VILNIUS UNIVERSITY

FACULTY OF MEDICINE

Medicine

Department of Public Health Institute of Health Sciences

Clinic of Ear, Nose, Throat and Eye Diseases

Oleksii Onyshchenko 2026, group 1

INTEGRATED STUDY MASTER'S THESIS

Cataract Innovative Treatment (Multifocal vs Monofocal Intraocular Lenses). Literature Review

Supervisor Assoc. Professor. Dr. Saulius Galgauskas

Head of the department Professor. Dr. Eugenijus Lesinskas

Vilnius, 2026

oleksii.onyshchenko@mf.stud.vu.lt

TABLE OF CONTENTS

1. Keywords

Cataract; cataract surgery; intraocular lens; monofocal intraocular lens; multifocal intraocular lens; spectacle independence.

2. Abbreviations

ECCE - Extracapsular cataract extraction

EDOF - Extended depth of focus

ESCRS - European Society of Cataract and Refractive Surgeons

FLACS - Femtosecond laser-assisted cataract surgery

ICCE - Intracapsular cataract extraction

IOL - Intraocular lens

OCT - Optical coherence tomography

RCT - Randomized controlled trial

UDVA - Uncorrected distance visual acuity

UNVA - Uncorrected near visual acuity

3. Summary

Theme:

Multifocal and Monofocal Intraocular Lenses in Innovative Cataract Treatment: A Literature Review.

Cataract remains one of the leading causes of visual impairment worldwide and continues to pose a major clinical and public health burden, particularly in ageing populations. Modern cataract surgery is no longer limited to removal of the opaque lens, but increasingly aims to optimize postoperative visual quality, refractive outcomes, and patient satisfaction through appropriate intraocular lens (IOL) selection. In this context, the comparison between monofocal and multifocal IOLs has become especially relevant, as clinicians must balance optical quality, spectacle independence, patient expectations, and economic considerations.

Aim of the study:

To compare monofocal and multifocal intraocular lenses in modern cataract surgery and to evaluate their visual outcomes, patient satisfaction, spectacle independence, optical side effects, clinical indications, and relevance in the context of recent innovations in cataract treatment.

Methods:

This thesis was designed as a structured narrative literature review with a comparative focus. The literature search was conducted using PubMed, with supplementary searches in Google Scholar and ScienceDirect, between May 2025 and February 2026. Keywords included “multifocal intraocular lens”, “monofocal intraocular lens”, “cataract surgery”, “visual outcomes”, “patient satisfaction”, “contrast sensitivity”, and “spectacle independence”. Peer-reviewed studies, systematic reviews, meta-analyses, randomized controlled trials, observational studies, and guideline-based sources published mainly between 2018 and 2026 were prioritized. A total of 40 studies were selected for detailed analysis and synthesized thematically.

Results:

The reviewed literature showed that multifocal IOLs generally provide better uncorrected near and intermediate vision and significantly greater spectacle independence than monofocal IOLs. However, these benefits are associated with a higher incidence of dysphotopsias, including halos and glare, as well as some reduction in contrast sensitivity, particularly under mesopic conditions. Monofocal IOLs remain the most predictable and broadly applicable option, offering excellent distance vision, better optical clarity, and fewer visual side effects. They are especially suitable for patients with ocular comorbidities such as macular disease, glaucoma, diabetic retinopathy, or corneal irregularities. Recent innovations, including enhanced monofocal and extended-depth-of-focus lenses, have expanded the range of available options and may partially bridge the gap between standard monofocal and multifocal technologies.

Conclusions:

Both monofocal and multifocal intraocular lenses are effective in cataract treatment, but they serve different clinical needs and patient priorities. Multifocal IOLs are most appropriate for carefully selected, well-counseled patients who strongly value spectacle independence and have no significant ocular comorbidities. Monofocal IOLs remain the first-line and most reliable choice in routine practice due to their safety, accessibility, and optical stability. Optimal outcomes depend on individualized lens selection, realistic preoperative counseling, and shared decision-making. The future of cataract surgery lies in increasingly personalized approaches that integrate technological innovation with clinical pragmatism.

3. Santrauka

Tema:

Multifokaliniai ir monofokaliniai intraokuliniai lęšiai inovatyviame kataraktos gydyme: literatūros apžvalga.

Katarakta išlieka viena pagrindinių regėjimo sutrikimo priežasčių pasaulyje ir toliau kelia didelę klinikinę bei visuomenės sveikatos naštą, ypač senėjančiose populiacijose. Šiuolaikinė kataraktos chirurgija jau neapsiriboja vien tik drumsto lęšiuko pašalinimu, bet vis dažniau siekia optimizuoti pooperacinę regėjimo kokybę, refrakcinius rezultatus ir pacientų pasitenkinimą, parenkant tinkamą intraokulinį lęšį (IOL). Šiame kontekste monofokalinių ir multifokalinių IOL palyginimas tapo ypač aktualus, nes gydytojai turi derinti optinę kokybę, nepriklausomumą nuo akinių, pacientų lūkesčius ir ekonominius aspektus.

Tyrimo tikslas:

Palyginti monofokalinius ir multifokalinius intraokulinius lęšius šiuolaikinėje kataraktos chirurgijoje bei įvertinti jų regėjimo rezultatus, pacientų pasitenkinimą, nepriklausomumą nuo akinių, optinius šalutinius reiškinius, klinikines indikacijas ir reikšmę naujausių kataraktos gydymo inovacijų kontekste.

Metodai:

Šis darbas parengtas kaip struktūruota naratyvinė literatūros apžvalga, orientuota į lyginamąją analizę. Literatūros paieška buvo atlikta PubMed duomenų bazėje, papildomai ieškant Google Scholar ir ScienceDirect laikotarpiu nuo 2025 m. gegužės iki 2026 m. vasario mėn. Raktažodžiai buvo „multifocal intraocular lens“, „monofocal intraocular lens“, „cataract surgery“, „visual outcomes“, „patient satisfaction“, „contrast sensitivity“ ir „spectacle independence“. Pirmenybė teikta recenzuotiems tyrimams, sisteminėms apžvalgoms, metaanalizėms, randomizuotiems kontroliuojamiems tyrimams, stebimiesiems tyrimams ir klinikinėmis gairėmis pagrįstiems šaltiniams, daugiausia publikuotiems 2018–2026 m. laikotarpiu. Iš viso išsamiai analizei atrinkta 40 tyrimų, kurie buvo susisteminti teminiu principu.

Rezultatai:

Apžvelgta literatūra parodė, kad multifokaliniai IOL paprastai užtikrina geresnį nekoreguotą artimą ir tarpinį regėjimą bei reikšmingai didesnį nepriklausomumą nuo akinių nei monofokaliniai IOL. Tačiau šie privalumai siejami su didesniu disfotopsijų, įskaitant halo ir akinimą, dažniu, taip pat tam tikru kontrastinio jautrumo sumažėjimu, ypač mezopinėmis sąlygomis. Monofokaliniai IOL išlieka

labiausiai nuspėjamu ir plačiai pritaikomu pasirinkimu, užtikrinančiu puikų regėjimą į tolį, geresnį optinį aiškumą ir mažiau regėjimo šalutinių reiškinių. Jie ypač tinkami pacientams, turintiems gretutinių akių ligų, tokių kaip geltonosios dėmės patologija, glaukoma, diabetinė retinopatija ar ragenos nelygumai. Naujausios inovacijos, įskaitant patobulintus monofokalinius ir pailginto židinio gylio lęšius, išplėtė galimų pasirinkimų spektrą ir gali iš dalies užpildyti tarpą tarp standartinių monofokalinių ir multifokalinių technologijų.

Išvados:

Tiek monofokaliniai, tiek multifokaliniai intraokuliniai lęšiai yra veiksmingi gydant kataraktą, tačiau jie atitinka skirtingus klinikinius poreikius ir pacientų prioritetus. Multifokaliniai IOL labiausiai tinka kruopščiai atrinktiems, tinkamai konsultuotiems pacientams, kurie labai vertina nepriklausomumą nuo akinių ir neturi reikšmingų gretutinių akių ligų. Monofokaliniai IOL išlieka pirmo pasirinkimo ir patikimiausiu sprendimu kasdienėje praktikoje dėl savo saugumo, prieinamumo ir optinio stabilumo. Optimalūs rezultatai priklauso nuo individualizuoto lęšio parinkimo, realistiško priešoperacinio konsultavimo ir bendro sprendimų priėmimo. Kataraktos chirurgijos ateitis siejama su vis labiau individualizuotais metodais, jungiančiais technologines inovacijas ir klinikinį pragmatizmą.

4. Introduction

4.1 Background on Cataract

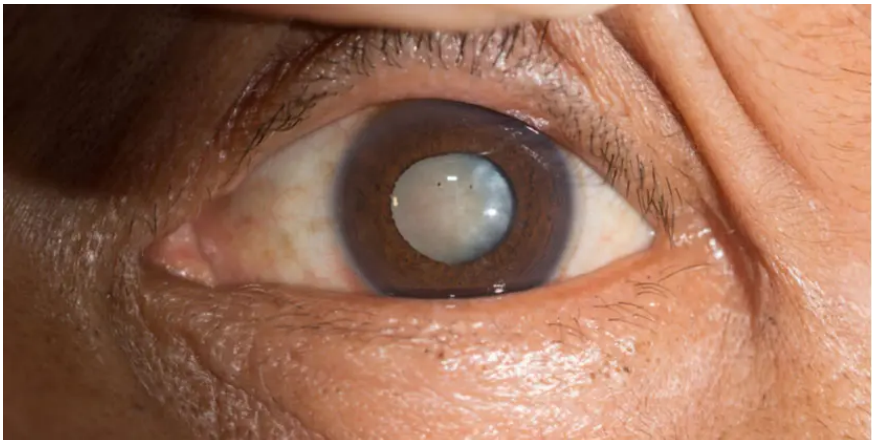


Figure 1 Clinical photograph of a mature cataract with visible lens opacity in the pupillary area. Source: American Academy of Ophthalmology [4].

Cataract is defined as a progressive opacification of the natural crystalline lens of the eye, leading to gradual deterioration of vision and reduced visual function. It remains one of the most important causes of visual impairment worldwide and is the leading cause of avoidable blindness, particularly among older adults. According to the World Health Organization, cataract is responsible for a substantial proportion of global blindness and continues to place a major burden on healthcare systems, especially in low- and middle-income countries where access to surgical treatment may be limited [3]. This makes cataract not only a clinical ophthalmic condition, but also a significant public health issue [3,4].

The development of cataract is most commonly associated with ageing and reflects progressive biochemical and structural changes within the lens. These include protein denaturation, aggregation of crystallins, oxidative stress, and alterations in lens hydration, all of which reduce lens transparency over time [1,2]. In addition to age-related cataract, a number of secondary causes have been identified, including diabetes mellitus, ocular trauma, prolonged corticosteroid use, uveitis, ionizing radiation, and congenital or hereditary disorders [1,2,4]. Such factors may accelerate lens opacification or influence the morphology and progression of the cataract.

Figure 2 Examples of visual disturbances caused by cataract, including blurred, dimmed, yellowed, and distorted vision. Source: American Academy of Ophthalmology [4].

Clinically, patients with cataract typically present with blurred or dimmed vision, glare sensitivity, halos around lights, decreased contrast sensitivity, colour desaturation, and increasing difficulty with night driving or reading [1,4]. Cataracts often develop slowly and may affect one or both eyes. Slit-lamp biomicroscopy remains the standard method of diagnosis and allows classification of cataracts according to the anatomical location of lens opacity. The main subtypes include:

- nuclear cataract, which is commonly associated with age-related lens sclerosis;
- cortical cataract, characterized by spoke-like peripheral opacities;
- posterior subcapsular cataract, which tends to impair near vision disproportionately and is frequently associated with glare symptoms [1,4].

At present, the only definitive treatment for cataract is surgical removal of the opacified lens followed by implantation of an intraocular lens (IOL). Modern cataract surgery, most commonly performed by phacoemulsification with implantation of a foldable IOL, is one of the safest, most effective, and most frequently performed surgical procedures worldwide [1,4]. In addition to restoring lens transparency, contemporary cataract surgery also has an important refractive function, as postoperative visual outcomes increasingly depend on appropriate IOL selection and individualized surgical planning. For this reason, effective treatment of cataract today involves not only removal of the diseased lens, but also optimization of postoperative quality of vision and patient satisfaction [1,3,4].

4.2 Objective and Relevance of the Topic

4.2.1 Objective:

The primary objective of this thesis is to perform a structured and critical literature review comparing multifocal and monofocal intraocular lenses (IOLs) in the context of cataract surgery. This analysis will explore not only visual acuity and quality of vision, but also patient satisfaction, postoperative independence from spectacles, and rates of dysphotopsia (e.g., glare and halos). Special emphasis is placed on evaluating clinical indications, selection criteria, and the evolving role of each IOL type in modern cataract practice. By synthesizing up-to-date evidence and clinical guidelines, the thesis aims to support more evidence-informed, patient-centered decision-making.

