. **IF:1.4**
- ◊ **Magyar M**, Sándor GL, Ujváry L, Nagy ZZ, Tóth G. Szürkehályog-műtétek során fellépő intraoperatív szövődmények rezidenseknél és szakorvosoknál, Szemészet. 2022;159(2):86–90.
- ◊ **Magyar M**, Szentmáry N, Ujváry L, Sándor GL, Schirra F, Nagy ZZ, Tóth G. Indications and outcomes of intraocular lens explantation in a tertiary eyecare center in Hungary between 2006 and 2020. J Ophthalmol. 2024;2024:6653621. **IF:1.8**
- ◊ **Magyar M**, Tóth G, Ujváry L, Sándor GL, Nagy ZZ. Intraoperative complication rates in cataract surgery performed by women and men surgeons in a tertiary eyecare centre in Hungary. DHS. 2024. Published online ahead of print 2024.

∑ Impact factor: 3.2

9.2. Publications not related to the PhD thesis

- ◊ **Magyar M**, Zsiros V, L Kiss A, Nagy ZZ, Szepessy Z. Caveolák szerepe a szürke hályog képződésében: humán szemlencse epithelsejtjeinek vizsgálata. Orv Hetil. 2019;160(8):300-308. **IF:0.497**
- ◊ **Magyar M**, Gunda B, Rudas G, Resch M, Nagy ZZ, Dohán J. Akut retinanekrózis és ischaemiás stroke társulása. Orv Hetil. 2021;162(48):1940-1945. **IF:0.707**

- ◊ Balogh P, **Magyar M**, Szabó A, Müllner N, Likó I, Patócs A, L. Kiss A. The subcellular compartmentalization of TGFβ-RII and the dynamics of endosomal formation during the signaling events: An in vivo study on rat mesothelial cells. Eur J Cell Biol. 2015; 94(5):204-13. **IF:4.011**

- ◊ Ujváry L, Salomváry B, Szalóki T, Geiszelhardt B, Nagy ZZ, **Magyar M**, Nyilas N, Zoltai B, Korányi K. Intraorbitalis tumorok műtéti ellátása egy tercier centrumban. Orv Hetil. 2023;164(49):1947-1953. **IF:0.8**

- ◊ Végh A, Csorba A, Koller Á, Mohammadpour B, Killik P, István L, **Magyar M**, Fenesi T, Nagy ZZ. Presence of SARS-CoV-2 on the conjunctival mucosa in patients hospitalized due to COVID-19: Pathophysiological considerations and therapeutic implications. Physiol Int. 2022;109(4):475-485. **IF:1.4**

- ◊ Németh J, Nyitrai B, Karacs K, Szabó D, Ecsedy M, Szalai I, Tóth G, Sándor GL, **Magyar M**, Benyó F, Papp A. OCT-leletek telemedicinális értékelésének pontossága cukorbetegekben. Szemészet. 2022;159(2):64–68.

- ◊ Szalai K, Farkas K, Gergely H, Varga NN, **Magyar M**, Nagy ZZ, Fésűs L, Bozsányi S, Jobbágy A, Medvecz M, Bánvölgyi A, Lőrincz K, Wikonkál N, Kiss, N. Magas frekvenciájú ultrahang, optikai koherencia tomográfia és mágnesesrezonancia képalkotás alkalmazási lehetőségei a bőrgyógyászati gyakorlatban. Bőrgyógyászati és Venerológiai Szemle. 2022;98(3):125–132.

- ◊ Ujváry L, Resch M, **Magyar M**, Zoltai B, Barta A, Nagy ZZ. Evulsio nervi optici, egy saját eset bemutatása, történeti áttekintés és nevezéktani ajánlás. Szemészet. 2022;159(4):183–187.

- ◊ Ujváry L, Knézy K, Maka E, **Magyar M**, Nagy ZZ. Kétszáz éve született Petőfi Sándor, a költő, aki a Napba nézett : A solaris retinopathia egy esetének bemutatása. Szemészet. 2023;160(4):203–206.

10. Acknowledgements

I would like to thank my supervisor, **Professor Dr. Zoltán Zsolt Nagy**, for his support and guidance since my entry into the Department of Ophthalmology at Semmelweis University and throughout the course of my PhD research.

I am eternally indebted to **Dr. Gábor Tóth**, who served as my mentor during my scientific endeavours, and without whose guidance the entire thesis would have remained a mere concept.

I would like to express my sincere gratitude to **Dr. Zsuzsanna Szepessy**, who initially ignited my interest in ophthalmology and scientific research.

In addition, I would like to express my appreciation to my esteemed colleagues and friends, **Dr. László Ujváry** and **Dr. Gábor László Sándor**, for their invaluable support throughout the course of my PhD studies.

I am grateful to **Professor Dr. Nóra Szentmáry** and **Professor Dr. János Németh** for their continuous support and advice.

I would like to express my profound gratitude to my colleagues at the Department of Ophthalmology, Semmelweis University, for their invaluable assistance and support.

Finally, I would like to express my sincere gratitude to my family, particularly my wife, for their unwavering patience, invaluable advice, and for creating the conditions that enabled me to accomplish my seemingly endless work.