4.2.2 Relevance of the Topic:

Cataract surgery is currently the most frequently performed ophthalmic procedure worldwide, and intraocular lens (IOL) implantation is its core component [1,9]. For decades, monofocal IOLs have been the standard of care, offering predictable distance vision and high optical quality [1,17].

However, the growing demand for spectacle independence has led to the development and broader adoption of multifocal, extended-depth-of-focus (EDOF), and other presbyopia-correcting lenses [18,19,23].

While these premium lenses offer distinct advantages for certain patients, they also introduce new challenges, including visual disturbances, higher costs, and stricter eligibility criteria [19,25,28,31]. Simultaneously, enhanced monofocal lenses have emerged, blurring the boundary between "standard" and "premium" options [18,21]. In this context, clinicians are increasingly required to tailor IOL choice to individual patient profiles, while navigating technological complexity, economic considerations, and patient expectations [9,42].

Despite the wealth of available studies, a clear comparative synthesis is still lacking in the literature – particularly in light of recent innovations and shifting clinical paradigms. This thesis addresses this gap by providing a balanced review of the evidence, aiming to clarify the advantages and limitations of each lens type and to guide future decision-making in both clinical and policy contexts.

4.3 Results

The literature review demonstrated that multifocal intraocular lenses (IOLs) provide superior near and intermediate vision and a significantly higher rate of spectacle independence compared to monofocal IOLs. However, they are also associated with a higher incidence of dysphotopsias, such as halos and glare, and may result in reduced contrast sensitivity. Monofocal IOLs remain the standard in patients with ocular comorbidities or lower tolerance for visual disturbances. Shared decision-making, proper patient selection, and preoperative counseling are critical to improving satisfaction and visual outcomes.

4.4 Conclusions

Multifocal IOLs represent a promising option for motivated patients seeking freedom from glasses, provided they are properly counseled about potential side effects. Monofocal IOLs, however, remain the most reliable and widely applicable solution, especially in public health settings and in patients with existing retinal or optic nerve pathologies. Clinical decisions should be based on individual visual goals, ocular status, and healthcare accessibility, highlighting the importance of personalized and evidence-based cataract care.

4.5 Research question

What are the key differences between multifocal and monofocal intraocular lenses (IOLs) with respect to visual performance, postoperative outcomes, patient satisfaction, and the incidence of optical side effects in the context of modern cataract surgery?

4.6 Hypothesis

Multifocal intraocular lenses offer superior spectacle independence and enhanced near vision compared to monofocal lenses. However, this benefit may be offset by a higher incidence of dysphotopsias, such as glare and halos, and reduced contrast sensitivity, potentially leading to lower overall satisfaction in certain patient populations.

4.7 Methodology

This thesis is based on a structured narrative literature review comparing multifocal and monofocal intraocular lenses (IOLs) in the context of cataract surgery. The primary focus was on visual outcomes, patient-reported satisfaction, spectacle independence, and clinical applicability.

4.7.1 Literature Search Strategy

The literature search was conducted using the PubMed database, as well as supplemental searches in Google Scholar and ScienceDirect, between May 2025 and February 2026. The search strategy included keywords such as:

“multifocal intraocular lens”, “monofocal intraocular lens”, “cataract surgery”, “visual outcomes”, “patient satisfaction”, “contrast sensitivity” and “spectacle independence”.

Textbooks (particularly Kanski’s Clinical Ophthalmology, 8th ed.) were consulted to provide foundational background.

4.7.1.1 Inclusion Criteria

- Studies published in peer-reviewed journals
- Study types: randomized controlled trials, systematic reviews, meta-analyses, observational studies, and case reports where clinically relevant

- Comparative studies of monofocal vs multifocal IOLs, including newer technologies such as enhanced monofocal and EDOF lenses
- Studies published from 2000 to 2026, with priority given to recent studies (2018 - 2026)
- Articles available in English

4.7.1.2 Exclusion Criteria

- Focused exclusively on pediatric cataracts or congenital lens anomalies;
- Were editorials, opinion articles, or letters without original data;
- Lacked accessible full-text versions;
- Did not provide outcome data relevant to visual function or quality of life

4.8 Selection Process

Initial screening was based on titles and abstracts. Full-text review was then conducted to assess clinical relevance, study design, and data quality. When available, high-level evidence (e.g., RCTs or systematic reviews) was prioritized. Studies of lower methodological rigor were used to illustrate specific clinical scenarios or real-world variability.

A total of 40 studies were selected for in-depth analysis. Findings were synthesized with attention to study heterogeneity, population characteristics, and IOL types evaluated. All included sources were critically appraised and integrated into the thematic structure of the thesis.

5. Literature Review

5.1 History

Cataract surgery has evolved from rudimentary and risky procedures into one of the most refined and successful interventions in modern medicine. This transformation reflects centuries of innovation in surgical techniques, materials, and understanding of ocular anatomy.

5.1.1 Early Methods and Couching

The earliest documented method for treating cataract was couching, practiced as far back as 600 BCE in India and later in ancient Greece and Rome. The technique involved displacing the opaque lens into the vitreous cavity using a sharp instrument. While it sometimes improved light perception, it often led to complications such as inflammation, glaucoma, or blindness. Despite this, couching persisted for centuries, particularly in regions lacking surgical infrastructure. As Leffler et al. explain, other pre-modern techniques like discission (lens division), aspiration, and primitive extraction were introduced sporadically, but none offered reliable or safe long-term vision restoration [6].

Figure 3. Historical depiction of cataract couching, an early method of cataract treatment in which the opaque lens was displaced away from the visual axis. Source: adapted from Leffler et al. [6].

5.1.2 Extracapsular and Intracapsular Extraction

The Enlightenment and early modern periods brought anatomical advances that shaped more refined surgical approaches. In the 18th century, extracapsular cataract extraction (ECCE) emerged, wherein the lens contents were removed while preserving the posterior capsule – reducing the risk of vitreous loss. In contrast, intracapsular cataract extraction (ICCE), introduced later, involved removing the entire lens and capsule in one piece but was more invasive and posed greater risks. Nevertheless, ICCE dominated in the 20th century until phacoemulsification became widespread. As Davis notes, surgical refinements and improvements in asepsis gradually increased safety and efficacy, with modern success rates now exceeding 90% [5].

5.1.3 The First Intraocular Lenses

A defining moment occurred in 1949–1950 when Sir Harold Ridley, a British ophthalmologist, implanted the world's first intraocular lens (IOL) in a patient at St Thomas' Hospital, London. Ridley's inspiration reportedly came from observing WWII pilots whose acrylic canopy fragments remained inert in the eye. Despite early skepticism and postoperative complications, his pioneering concept – restoring the eye's refractive power with a synthetic lens – eventually reshaped the field. Today, IOL implantation is considered indispensable in cataract surgery. Ridley's legacy lies in transforming the procedure from a rehabilitative intervention into a refractive one [8].

5.1.4 Phacoemulsification and Minimally Invasive Surgery

In the 1960s, Dr. Charles D. Kelman introduced phacoemulsification – a technique that uses ultrasonic energy to emulsify the lens through a microincision. Inspired by the mechanics of dental drills, Kelman's innovation was initially met with resistance due to its technical complexity.

Figure 4 Early phacoemulsification handpiece associated with the development of modern small-incision cataract surgery. Source: adapted from Leffler et al. [7].

However, over time it revolutionized cataract surgery by reducing incision size, decreasing recovery time, and minimizing intraoperative trauma. Phacoemulsification became the gold standard and catalyzed the development of foldable IOLs and minimally invasive procedures. As noted in Leffler's 2024 overview, Kelman's work fundamentally altered the surgical landscape and patient expectations [7].

5.1.5 Modern Lens Technology and Refractive Focus

Today, cataract surgery is no longer viewed merely as lens removal but as an opportunity to optimize postoperative refractive outcomes. Modern IOLs, including multifocal, toric, and extended-depth-of-focus (EDOF) designs, aim to correct presbyopia and astigmatism. The integration of advanced biometry, small-incision surgery, and customized lens selection reflects this shift toward personalized visual restoration. As Davis highlights, newer technologies focus not just on safety and efficacy, but on achieving the highest possible quality of life for patients post-surgery [5].

5.1.6 Conclusion of the Historical Overview

The evolution of cataract surgery – from couching to phacoemulsification and premium IOLs – illustrates a remarkable continuum of medical advancement. Each milestone contributed to today's standards of precision, safety, and patient satisfaction. As modern cataract surgery increasingly involves decisions about lens type (monofocal vs multifocal), understanding its historical context helps frame current debates and future directions [5-8].

5.2 Overview of Cataract Surgery

Cataract surgery is one of the most frequently performed surgical procedures worldwide and remains the definitive treatment for lens opacification. The primary goal of surgery is to remove the cloudy lens and replace it with a clear intraocular lens (IOL), thereby restoring visual acuity and improving the patient's quality of life [1,9].

5.2.1 Indications and Preoperative Assessment

Surgery is indicated when a cataract significantly impairs visual function and reduces a patient's quality of life – particularly when it interferes with daily activities such as reading, driving, or occupational tasks [9]. According to current clinical recommendations from the European Society of Cataract and Refractive Surgeons (ESCRS), cataract surgery should be considered based not only on objective findings (such as decreased best-corrected visual acuity), but also on subjective symptoms and patient needs [9].

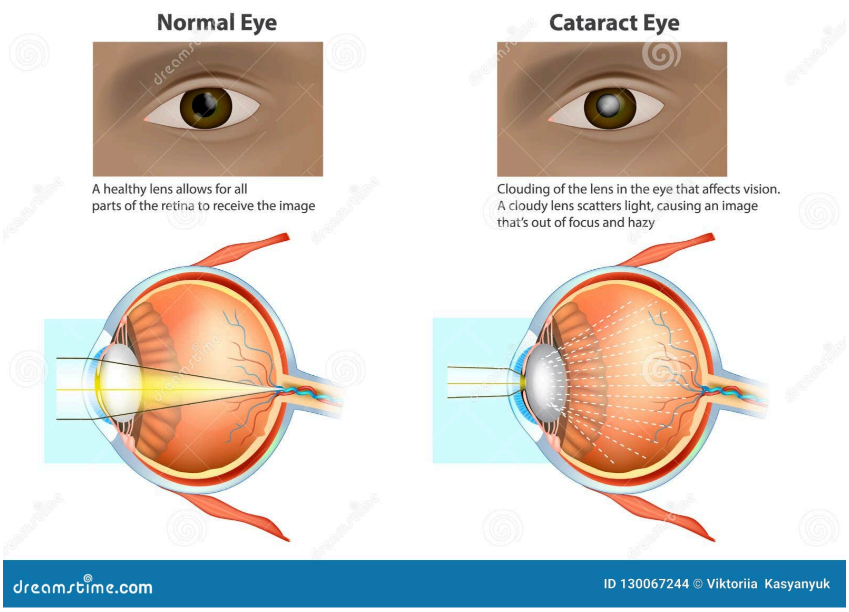


Figure 5 Schematic comparison of a normal eye and a cataractous eye, illustrating lens opacity and its effect on image formation. Source: Dreamstime [14].

A comprehensive preoperative evaluation is essential to identify potential risks, optimize surgical planning, and personalize intraocular lens (IOL) selection. This includes:

- Slit-lamp biomicroscopy to assess cataract density, anterior segment anatomy, and corneal health.
- Ocular biometry to measure axial length and calculate IOL power.

- Keratometry (manual or automated) to evaluate corneal curvature, detect astigmatism, and aid toric IOL planning.
- Optical coherence biometry (IOLMaster or LENSTAR) for more precise axial length and anterior chamber depth measurements.
- Dilated fundus examination to assess retinal and optic nerve status, and exclude significant comorbidities such as macular degeneration or diabetic retinopathy [9,12].

Additional diagnostic tests may be required in patients with risk factors or comorbidities. These may include:

- Specular microscopy to assess corneal endothelial cell count (especially important in Fuchs' dystrophy or previous surgery) [13].
- B-scan ultrasonography in cases of dense cataract where posterior segment visualization is limited.
- Macular OCT to detect subclinical epiretinal membranes, macular edema, or foveal atrophy [9].

The ESCRS guidelines emphasize the importance of preoperative risk stratification, especially in patients with pseudoexfoliation syndrome, shallow anterior chamber, high myopia, or history of uveitis. Identifying such risks allows for adjusted surgical technique, choice of viscoelastics, and postoperative care [9].

Moreover, it is essential to provide realistic patient counselling before surgery. Patients should be informed about potential complications such as posterior capsule rupture, cystoid macular edema, corneal decompensation, and postoperative refractive surprise. They should also be aware of the possibility of needing glasses after surgery – particularly with monofocal IOLs – and the role of additional procedures such as YAG capsulotomy in case of posterior capsule opacification [9,12].

5.2.2 Surgical Technique: Phacoemulsification as the Gold Standard

The most widely used surgical technique in modern cataract surgery is phacoemulsification, originally introduced by Charles D. Kelman. It is currently considered the standard approach due to its safety profile, refractive predictability, and fast visual rehabilitation [1,10]. The procedure is typically performed under local (topical or sub-Tenon's) anaesthesia and begins with the creation of a small clear corneal incision (commonly around 2.2 mm, depending on the surgeon and IOL system). A continuous curvilinear capsulorhexis (CCC) is then performed to provide controlled access to the lens while maintaining capsular stability. After hydrodissection (and often hydrodelineation), the lens nucleus is fragmented and removed using ultrasonic energy (phacoemulsification), followed by aspiration of residual cortical material. Finally, a foldable intraocular lens (IOL) is implanted into the capsular bag, which remains the preferred anatomical position for long-term centration and stability. In most cases, the incision is self-sealing, and sutures are rarely required [1,10].

Phacoemulsification offers several clinically relevant advantages compared with older techniques. These include reduced surgical trauma, smaller incision size, lower risk of surgically induced astigmatism, and faster postoperative recovery, which contributes to improved patient satisfaction and earlier return to daily activities [10,11]. The technique also allows consistent integration of modern

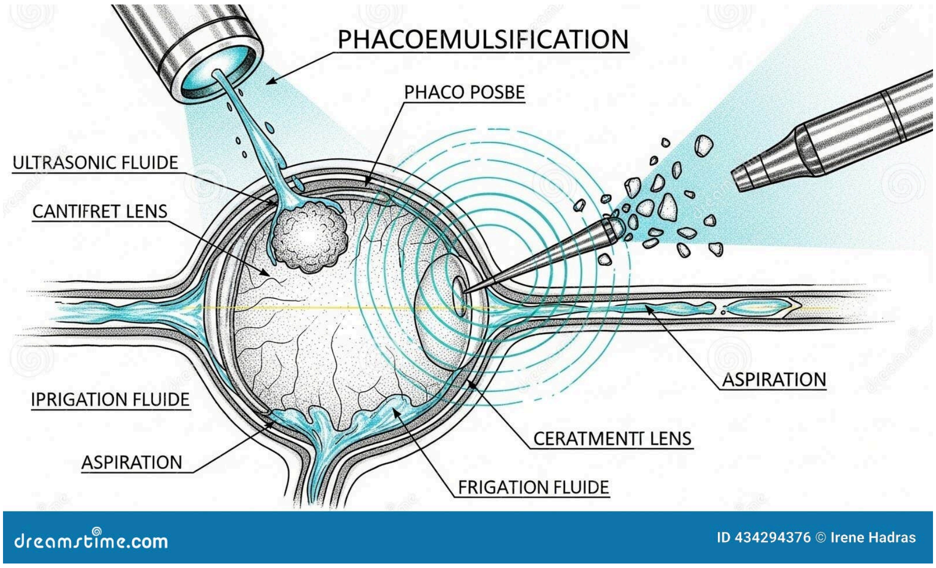


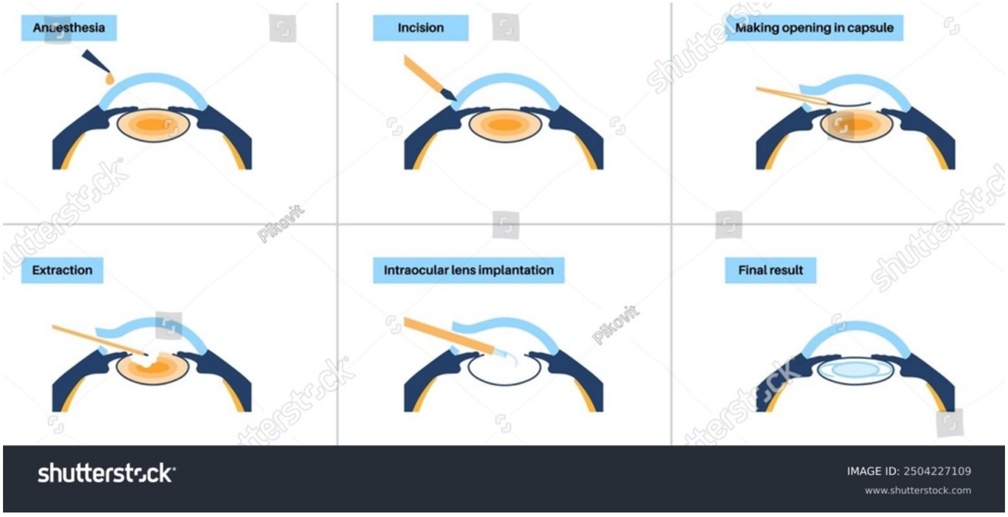
Figure 6 Schematic illustration of phacoemulsification, showing ultrasonic fragmentation and aspiration of the cataractous lens. Source: Dreamstime [15].

planning, supporting the current concept of cataract surgery as both a restorative and refractive procedure [9,10]. Although alternative approaches such as manual small-incision cataract surgery (MSICS) and extracapsular cataract extraction (ECCE) remain important in selected complex cases or in low-resource settings, phacoemulsification continues to be the dominant method in most healthcare systems due to its efficiency and outcomes [9,10].

5.2.3 Intraocular Lens Implantation: The Role of Monofocal IOLs

Following lens removal during cataract surgery, the standard practice is the implantation of an intraocular lens (IOL) to restore the eye’s focusing ability. Among the available options, the monofocal intraocular lens remains the most commonly used type worldwide [9]. This lens provides a single focal point, typically targeted for distance vision, which enables patients to perform tasks such as driving or watching television without corrective lenses. However, because monofocal IOLs lack the ability to adjust focus across different distances, most patients will require spectacles for near and intermediate activities, including reading, smartphone use, or computer work [9,11].

Figure 7 Main stages of cataract surgery, including anaesthesia, corneal incision, capsular opening, lens extraction, intraocular lens implantation, and final result. Shutterstock [16].



Monofocal lenses are available in spherical and aspheric designs, with the latter offering improved contrast sensitivity and better visual quality in low-light conditions. Additionally, toric monofocal IOLs are used to correct pre-existing corneal astigmatism, allowing for improved uncorrected distance vision in patients with regular astigmatic profiles [9]. These lenses are highly biocompatible, cost-effective, and surgically straightforward, making them an ideal choice in most standard cases, especially within public health systems and in low-resource settings [1,9].

Another key advantage of monofocal IOLs is their low incidence of optical side effects, such as glare, halos, or reduced contrast sensitivity — phenomena more frequently associated with multifocal or other premium IOLs. This makes monofocal lenses especially appropriate for patients with ocular comorbidities, such as macular degeneration, glaucoma, diabetic retinopathy, or corneal irregularities, where optical quality must be prioritized over spectacle independence [1,9].

Although monofocal IOLs do not eliminate the need for glasses at all distances, their predictable performance, wide availability, and excellent safety profile continue to support their status as the "gold standard" in routine cataract surgery. For many patients, especially those with realistic visual expectations, monofocal IOLs provide a reliable and satisfactory solution for restoring vision after cataract extraction [9,11].

5.2.4 Modern Practices and Patient-Centered Decision Making

Modern cataract surgery is not only a restorative but also a refractive procedure, with growing emphasis on tailoring both the surgical plan and intraocular lens (IOL) choice to the patient's visual needs, lifestyle, and expectations. This shift reflects the increasing demand for spectacle independence and higher visual performance in all distances [9,11].

Shared decision-making and thorough informed consent are now integral to preoperative counseling. Patients should be actively involved in choosing the most appropriate IOL type based on their goals, tolerance for potential visual side effects, and any existing ocular conditions [9].

Thanks to advances in IOL technology, premium lenses – such as multifocal, extended-depth-of-focus (EDOF), and toric IOLs – can now offer tailored solutions for presbyopia and astigmatism correction, particularly for patients who prioritize spectacle independence [9,11]. However, monofocal IOLs remain the most widely used option due to their optical quality, predictability, lower cost, and minimal risk of dysphotopsias. They are especially suitable for patients with realistic expectations or pre-existing ocular comorbidities [1,9,10].

This patient-centered approach improves satisfaction, aligns expectations with outcomes, and reinforces the role of cataract surgery as a personalized, vision-enhancing intervention.

5.3 Monofocal Lenses

Monofocal intraocular lenses (IOLs) are the most widely used type of lens implanted after cataract extraction and remain the gold standard for restoring distance vision. Designed to provide a single point of focus, typically set for far distance, monofocal lenses deliver high-quality uncorrected vision for activities such as driving and watching television, though spectacles are usually required for near and intermediate tasks like reading or computer use [1,17].

Figure 8 Examples of monofocal intraocular lens designs used in cataract surgery. Source: ZEISS [22].

5.3.1 Mechanism of Action

Monofocal IOLs are optically simple in design, focusing light onto one focal point on the retina. They do not split incoming light like multifocal or extended-depth-of-focus (EDOF) lenses do. This design preserves contrast sensitivity and reduces the risk of unwanted visual phenomena such as glare, halos, or starbursts, especially under mesopic or night conditions [17,18]. The lenses are typically made of biocompatible hydrophobic acrylic materials and are available in spherical or aspheric forms, the latter offering enhanced contrast in low-light conditions [1].

5.3.2 Advantages

The key strengths of monofocal IOLs lie in their optical clarity, safety, and predictability:

- They offer excellent distance vision with minimal dysphotopsia, making them ideal for most patients, especially those with coexisting ocular conditions (e.g., age-related macular degeneration or glaucoma) [1,17,19].
- The low rate of visual side effects, combined with broad surgical familiarity, contributes to high patient satisfaction [18].
- Toric versions of monofocal IOLs are available for correcting regular corneal astigmatism, further expanding their utility [1,18].

In addition, cost-effectiveness and global availability make monofocal lenses the most accessible and widely accepted option in both public and private healthcare systems [1,17].

5.3.3 Disadvantages

The main limitation of monofocal IOLs is their inability to provide spectacle independence across all distances. Most patients will require reading glasses for near and intermediate vision tasks [17,18]. While this is acceptable for many, it may be a drawback for those who prioritize visual freedom.

Additionally, conventional monofocal lenses do not correct presbyopia, and patients with high visual demands may perceive the need for glasses as a limitation of the procedure, even if overall satisfaction remains high [18].

5.3.4 Enhanced Monofocal IOLs

Recent innovations have led to the development of enhanced monofocal or “monofocal plus” IOLs, which aim to slightly extend the depth of focus without introducing the side effects typical of multifocal designs. These lenses use modified optics – such as increased negative spherical aberration or elongated aspheric profiles – to improve intermediate visual function while maintaining distance performance and contrast sensitivity [18,19].

Clinical trials comparing standard and enhanced monofocal IOLs (e.g., TECNIS Eyhance, Vivinex Impress, RayOne EMV) show that enhanced lenses can offer measurable improvement in intermediate vision (e.g., dashboard reading, computer use) without significantly increasing glare or halos [19,20,21].

5.3.5 Patient Outcomes

Multiple studies confirm that patients implanted with monofocal IOLs achieve high levels of uncorrected distance visual acuity, low complication rates, and stable refractive outcomes [17,20]. Satisfaction levels are especially high among patients with realistic expectations and those who accept or prefer using reading glasses [1,17].

Patients receiving enhanced monofocal IOLs also report improved intermediate vision performance and greater functional independence, with minimal trade-offs in optical quality or incidence of dysphotopsia [19-21]. These newer designs may serve as an optimal solution for patients who want improved vision range but are not ideal candidates for multifocal or EDOF lenses.

5.4 Multifocal Lenses

Multifocal intraocular lenses (IOLs) are designed to correct both cataract and presbyopia by providing visual focus at multiple distances—typically far, intermediate, and near. Unlike monofocal IOLs, which focus light at a single distance, multifocal IOLs split incoming light into several focal points, offering patients greater independence from spectacles across a range of daily activities. Their development reflects the growing demand for spectacle-free vision following cataract surgery, particularly among active and professionally engaged individuals [1,18].

5.4.1 Mechanism of Action

Multifocal IOLs work by dividing incoming light into two or more focal points. Depending on the optical design, they redirect light to provide simultaneous vision at different distances. While this comes at the cost of some reduction in contrast sensitivity, the benefit is functional vision without spectacles across various ranges [1,23].

Figure 9 Example of a trifocal diffractive intraocular lens used for presbyopia correction and increased spectacle independence. Source: Alcon [27].

There are two main optical principles used in multifocal IOLs:

- Diffractive lenses, which use concentric rings to create distinct focal zones via constructive and destructive interference. These lenses are generally pupil-independent and offer consistent performance under various lighting conditions [23,25].

- Refractive lenses, which utilize concentric zones of differing curvature or power to focus light at various distances. These lenses may be more pupil-dependent, with outcomes influenced by lighting and pupil size [1,24].

Hybrid lenses combining both optical principles have also been introduced to optimize visual outcomes and reduce adverse effects [18].

5.4.2 Types of Multifocal Lenses

1. Bifocal IOLs provide two focal points – usually distance and near – and are the earliest form of multifocal lenses.
2. Trifocal IOLs, such as PanOptix and FineVision, introduce an intermediate focal point, significantly improving computer and dashboard vision [24,18].
3. Hybrid diffractive-refractive IOLs (e.g., Precizon Presbyopic) aim to enhance depth of focus while minimizing dysphotopsias [25].
4. EDOF (Extended Depth-of-Focus) lenses are sometimes grouped with multifocal IOLs due to similar goals, but their design and light distribution differ (discussed separately).

Advantages:

Multifocal IOLs offer several clinical and functional benefits:

- High levels of spectacle independence, especially for near and intermediate tasks like reading, phone use, and computer work [23,25].
- Restoration of vision across multiple focal ranges, reducing the need for glasses in daily life.
- Availability of multiple design options, allowing for customization based on patient preferences and anatomical factors [24,18].

Disadvantages and Limitations:

Despite their benefits, multifocal IOLs have some limitations:

- Reduced contrast sensitivity, particularly under mesopic or scotopic conditions, due to the division of light energy among multiple focal points [1,23].
- Photopic phenomena, including halos, glare, and starbursts, are more frequent with multifocal lenses, especially diffractive designs [24].

- Higher cost compared to monofocal lenses, often not covered by national insurance systems [18].
- Patient dissatisfaction may occur in cases of inadequate counselling, unrealistic expectations, or unrecognized ocular comorbidities (e.g., macular disease, irregular astigmatism) [25].

Proper patient selection, including evaluation of personality, lifestyle, and visual goals, is critical to achieving good outcomes. Contraindications may include significant corneal pathology, uncontrolled glaucoma, or retinal disease [1,18].

Management of dissatisfaction after multifocal IOL implantation should begin with identifying potentially reversible causes such as residual refractive error, dry eye disease, posterior capsule opacification, lens decentration, or unrecognized ocular pathology. Conservative measures may include spectacles, treatment of ocular surface disease, laser vision correction, or Nd:YAG capsulotomy when appropriate. Patients are also often encouraged to allow a period of neuroadaptation, usually several months, as symptoms such as halos or glare may gradually improve over time. However, if severe dysphotopsia and dissatisfaction persist despite these measures, intraocular lens exchange may be considered. Recent evidence suggests that exchange to another multifocal IOL with a different optical profile may preserve some degree of spectacle independence while reducing symptoms, whereas exchange to a monofocal IOL usually provides the greatest improvement in visual quality and reduction of photic phenomena, though at the expense of near vision without glasses [48].

5.4.3 Patient Outcomes

Numerous clinical studies have demonstrated that multifocal IOLs provide excellent uncorrected visual acuity across distance and near ranges. Trifocal designs, in particular, offer improved intermediate vision without significantly compromising distance acuity [23,24].

In a recent comparative study, diffractive trifocal IOLs (such as PanOptix and Synergy) showed higher patient satisfaction and broader range of clear vision compared to older bifocal designs. However, rates of glare and halos remained notable, especially in nighttime settings [24,26].

A prospective study evaluating the Precizon Presbyopic NVA IOL demonstrated good binocular visual acuity at all distances and high satisfaction rates, with over 80% of patients reporting full spectacle independence at 6 months postoperatively [25]. Neural adaptation also plays a role in subjective outcomes, and many patients report improved comfort with time.

5.5 Comparative Analysis

5.5.1 Comparative Analysis: Multifocal vs Monofocal Lenses

Numerous studies have compared monofocal and multifocal intraocular lenses (IOLs) in terms of visual outcomes, patient satisfaction, complication rates, and cost-effectiveness. These comparisons are essential for guiding IOL selection and aligning surgical choices with individual patient priorities.

5.5.2 Visual Outcomes

Recent data confirm that multifocal IOLs offer superior uncorrected near and intermediate vision compared to monofocal lenses, which provide sharp distance vision but require spectacles for other ranges. Yuan et al. (2025) conducted a comprehensive clinical comparison, demonstrating that patients with multifocal IOLs achieved significantly better uncorrected near visual acuity (UNVA) and intermediate vision while maintaining comparable distance visual acuity (UDVA) to monofocal IOL recipients [28]. Nevertheless, contrast sensitivity was slightly reduced in the multifocal group, particularly under mesopic conditions, reflecting a known trade-off in multifocal optics.

Table 1. Postoperative visual outcomes and patient satisfaction assessment.

Characteristics	Multifocal IOL group (n=92)	Monofocal IOL group (n=108)	t/χ^2	*P*-value
Uncorrected distance visual acuity (UDVA)	0.86±0.11	0.85±0.10	t=0.85	>0.05
Uncorrected near visual acuity (UNVA)	0.35±0.15	0.60±0.20	t=4.56	<0.001
Uncorrected intermediate visual acuity (UIVA)	0.45±0.12	0.55±0.15	t=1.23	>0.05
Contrast sensitivity (CS)	1.50±0.20	1.55±0.22	t=0.98	>0.05
Halos/glare complaints (%)	15%	5%	χ^2=6.78	<0.05
Patient satisfaction (%)	92%	88%	χ^2=1.45	>0.05
Postoperative complications (%)	2%	3%	χ^2=0.56	>0.05
Defocus curve performance	1.50 - 3.00	0.50 - 1.50	t=3.45	<0.05
Reading acuity at preferred distance	0.10±0.05	0.20±0.10	t=3.21	<0.05

Table 1. Postoperative visual outcomes and patient satisfaction after multifocal versus monofocal intraocular lens implantation. Source: adapted from [29].

5.5.3 Patient Satisfaction and Spectacle Independence

Spectacle independence remains a key motivator for choosing multifocal IOLs, particularly among patients with active lifestyles who wish to minimize the need for glasses for near and intermediate tasks such as reading, smartphone use, and computer work. In the systematic review by Wu et al. (2025), more than 80% of patients implanted with multifocal IOLs reported being completely free from spectacles for most everyday activities, whereas this outcome was observed in only around 25% of patients with monofocal IOLs, reflecting the fundamental optical advantage of multifocal designs in functional vision range [29]. This increased spectacle independence is frequently associated with higher perceived convenience and quality-of-life improvements, especially in patients who strongly prioritize visual autonomy.

However, spectacle independence does not always translate into universal satisfaction. A subset of patients with multifocal IOLs reported visual disturbances, most commonly halos and glare, particularly under low-light or night-driving conditions. These symptoms are closely linked to the light-splitting mechanism of multifocal optics and may vary depending on lens design, pupil size, and individual neuroadaptation. Importantly, dissatisfaction is more likely when such effects are unexpected or insufficiently addressed during preoperative counselling, highlighting the role of realistic expectation management and careful patient selection in achieving optimal patient-reported outcomes [29].

5.5.4 Complications and Quality of Vision

While both intraocular lens (IOL) types demonstrate excellent overall safety profiles and low rates of serious complications, multifocal IOLs are consistently associated with a higher incidence of dysphotopsias, especially halos, glare, and starbursts under mesopic or scotopic conditions. These visual disturbances stem from the light-splitting principles of diffractive and refractive optical designs, which intentionally divide incoming light to multiple focal points. Although most patients adapt to these phenomena over time through neuroadaptation, the degree of tolerance varies, and in some cases, symptoms may persist and impact night-time visual tasks such as driving. In rare but clinically significant situations, persistent dysphotopsias may lead to lens explantation and replacement with a monofocal IOL [30].

By contrast, monofocal IOLs are rarely associated with such optical side effects, offering a more stable and artifact-free image, especially in low-light conditions. This makes them the preferred option for patients with pre-existing ocular pathology – such as age-related macular degeneration, diabetic retinopathy, or glaucoma – where maximal contrast sensitivity and minimized visual noise are essential for functional vision. Moreover, monofocal lenses are often better tolerated by patients who have low neuroadaptation capacity, including older individuals or those with significant anxiety regarding visual changes [32].

5.5.5 Cost-Effectiveness

Economic analyses have shown that although multifocal IOLs involve higher initial surgical costs, they may provide greater long-term value due to decreased reliance on spectacles and reduced need for additional corrective procedures. A 2025 study by Min et al. found that multifocal lenses yielded higher quality-adjusted life years (QALYs) at a cost-effective threshold in most healthcare systems, particularly when spectacle independence was highly valued by the patient [30]. This was further supported by a 2023 Springer review, which concluded that multifocal IOLs are cost-effective in appropriately selected patients, especially when the cost of postoperative visual aids and productivity gains are factored in [31].

5.5.6 Clinical Recommendations

According to Cochrane evidence summaries, the choice between multifocal and monofocal intraocular lenses (IOLs) should be individualized and based on a balance between expected benefits and potential trade-offs. Multifocal IOLs are generally more suitable for patients who strongly prioritize spectacle independence, particularly for near and intermediate activities, and who are willing to accept a higher likelihood of optical side effects such as halos or glare, especially in low-light conditions. In this context, successful outcomes depend not only on the optical performance of the lens but also on careful patient selection, including assessment of visual demands, occupational requirements (e.g., night driving), and tolerance for visual disturbances [32].

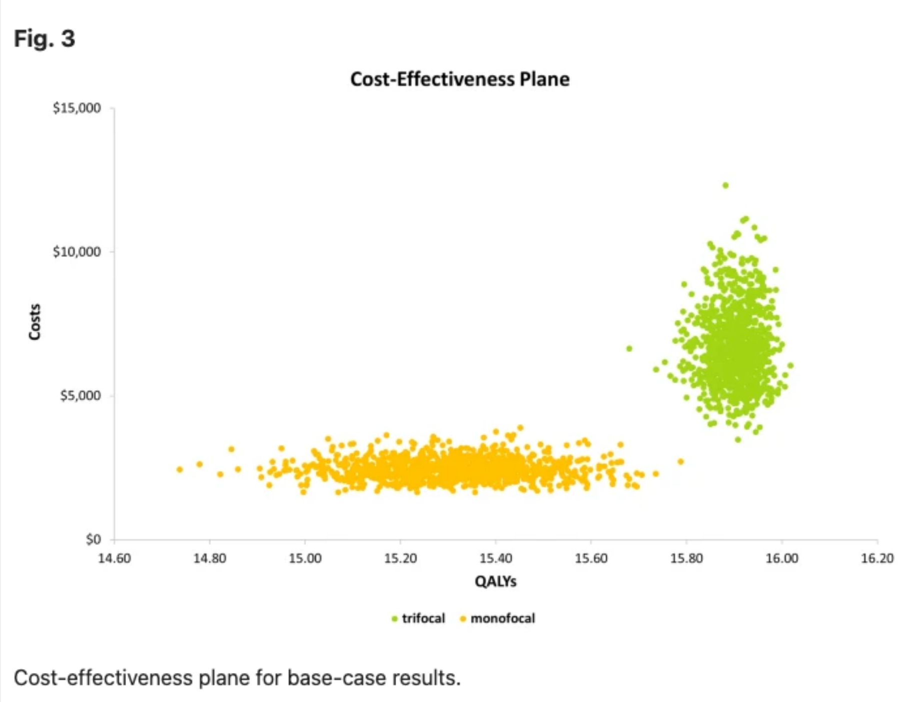


Figure 10 Cost-effectiveness plane comparing multifocal and monofocal intraocular lenses in the base-case analysis. Source: adapted from [31].

In contrast, monofocal IOLs remain the first-line option for many cataract patients due to their excellent and predictable distance visual acuity, better preservation of contrast sensitivity, and a lower incidence of dysphotopsias. They are particularly recommended in patients with ocular comorbidities – such as macular degeneration, glaucoma, diabetic retinopathy, or corneal irregularities – where maximizing image quality is clinically more important than achieving spectacle independence. Overall, Cochrane-based guidance supports a patient-centered approach in which IOL selection is aligned with both anatomical suitability and realistic postoperative expectations, minimizing the risk of dissatisfaction and postoperative regret [32].

5.6 Innovative Advances

Cataract surgery has undergone a remarkable transformation in recent years, evolving from a vision-restoring intervention into a highly individualized, refractive procedure. Innovations span across surgical techniques, intraocular lens (IOL) technologies, imaging modalities, and digital integration. These advances aim to improve precision, safety, and visual outcomes, while enhancing patient satisfaction and spectacle independence.

5.6.1 Advances in Intraocular Lens Design: EDOF and Enhanced Monofocal IOLs

One of the most significant developments in cataract surgery has been the improvement of intraocular lens designs beyond traditional monofocal and basic multifocal models. Modern Extended Depth of Focus (EDOF) IOLs offer smoother transitions across visual distances and improved intermediate vision, while significantly reducing photic phenomena (e.g., halos, glare) that are common with older multifocal lenses. According to Srivastava et al. (2024), patients with EDOF IOLs demonstrated better contrast sensitivity, higher rates of spectacle independence, and fewer complaints of dysphotopsia compared to those with standard diffractive multifocal lenses [33].

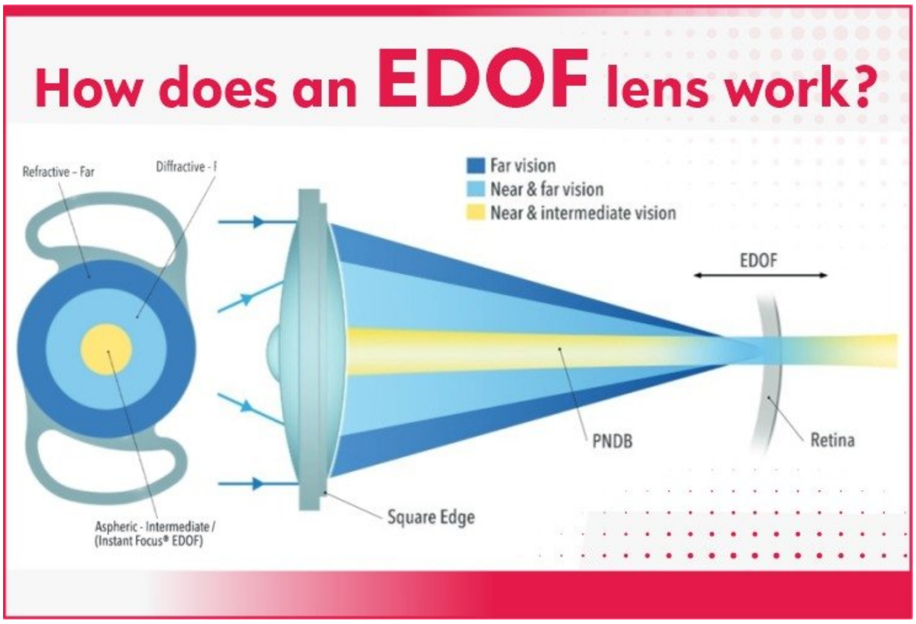


Figure 11 Optical principle of an extended depth-of-focus (EDOF) intraocular lens, illustrating elongation of the focal range to improve distance and intermediate vision. Source: reproduced from [38].

In parallel, enhanced monofocal lenses have been introduced to bridge the gap between standard monofocals and premium options. These IOLs, while technically monofocal, use aspheric optics, wavefront shaping, or specific light distribution zones to extend the range of focus and improve intermediate vision without compromising contrast sensitivity. Qureshi et al. (2024) emphasized that such lenses may be particularly valuable for patients with lower visual demands who still wish to reduce their reliance on reading glasses, without accepting the trade-offs of multifocality [34].

Moreover, modern IOL materials now feature improved biocompatibility, reduced glistening formation, and enhanced surface properties that help minimize posterior capsule opacification and promote long-term optical clarity.

Recent comparative evidence further supports the view that newer non-diffractive or refractive EDOF lenses may offer a meaningful extension of functional vision beyond that achieved with enhanced monofocal IOLs. In a 2025 retrospective real-world study, Kim et al. compared the TECNIS PureSee EDOF IOL with the TECNIS Eyhance enhanced monofocal IOL after bilateral cataract surgery and found that the PureSee lens provided significantly better uncorrected intermediate and near visual acuity, while maintaining comparable distance visual acuity and contrast sensitivity. Although photic phenomena were reported somewhat more frequently in the EDOF group, spectacle dependence for near vision was significantly lower, and overall patient satisfaction remained high. These findings suggest that next-generation refractive EDOF lenses may represent an attractive intermediate option for patients seeking greater functional range of vision than enhanced monofocal IOLs can provide, without the full dysphotopsia burden classically associated with multifocal technology [37].

5.6.2 Femtosecond Laser-Assisted Cataract Surgery (FLACS) and Image-Guided Technology

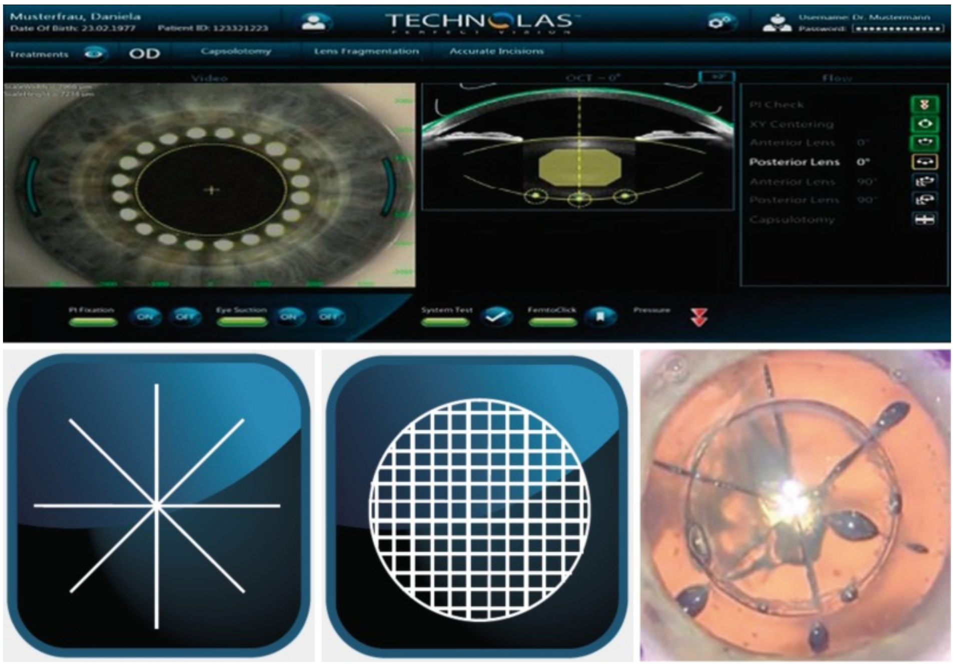
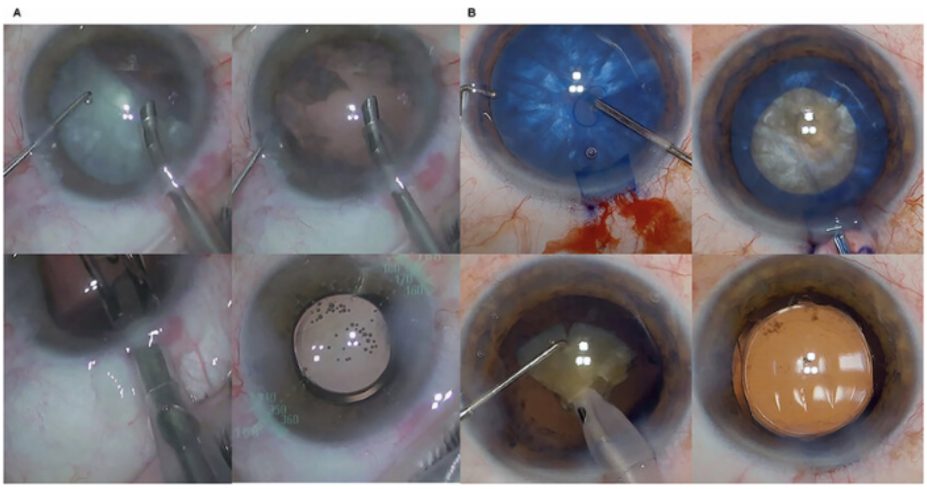


Figure 12 Femtosecond laser-assisted cataract surgery (FLACS): digital planning interface, laser fragmentation patterns, and intraoperative application. Source: reproduced from [39].

Surgical technique has also been revolutionized by the integration of femtosecond laser-assisted cataract surgery (FLACS), a major leap in precision ophthalmic surgery. This advanced technology automates several critical steps of cataract surgery – such as corneal incisions, anterior capsulotomy, and nuclear fragmentation – which were traditionally performed manually. The laser delivers pulses with submicron accuracy, resulting in more consistent and centered capsulorhexis, which is essential for optimal IOL positioning and long-term visual outcomes. Compared to conventional manual techniques, FLACS has been shown to reduce ultrasound energy required during phacoemulsification, decrease endothelial cell loss, and potentially lower the risk of intraoperative complications. Leffler et al. (2025) emphasized that FLACS not only enhances safety and reproducibility, but also contributes to the predictability of refractive results – a factor of growing importance in the era of premium IOLs and individualized visual correction [35].

Complementing FLACS, image-guided systems and intraoperative aberrometry provide real-time visual mapping of the eye's anatomy and precise alignment tools during surgery. These technologies enable accurate centration and axis alignment of toric IOLs, which is crucial for correcting pre-existing astigmatism and achieving the desired refractive outcome. Their use significantly reduces residual refractive error and the likelihood of needing postoperative enhancements. As astigmatism-correcting and multifocal lenses become increasingly popular, such digital tools are evolving from optional upgrades into standard components of high-precision cataract surgery, particularly in practices offering refractive lens exchange or customized visual correction [36].

5.6.3 Minimally Invasive Techniques and Microincision Surgery



(A and B) Phacoemulsification performed in the usual manner, after using the automated technique and with the intraocular lens inside the capsular bag.

Figure 13 Phacoemulsification performed after automated capsulotomy, with the intraocular lens implanted inside the capsular bag. Source: reproduced from [40].

The trend toward minimally invasive cataract surgery continues to gain momentum as both technology and surgical expertise evolve. A key development in this area is the widespread adoption of microincisional cataract surgery (MICS), which involves corneal incisions smaller than 2.0 mm. These smaller incisions offer multiple benefits: they reduce surgically induced astigmatism, facilitate faster hem particularly advantageous for patients with predisposing factors such as thin corneas, high myopia, or previous ocular surgeries [36]. Additionally, smaller incisions lower the risk of infection, reduce postoperative inflammation, and result in better patient comfort. From a practical perspective, MICS is ideally suited for the insertion of foldable, preloaded intraocular lenses (IOLs), which simplifies the surgical process, shortens operative time, and improves consistency in lens delivery.

Alongside smaller incisions, significant progress has been made in nuclear disassembly techniques. Traditional divide-and-conquer methods are increasingly being replaced by more efficient approaches such as "soft chop," "phaco flip," "phaco prechop," and "femtodelineation." These techniques enable more effective fragmentation of the nucleus with reduced mechanical manipulation and ultrasound energy, thereby preserving intraocular structures like the corneal endothelium and zonular fibers. For instance, femtodelineation – when combined with FLACS – creates concentric cleavage planes that assist in controlled phacoemulsification of denser cataracts.

Moreover, modern phacoemulsification platforms have introduced features such as thermal protection sleeves, pulse modulation systems, torsional ultrasound, and active fluidics management, which together reduce turbulence, maintain anterior chamber stability, and improve followability of nuclear fragments. As demonstrated in the study by Biman et al. (2025), these innovations contribute to a safer intraoperative environment, especially in complex or dense cataracts, and support better postoperative recovery with fewer complications [35].

5.6.4 Artificial Intelligence and Personalized Planning

Artificial intelligence (AI) is emerging as a powerful tool in surgical planning, patient triage, and outcome prediction. Algorithms trained on biometric and demographic data can now assist in IOL power calculations, anticipate surgical risks, and recommend the most appropriate IOL type based on patient preferences and ocular characteristics. Ali et al. (2024) presented evidence that AI-based platforms outperformed traditional methods in predicting postoperative refraction, especially in atypical eyes such as post-refractive surgery or keratoconus cases [37].

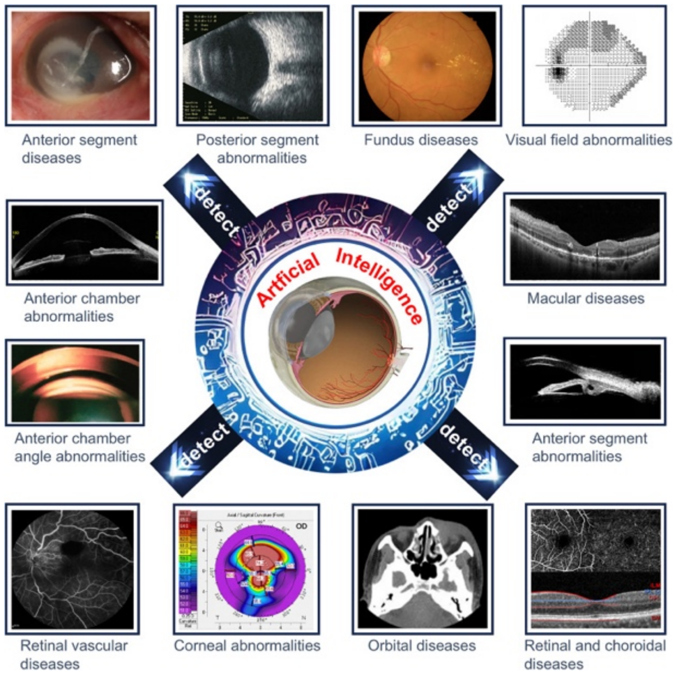


Figure 14 Artificial intelligence applications in ophthalmology for detection of anterior segment, retinal, macular, and orbital abnormalities relevant to cataract assessment and surgical planning. Source: reproduced from [37].

Recent advances in artificial intelligence have also improved the accuracy of intraocular lens (IOL) power calculations. Traditional vergence-based formulas may be less reliable in eyes with unusual anatomical characteristics, such as very short or long axial lengths, previous corneal refractive surgery, keratoconus, or irregular astigmatism. AI-based formulas, including machine learning and hybrid predictive models, are able to analyze large datasets of biometric parameters and postoperative outcomes to generate more precise refractive predictions. According to Stopyra et al. (2025), these technologies consistently outperform older-generation formulas in complex eyes and may help reduce postoperative refractive surprises, thereby improving patient satisfaction and reducing the need for secondary corrective procedures [49].

In addition, AI is increasingly being integrated into preoperative counselling and personalized lens selection. Predictive systems can combine biometric data with information about patient lifestyle, occupation, visual priorities, and tolerance for optical phenomena in order to recommend the most suitable IOL type. For example, AI may identify patients who are likely to benefit from multifocal or EDOF lenses, while simultaneously recognizing those who are at higher risk of dissatisfaction due to ocular comorbidities, poor contrast sensitivity, or limited neuroadaptation capacity. Such individualized planning supports a more patient-centered approach and may contribute to better visual outcomes, higher satisfaction rates, and more realistic postoperative expectations [49]. Personalized medicine in cataract surgery is increasingly emphasized. Patients are no longer offered a single lens option but are guided through a shared decision-making process based on lifestyle, occupational needs, and visual priorities. Digital simulations, patient-reported outcome measures (PROMs), and risk stratification tools support more informed and collaborative choices between monofocal, EDOF, and multifocal lenses.

5.6.5 Future Perspectives

Looking ahead, innovations such as light-adjustable IOLs (LALs) – which allow postoperative refractive fine-tuning through ultraviolet light treatments – are gaining increasing attention. These lenses offer the possibility of modifying refractive power after surgery, helping to reduce residual refractive error and improve uncorrected visual acuity without additional invasive procedures. Newer generations of LALs are also being developed with enhanced range of vision and improved control of astigmatism. In addition, the Light Adjustable Lens Plus (LAL+) has recently been introduced as a modified version designed to provide a broader depth of focus and better intermediate vision while maintaining the adjustability of the original platform.

Other investigational technologies include accommodating IOLs, which are designed to restore dynamic focusing ability by responding to ciliary body movement, thereby mimicking the natural accommodative function of the crystalline lens. Although no truly effective accommodating lens is yet widely available, several concepts are under active development, including the JelliSee lens, which is considered one of the most promising accommodative designs currently in the research pipeline. Additional premium IOL technologies expected to gain importance include modular IOL systems with exchangeable optical components, such as Juvene, Harmoni, and Gemini, which could allow future optic exchange without removing the entire implanted lens. New EDOF and multifocal platforms, including PureSee, FineVision, and Galaxy, are also being developed to improve intermediate and near vision while reducing dysphotopsias such as glare and halos.

Although many of these technologies are still in the experimental or early clinical stages, they indicate that cataract surgery is moving toward increasingly personalised approaches. The future of cataract care is likely to involve not only restoration of vision, but also individualized refractive optimization tailored to each patient's anatomy, lifestyle, and visual priorities. As visual expectations continue to rise and patients become more informed, innovations in lens technology and surgical planning will further support a more precise, personalized, and effective approach to cataract management. [50]

5.7 Clinical Guidelines

The selection of intraocular lenses (IOLs) is a cornerstone of modern cataract surgery, guided by patient-specific factors, ocular health, and shared decision-making. According to international standards – including the ESCRS Guidelines (2024), the AAO Preferred Practice Pattern (2021), and evidence-based reviews – lens selection should balance safety, visual performance, cost, and patient expectations [9,17,41,42].

5.7.1 Monofocal IOLs: First-Line Standard

Monofocal IOLs continue to be the most frequently implanted and recommended lens type worldwide. Both ESCRS and the AAO PPP designate monofocal IOLs as the default option in most cataract surgeries, especially in publicly funded healthcare systems and in patients with ocular comorbidities [9,42]. These lenses provide clear vision at one distance (usually far), with spectacle correction needed for near or intermediate tasks.

Clinical scenarios favoring monofocal IOLs include:

- **Macular pathology** (e.g., age-related macular degeneration, diabetic maculopathy):

These conditions impair central vision and reduce contrast sensitivity, which are essential for the functional benefit of multifocal optics. Since multifocal IOLs split light between focal points, they reduce contrast sensitivity further – potentially worsening visual quality in eyes with pre-existing macular disease. Monofocal IOLs, offering better contrast and image clarity, are therefore preferred in such cases [17,42].

- **Glaucoma with visual field loss or advanced optic nerve cupping:**

Glaucoma affects peripheral vision and may lead to central visual impairment. Multifocal IOLs can exacerbate functional visual limitations due to their inherent reduction in contrast sensitivity and possible dysphotopsias. In patients with progressing field loss or optic nerve damage, a monofocal IOL maximizes remaining visual function without introducing optical artifacts [17,42].

- **Corneal abnormalities** (irregular astigmatism, Fuchs' dystrophy):

Eyes with corneal irregularities often have unpredictable visual outcomes and higher-order aberrations. Multifocal IOLs require a stable and regular optical surface for optimal performance. In contrast, monofocal lenses are more forgiving and deliver more consistent vision in the presence of corneal surface disease or endothelial dysfunction (as in Fuchs' dystrophy) [17].

- **Monocular vision:**

In patients with only one functional eye, maximizing image clarity and minimizing risk is critical. Because multifocal IOLs involve neuroadaptation and may cause initial visual discomfort or reduced quality under certain conditions, monofocal lenses are safer and more predictable. The goal in monocular patients is to preserve the best possible quality of vision without risking dysphotopsia or refractive surprise [17,42].

- **Patients with limited ability to tolerate dysphotopsia or neuroadaptation:**

Some patients (due to personality, cognitive status, or history of intolerance to optical phenomena such as glare or halos) may struggle to adapt to multifocal optics. Such individuals are more likely to be dissatisfied with premium lenses, and monofocal IOLs – being optically simpler and more stable – are generally recommended [17,42].

Monofocal toric IOLs are indicated for patients with regular corneal astigmatism ≥1.00 D, providing better uncorrected distance vision without the photic phenomena associated with multifocal optics [42].

5.7.2 Multifocal and Premium IOLs: Patient Selection and Cautions

Premium IOLs – including multifocal, extended-depth-of-focus (EDOF), and trifocal designs – are reserved for carefully selected patients aiming for spectacle independence. The ESCRS and AAO

PPP agree that these lenses can offer excellent outcomes, provided proper selection and counseling [9,42].

Multifocal IOLs	EDF	Monovision
Good near, intermediate and distance visual acuity	Good intermediate and distance visual acuity	Good intermediate and distance visual acuity
Spectacle independence	Spectacles for near vision needed in most cases	Spectacles for near vision needed in most cases
Higher probability of halos, glare, dysphotopsia, reduced contrast sensitivity	Reduced probability of halos, glare, dysphotopsia	Small probability of halos, glare, dysphotopsia
Increased costs (depending on IOL/clinic)	Increased costs (depending on IOL/ clinic)	Mostly covered by insurance

Table 2 Comparison of multifocal intraocular lenses, extended depth-of-focus lenses, and monovision in terms of visual outcomes, spectacle independence, dysphotopsia, and cost. Source: reproduced from [46].

Key inclusion criteria for multifocal or EDOF IOLs:

- **No visually significant comorbidities:**

Multifocal lenses rely on optimal optical conditions to deliver good outcomes. Ocular comorbidities such as diabetic retinopathy, macular degeneration, or advanced glaucoma impair retinal processing and reduce contrast sensitivity, which may compromise the benefits of multifocal optics. Therefore, multifocal IOLs are most effective in patients with no visually significant co-existing pathologies [17,41,42].

- **Healthy macula and optic nerve:**

A functioning macula is critical for high-resolution central vision, and a healthy optic nerve ensures proper signal transmission to the brain. Both structures must be intact to fully benefit from the multifocal light-splitting design, which inherently reduces contrast. In the absence of disease, multifocal IOLs can provide high levels of visual acuity at various distances [17,41,42].

- **High patient motivation for spectacle independence:**

Multifocal IOLs are designed to reduce or eliminate the need for glasses across near, intermediate, and distance vision. These lenses are ideal for patients who express a strong desire for spectacle freedom in everyday activities such as reading, driving, and using a smartphone. Motivated patients are more likely to adapt well and report higher satisfaction [17,41,42].

- **Realistic expectations regarding potential optical phenomena** (e.g., halos, glare):

Because multifocal IOLs split light into multiple foci, they are associated with visual side effects – particularly in dim lighting or night driving. Patients who are well-informed and accept the trade-off between spectacle independence and optical phenomena are better candidates, as they are less likely to experience dissatisfaction or request IOL exchange [17,41,42].

- **Regular pupil and corneal anatomy:**

Proper pupil size and shape are important for optimal light distribution through different optical zones of multifocal lenses. Similarly, a regular, astigmatism-free corneal surface ensures proper centration and minimizes aberrations. Patients with irregular corneas or large pupils in low light may experience more dysphotopsia and reduced visual quality with multifocal IOLs. Thus, anatomical suitability is a prerequisite for good outcomes [17,41,42].

According to Yesilirmak et al., EDOF lenses offer a safer alternative to multifocals in borderline cases, as they tend to induce fewer dysphotopsias while still improving intermediate vision [41].

5.7.3 Premium IOLs are contraindicated in patients with:

- **Irregular corneas, keratoconus, or high astigmatism without toric correction:**

Multifocal lenses are highly sensitive to optical imperfections. In the presence of irregular corneal surfaces – such as keratoconus or significant uncorrected astigmatism – the incoming light is distorted before reaching the lens. Since multifocal optics already split light into multiple foci, such additional aberrations may result in poor image quality, ghosting, or reduced contrast sensitivity. In these cases, monofocal or toric lenses are preferred [17,42].

- **Advanced glaucoma:**

Glaucoma leads to irreversible optic nerve damage and visual field loss. Patients with moderate to severe disease often suffer from reduced contrast sensitivity and peripheral vision loss. Multifocal IOLs, which are inherently associated with lower contrast, can further degrade visual function. Therefore, in advanced glaucoma, monofocal IOLs are recommended to preserve maximum visual quality and avoid compounding optical issues [17,42].

- **Poor contrast sensitivity or neuroadaptation issues:**

Patients with pre-existing low contrast sensitivity – whether due to retinal disease, neurological conditions, or aging – may not tolerate the reduced contrast associated with multifocal optics. Moreover, individuals with limited capacity for neuroadaptation (e.g., elderly, anxious, or neurologically compromised patients) may experience persistent dysphotopsia, visual discomfort, and dissatisfaction. These patients generally fare better with monofocal IOLs [17,42].

- **Prior refractive surgery** (with caution, depending on corneal status and biometry predictability):

Corneal refractive surgeries like LASIK or PRK alter corneal curvature and biomechanics, making IOL power calculation less predictable. Multifocal IOLs require precise centration and accurate biometry for optimal function. In post-refractive eyes, small residual refractive errors or decentration can lead to significantly worse outcomes. While not an absolute contraindication, multifocal IOLs in such cases should only be considered with great caution and after extensive evaluation of corneal topography, optical quality, and patient expectations [17,42].

Table 3.

Multiple Linear Regression Analysis of Factors That Influence the Level of Participation in SDM of Patients with Cataracts (n=176)

Variable	*B*	*SE*	*β*	*t*	*P*
(constant)	7.79	20.182		0.386	0.700
Age	−6.89	4.696	−0.101	−1.467	0.144
Place of residence	−0.112	4.497	−0.002	−0.025	0.98
History of surgery in the operative eye	16.186	6.973	0.128	2.321	0.022
PrepDM score	17.851	4.993	0.279	3.575	<0.001
Education					
Below primary school	Ref				
Primary school	13.268	5.191	0.2	2.556	0.012
Junior high school	18.393	7.186	0.231	2.56	0.011
High school/Technical secondary school	23.145	8.283	0.274	2.794	0.006
Junior college/Bachelor's degree or above	21.854	10.083	0.208	2.167	0.032
Payment method of medical expenses					
Medicare	Ref				
Employee medical insurance	−4.227	6.56	−0.04	−0.644	0.52
Rural insurance	−6.784	4.668	−0.105	−1.453	0.148
Self-finance	−7.36	16.853	−0.025	−0.437	0.663
Occupation/Preretirement occupation					
Laborers/Service workers	Ref				
Farmer	−11.223	5.832	−0.154	−1.925	0.056
Cadre/Staff	5.936	6.568	0.082	0.904	0.367
Freelance	2.75	6.104	0.034	0.45	0.653
Nonprofessional	−6.343	7.152	−0.059	−0.887	0.376

Open in a new tab

Notes: F=12.093, P<0.001; R^2=0.531; adjusted R^2=0.487.

Table 3 Multiple linear regression analysis of factors influencing the level of participation in shared decision-making among patients with cataracts. Source: reproduced from [43].

5.7.4 Shared Decision-Making and Counseling

Shared decision-making (SDM) has become a core component of modern cataract care and is emphasized across all major clinical guidelines [9,17,41,42]. Beyond informed consent, SDM ensures that patients are actively involved in selecting an intraocular lens (IOL) that aligns with their visual priorities, lifestyle, and expectations.

Recent studies confirm the clinical value of SDM. A 2024 study by Dai et al. found that a higher degree of patient involvement in IOL selection was strongly associated with improved satisfaction and confidence in the surgical decision. Notably, SDM mediated the relationship between how well-informed patients felt and how satisfied they were with their choice, confirming that collaborative discussions enhance the quality of the decision itself [43].

A scoping review by Bouaziz et al. (2022) further supports this, demonstrating that SDM interventions in ophthalmology consistently improve patient knowledge, reduce decisional conflict, and contribute to more patient-centered outcomes [44]. Moreover, general ophthalmology research highlights that shared decision-making strengthens communication, builds trust, and leads to more appropriate and satisfying care choices [45].

To support this process, the AAO Preferred Practice Pattern and ESCRS guidelines recommend the use of structured lifestyle questionnaires, patient-reported outcome measures (PROMs), and individualized counseling. Informed consent should clearly document IOL type, postoperative expectations regarding spectacle use, the potential for dysphotopsias, and rare possibilities such as YAG capsulotomy or IOL exchange [41,42].

These findings and recommendations collectively underscore that SDM is not only an ethical imperative but a practical strategy to optimize surgical outcomes and patient satisfaction.

6. Discussion

6.1 Synthesis of findings

The comparative analysis of monofocal and multifocal intraocular lenses (IOLs) across recent literature highlights clear trends in outcomes, patient satisfaction, and clinical utility. Monofocal IOLs remain the gold standard in cataract surgery due to their optical clarity, low rate of side effects, and cost-effectiveness. Multifocal IOLs, by contrast, offer significant advantages in terms of spectacle independence but require careful patient selection and thorough preoperative counseling due to the potential for visual phenomena such as halos and glare.

Numerous studies reviewed in this thesis confirm the strong safety and effectiveness profiles of both lens types, though they serve different patient needs. Multifocal IOLs are particularly beneficial for patients without ocular comorbidities who prioritize visual freedom across distances, whereas monofocal IOLs remain preferable in cases of retinal pathology, glaucoma, or low tolerance for optical side effects.

The reviewed evidence supports the conclusion that each lens type has its distinct role, and selection must be individualized. Clinical guidelines such as those from the ESCRS and AAO also emphasize this need for tailored care.

To further illustrate the comparison, the following table summarizes the main advantages and limitations of each IOL type:

Feature	**Monofocal IOLs**	**Multifocal IOLs**
Main Focus	Monofocal lenses focus light at a single point, typically for distance, which simplifies the optical design and results in clearer image quality.	Multifocal IOLs split incoming light into multiple focal points, allowing patients to see at different distances without glasses.
Spectacle Independence	Due to their single focal point, most patients with monofocal IOLs need spectacles for near or intermediate tasks like reading or computer use.	Studies report that 80–90% of patients with multifocal IOLs achieve high levels of spectacle independence for most daily activities.

Visual Quality	Monofocal IOLs offer excellent image contrast and minimal optical aberrations, especially in low-light conditions.	The simultaneous focusing mechanism in multifocal IOLs may reduce contrast sensitivity, particularly under mesopic or scotopic conditions.
Side Effects	Monofocal lenses are associated with very low rates of halos, glare, or other dysphotopsias, making them well-tolerated.	Multifocal IOLs more frequently cause halos and glare due to their optical design, especially at night or in high-contrast settings.
Suitability for Comorbidities	Monofocal lenses are preferred in eyes with macular degeneration, glaucoma, or irregular cornea, where high optical quality and contrast sensitivity are critical.	Ocular comorbidities like retinal disease may reduce visual outcomes with multifocal IOLs and worsen side effects, making them less suitable.
Cost	Monofocal lenses are widely available, relatively inexpensive, and often fully covered by public healthcare systems.	Multifocal IOLs are considered premium devices and are usually associated with higher out-of-pocket costs for patients.
Neuroadaptation Required	Since vision is consistent and predictable, monofocal lenses do not require significant neural adjustment postoperatively.	Multifocal IOLs demand neuroadaptation for the brain to adjust to multiple simultaneous images; some patients may struggle with this.
Patient Satisfaction	Satisfaction is generally high when patients understand they will still need reading glasses and have no unrealistic expectations.	Satisfaction is also high, but depends heavily on proper patient selection and detailed preoperative counseling about potential side effects.

From a future-oriented perspective, I believe that multifocal IOLs represent the future of cataract surgery. As patient expectations grow and visual demands increase, especially in working-age or highly active older adults, the ability to provide a fuller range of vision without dependence on spectacles will become increasingly important.

However, the expansion of multifocal IOL use must be pragmatic and evidence-driven. Continued innovation in optical design, patient selection algorithms, and surgical precision will be essential to optimize outcomes and minimize side effects. Clinical decision-making should remain cautious and guided by objective criteria, particularly in patients with complex ocular histories.

In conclusion, a balanced, individualized approach remains essential. Monofocal IOLs will continue to play a central role in routine practice, while multifocal IOLs will likely become more prevalent as technologies evolve and patient awareness grows.

6.2 Clinical implications

The comparative findings between monofocal and multifocal intraocular lenses (IOLs) carry meaningful implications for real-world cataract surgery practice. While both lens types offer safe and effective visual rehabilitation, their benefits and trade-offs highlight the critical need for individualized patient assessment and clear communication.

A particularly important yet often underappreciated element in clinical practice is preoperative counseling and expectation management, which plays a decisive role in postoperative satisfaction. Cataract surgery involves complex optical principles and trade-offs that are not intuitive for most patients, yet these nuances are frequently communicated in terms that are either too technical or overly optimistic. In many cases, surgeons may focus on the potential benefits of a given intraocular lens while insufficiently explaining its limitations, assuming that patients will adapt or "understand later." As a result, patients may consent to a lens choice without fully grasping what their postoperative vision will realistically feel like in everyday situations.

This communication gap is particularly evident with multifocal IOLs, where the concept of spectacle independence can be highly appealing and may dominate the decision-making process. Without clear explanation, patients may underestimate the likelihood of optical side effects such as halos, glare, reduced contrast sensitivity, or night-time visual disturbances. When these phenomena appear after surgery, they may be perceived as complications or failures rather than expected trade-offs of the optical design. Consequently, dissatisfaction often arises not from inadequate surgical technique or incorrect lens implantation, but from a discrepancy between preoperative expectations and actual visual outcomes. This underscores the necessity for surgeons to invest time in structured, patient-centered counseling that sets realistic expectations and frames success in terms of functional vision rather than idealized perfection.

This issue becomes even more critical in healthcare systems where multifocal and other premium intraocular lenses (IOLs) are not covered by national health programs, placing the full financial responsibility on the patient. In Ukraine, for example, as of 2026, these lenses are not reimbursed through the National Health Service of Ukraine (NHSU) or other public channels. This means that patients must pay out of pocket, often at considerable personal expense, to access technologies that are readily available under insurance systems in more affluent countries.

In such settings, the financial investment creates a heightened expectation for perfect visual outcomes, as patients naturally associate higher costs with superior results. Unfortunately, the optical trade-offs associated with multifocal IOLs – such as the potential for dysphotopsias, neuroadaptation challenges, or residual refractive error – can come as an unpleasant surprise if not clearly explained in advance. When reality falls short of expectations, even if the surgery was technically flawless, patient dissatisfaction may escalate into emotional distress, complaints, or legal action.

Therefore, in resource-limited contexts like Ukraine and other countries where premium lenses are not publicly funded, surgeons bear an increased responsibility to ensure that patients are thoroughly informed and appropriately selected for multifocal IOL implantation. This includes transparent communication about benefits, risks, costs, and alternative options. It is essential that clinicians adopt a pragmatic approach – balancing technological enthusiasm with socioeconomic realities – to prevent disappointment, preserve trust, and deliver truly patient-centered care.

Beyond communication and access, clinical judgment remains the cornerstone of successful cataract management. Despite the growing popularity of premium lenses, monofocal intraocular lenses continue to represent the most appropriate and safest choice for many patients – particularly those with pre-existing ocular comorbidities such as age-related macular degeneration, diabetic maculopathy, glaucoma, or reduced contrast sensitivity. These patients often benefit more from the optical clarity and predictability of monofocal IOLs than from the potential but uncertain advantages of multifocal lenses. In such cases, prioritizing contrast sensitivity, visual quality, and minimal risk of dysphotopsias is clinically sound and ethically responsible.

In contrast, multifocal IOLs may be life-changing for carefully selected individuals – those who are ocularly healthy, highly motivated, and value functional independence from spectacles. For these patients, the potential for near-total spectacle independence can lead to significant improvements in quality of life. However, this benefit is only realized when patients clearly understand the optical compromises, including the possibility of halos, glare, or longer adaptation times. Here, the integration of evidence-based tools such as patient-reported outcome measures (PROMs), lifestyle assessments, and shared decision-making aids – as recommended by international guidelines – can significantly enhance preoperative planning. These tools help align patient expectations with achievable results, reduce postoperative regret, and increase satisfaction.

Finally, as IOL technologies and surgical techniques continue to evolve, the horizon of cataract surgery grows ever more promising. Innovations such as EDOF lenses, customizable optics, intraoperative guidance systems, and femtosecond-assisted procedures are already expanding the boundaries of visual rehabilitation. However, clinicians must remember that technological progress should complement – not replace – human interaction. No matter how advanced the tools, a pragmatic, patient-centered approach remains essential. Success in cataract surgery does not lie solely in the pursuit of the latest lens or laser, but in striking a careful balance between innovation, accessibility, education, and clinical realism. This balanced strategy is what ultimately delivers the best visual, emotional, and quality-of-life outcomes for patients around the world.

6.3 Limitations of current research

Despite the growing body of literature comparing monofocal and multifocal intraocular lenses (IOLs), several limitations persist. One major concern is the heterogeneity in study design, sample size, and follow-up duration, which complicates meaningful comparison between studies. Many trials prioritize short-term visual outcomes, while long-term data on satisfaction, neuroadaptation, and real-world functionality remain limited.

Moreover, there is a clear geographic and economic bias in current research. Most studies are conducted in high-income countries with access to cutting-edge technologies and a wide range of IOL options. However, this does not reflect the global reality. Patients in low- and middle-income countries often face limited access to premium lenses, differing healthcare infrastructure, and lower public awareness. Neglecting these settings hinders the creation of globally applicable guidelines and fails to address the needs of the majority of cataract patients worldwide.

Another critical limitation is the inconsistent use of patient-reported outcome measures (PROMs) and satisfaction scales, which leads to variability in reporting and interpretation. Many studies use non-standardized or industry-specific tools, reducing comparability. In addition, psychosocial and qualitative aspects – such as anxiety, lifestyle impact, or emotional adaptation – are often underreported, despite their importance for patient satisfaction.

As IOL technology evolves rapidly, clinical data often lag behind innovation. Some newer multifocal or EDOF lenses reach the market before independent evaluations are published, raising concerns about transparency and possible commercial bias in early reports. Furthermore, objective tools to guide IOL selection based on biometric and psychological profiles are underdeveloped, leaving clinicians to rely primarily on subjective judgment.

In light of these gaps, future research should focus on:

- Long-term comparative effectiveness of different IOL types.
- Standardized PROMs and visual quality metrics.
- Cost-effectiveness in diverse health systems.
- Equity in access to premium technologies.
- Inclusion of underrepresented regions, particularly low- and middle-income countries.
- Development of decision-support tools and AI-based algorithms to assist with lens selection.

Taken together, these research priorities are essential not only to improve clinical outcomes but also to ensure fairness, accessibility, and transparency in cataract surgery. As cataract surgery continues to evolve into a refractive and highly personalized procedure, the literature must keep pace – not just in technical data, but in understanding the patient experience, supporting diverse healthcare settings, and refining the tools clinicians use to make decisions. Without addressing these gaps, both patient satisfaction and system-wide efficiency may suffer.

7. Conclusion

7.1 Summary of findings

This thesis explored the evolving landscape of intraocular lens (IOL) technology in cataract surgery, with a focus on the comparative performance of monofocal and multifocal IOLs. A review of 40 studies, clinical guidelines, and historical data revealed that both lens types are effective in restoring visual acuity, but serve different patient needs and clinical contexts.

Monofocal IOLs remain the global standard due to their excellent distance vision, low rate of dysphotopsia, high predictability, and broad availability within public healthcare systems. They are especially indicated for patients with ocular comorbidities, reduced contrast sensitivity, or limited neuroadaptation capacity, and are strongly supported by both the ESCRS and AAO clinical guidelines as the first-line choice in most surgical scenarios.

In contrast, multifocal IOLs offer greater spectacle independence, particularly for near and intermediate tasks, and are preferred by patients seeking more functional freedom in their daily lives. However, they carry a higher risk of visual disturbances (e.g., glare, halos) and demand more rigorous patient selection, counseling, and expectation management. While satisfaction can be high, it is heavily influenced by psychological readiness, anatomical suitability, and quality of communication before surgery.

The evidence suggests that no single IOL type is universally superior. Rather, optimal outcomes are achieved when lens selection is individualized – guided by patient priorities, clinical findings, and socioeconomic context. The integration of shared decision-making, lifestyle assessments, and use of PROMs is essential to bridge the gap between surgical success and perceived satisfaction.

Importantly, current research reveals notable limitations: geographic bias, inconsistent metrics, and a lack of real-world long-term outcomes. There remains a critical need for more inclusive, standardized, and pragmatic research – especially in low- and middle-income settings, where access to premium IOLs is limited but patient expectations are rising.

In conclusion, cataract surgery has transitioned from a restorative to a refractive, highly personalized procedure, and IOL choice plays a central role in this transformation. While monofocal lenses remain the reliable workhorse of global ophthalmology, multifocal lenses – when used judiciously – represent a promising step toward enhanced visual freedom. Balancing innovation with clinical realism, education, and accessibility is the path forward in delivering not just visual clarity, but meaningful quality of life after cataract surgery.

7.2 Final recommendations

In light of the comprehensive review of current evidence, clinical guidelines, and technological developments, it becomes evident that cataract surgery is both increasingly sophisticated and profoundly human. The decision between monofocal and multifocal intraocular lenses is no longer merely a technical choice but a delicate equilibrium between science and subjectivity, between precision and perception. It is not enough to identify which lens performs better under clinical conditions; what matters most is how the chosen solution integrates into the unique life, vision, and expectations of the individual patient.

Monofocal IOLs, time-tested and universally accessible, continue to serve as the gold standard for patients with comorbidities, limited financial means, or low tolerance for visual disturbances. Their optical clarity, safety profile, and predictability make them indispensable in global ophthalmic care – especially in countries where premium IOLs remain financially out of reach. However, their limitations in terms of spectacle dependence should not be underestimated, especially in an era where quality of life is measured not just by survival, but by independence and functionality.

On the other hand, multifocal and extended-depth-of-focus IOLs embody the aspirations of modern refractive cataract surgery: freedom from glasses, seamless transition between visual ranges, and enhanced autonomy. Yet, these lenses also carry the risk of dissatisfaction when expectations are not aligned with realistic outcomes. As the literature shows, clinical success does not always equate to patient satisfaction, and the role of the surgeon as an educator and communicator becomes just as critical as their skill in the operating theatre.

Going forward, the field must embrace a dual mandate: to innovate responsibly and to communicate transparently. Future advances in optics, materials, and surgical technique must be matched by advances in accessibility, equity, and patient education. In countries like Ukraine and others with constrained public health resources, this means advocating for reimbursement reforms, pragmatic guidelines, and robust public information campaigns.

Ultimately, the evolution of cataract surgery is not only a story of better lenses or smaller incisions – it is a story of improving patient's awareness through knowledge, choice, and trust. The best outcomes depend not only on surgical precision, but also on effective communication, realistic expectations, and healthcare systems that support informed choice. In this light, every lens choice is also a test of our clinical integrity, reminding us that in ophthalmology clarity begins with understanding.

8. References:

1. Kanski JJ, Bowling B. Clinical ophthalmology: a systematic approach. 8th ed. Edinburgh: Elsevier; 2016.
2. Flaxman SR, Bourne RRA, Resnikoff S, Ackland P, Braithwaite T, Cicinelli MV, et al. Global causes of blindness and distance vision impairment 1990-2020: a systematic review and meta-analysis. Lancet Glob Health. 2017;5(12):e1221-e1234.
3. World Health Organization. World report on vision. Geneva: World Health Organization; 2019. Available from: https://www.who.int/publications-detail-redirect/world-report-on-vision
4. American Academy of Ophthalmology. What are cataracts? [Internet]. San Francisco (CA): American Academy of Ophthalmology; 2025. Available from: https://www.aao.org/eye-health/diseases/what-are-cataracts
5. Davis G. The evolution of cataract surgery. Mo Med. 2016;113(1):58-62. PMCID: PMC6139750. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6139750/
6. Leffler CT, Klebanov A, Samara WA, Grzybowski A. The history of cataract surgery: from couching to phacoemulsification. Ann Transl Med. 2020;8(22):1551. doi:10.21037/atm-2019-rcs-04. PMCID: PMC7729313. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7729313/
7. Awad AA, Shalaby WS, Abd Elhamid AH, Mahmoud AE. Charles Kelman: The father of phacoemulsification. Int Ophthalmol. 2024;44(1):329. doi:10.1007/s10792-024-03149-5. PMCID: PMC11225641. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11225641/
8. Maloney RK, Mahone A. Harold Ridley and the invention of the intraocular lens. J Cataract Refract Surg. 2024;50(11):1277-1281. PMCID: PMC12187139. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12187139/
9. European Society of Cataract and Refractive Surgeons. ESCRS guideline for cataract surgery [Internet]. Dublin: ESCRS; 2025. Available from: https://www.escrs.org/escrs-guideline-for-cataract-surgery
10. Nadeem S. Cataract surgery: historical devices, modern innovations, and future perspectives. Expert Rev Med Devices. 2024;21(11):991-994. doi:10.1080/17434440.2024.2419477. Available from: https://www.researchgate.net/publication/385097553_Cataract_surgery_historical_devices_modern_innovations_and_future_perspectives
11. Bupa. Cataract surgery: preparation, procedure and recovery [Internet]. London: Bupa. Available from: https://www.bupa.co.uk/health-information/eyes-sight/cataract-surgery
12. Majid Moshirfar; Dallin Milner; Bhupendra C. Patel. Cataract surgery [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2025. Available from: https://www.ncbi.nlm.nih.gov/books/NBK559253/
13. European Society of Cataract and Refractive Surgeons. Fuchs and cataract [Internet]. EuroTimes; 2023. Available from: https://escrs.org/channels/eurotimes-articles/fuchs-and-cataract
14. Figure 1. Medical illustration of a normal eye and cataract eye [Internet]. Dreamstime. Available from: https://www.dreamstime.com/medical-illustration-normal-eye-cataract-cataract-clouding-lens-clouded-image130067244
15. Figure 2. Cross-sectional illustration of phacoemulsification during cataract surgery [Internet]. Dreamstime. Available from: https://www.dreamstime.com/detailed-medical-illustration-depicting-cross-sectional-view-human-eye-phacoemulsification-cataract-surgery-image434294376
16. Figure 3. Cataract surgery process: anesthesia, incision, extraction and intraocular lens implantation [Internet]. Shutterstock. Available from: https://www.shutterstock.com/image-vector/cataract-surgery-process-anesthesia-incision-extraction-2504227109

17. Sridhar U, Tripathy K. Monofocal intraocular lenses [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2025. Available from: https://www.ncbi.nlm.nih.gov/books/NBK580484/
18. Nuijts R. 2022 ESCRS Clinical Survey Highlights: Trends in Presbyopia Correction [Internet]. ESCRS Supplement. 2024 Dec-Jan. Available from: https://www.escrs.org/media/xfijzzyv/dec-jan-2024-supplement.pdf
19. Charbel C, Lidia Pérez-Sanz, Nuria Garzón, Francisco Poyales, Jesús Carballo. Advanced vs. standard monofocal IOLs: optical quality and patient outcomes. J Clin Med. 2025;14(17):6255. Available from: https://www.mdpi.com/2077-0383/14/17/6255
20. Crook TB, Mina M Sitto, Ethan J Lindberg, Phillip C Hoopes, Majid Moshirfar. A comparative study and review of visual outcomes with enhanced versus standard monofocal intraocular lenses following cataract surgery. Med Hypothesis Discov Innov Ophthalmol. 2025;14(2):172-180. Available from: https://pubmed.ncbi.nlm.nih.gov/40787279/
21. Stejar LD, Ramona Barac, Dana Preoteasa. Preliminary visual outcomes of a novel non-diffractive extended monofocal intraocular lens. Vision. 2024;2(4):14. Available from: https://www.mdpi.com/2813-1053/2/4/14
22. Figure 4. Monofocal intraocular lens design and optical principles [Internet]. Carl Zeiss Meditec. Available from: https://www.zeiss.com/meditec/en/products/iols/monofocal-iols.html
23. Alió JL, Elinor Megiddo Barnir, Ronald Steven S. Medalle II, Ana B. Plaza-Puche, Antonio Martínez, Pilar Yébana, Blanca Poyales, Francisco Poyales. Clinical outcomes with a new diffractive multifocal intraocular lens optimized by the dynamic light utilization algorithm. Eye (Lond). 2025;39(2):359-365. doi:10.1038/s41433-024-03435-0. Available from: https://www.nature.com/articles/s41433-024-03435-0
24. Xinyue Yang, Zhuoya Li, He Zou, Fuqiang Li, Hui Zhang. Comparison of visual outcomes in patients with cataracts and high myopia after implantation of a zonal refractive multifocal or diffractive bifocal intraocular lens. Sci Rep. 2024;14:76020. doi:10.1038/s41598-024-76020-w. Available from: https://www.nature.com/articles/s41598-024-76020-w
25. Jorge L Alió, Antonio Martínez-Abad, Ramón Ruiz-Mesa, Hyo Myung Kim, Javier Mendicute, Filomena J Ribeiro, Mike P Holzer, Mario Cantó-Cerdán. Visual and patient reported outcomes provided by a refractive multifocal intraocular lens based on continuous transitional focus. Eye Vis (Lond). 2024;11:49. doi:10.1186/s40662-024-00408-y. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11479541/
26. Moshirfar M, Stapley SR, Corbin WM, Nour B. Comparative visual outcome analysis of a diffractive multifocal intraocular lens and a new diffractive multifocal lens with extended depth of focus. J Clin Med. 2022;11(24):7374. doi:10.3390/jcm11247374. Available from: https://www.researchgate.net/publication/366211503_Comparative_Visual_Outcome_Analysis_of_a_Diffractive_Multifocal_Intraocular_Lens_and_a_New_Diffractive_Multifocal_Lens_with_Extended_Depth_of_Focus
27. Figure 5. AcrySof IQ PanOptix trifocal intraocular lens and its optical zones [Internet]. Alcon; 2019. Available from: https://investor.alcon.com/news-and-events/press-releases/news-details/2019/Alcon-Introduces-AcrySof-IQ-PanOptix-Trifocal-IOL-in-the-US-the-First-and-Only-FDA-Approved-Trifocal-Lens/default.aspx
28. Yi Jing Yuan, Biyue Tu, Zhun Zhang, Xiangxiang Zhu, Zhuoqun Rao, Yingshu He, Zhen Zhao, Yanxia Tong. A comparative analysis of visual quality and patient satisfaction between monofocal and multifocal intraocular lenses in cataract surgery. Vision Res. 2025;228:108677. Available from: https://www.sciencedirect.com/science/article/pii/S0011384025001108
29. Ziwei Wu, Feng Cheng, Junfang Xu. Economic Evaluation of Intraocular Lens Targeting Cataract Patients: A Review and Future Directions. Transl Vis Sci Technol. 2025;14(9):6. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12372944/

30. Min S, Won YK, Kwon SH, Lim DH. Cost-benefit analysis of a trifocal intraocular lens versus a monofocal intraocular lens in South Korea. Sci Rep. 2025;15:712. doi:10.1038/s41598-025-00712-0. Available from: https://www.nature.com/articles/s41598-025-00712-0
31. Jose Ginel, Noemi Burguera, Carlos Rocha-de-Lossada, David Pinero, Alejandro Saez-Martın, Joaquın Fernandez: Economic Evaluation of Cataract: A Systematic Mapping Review. Adv Ther. 2023;40(8):3521-3535. doi:10.1007/s40123-023-00678-0. Available from: https://link.springer.com/article/10.1007/s40123-023-00678-0
32. Sara D. Khangura, Lorna Adcock, Kaitryn Campbell. Premium versus Standard Intraocular Lenses for Cataracts: A Review of Clinical Effectiveness and Cost-Effectiveness [Internet]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK581858/
33. Vanathi M. Cataract surgery innovations. Indian J Ophthalmol. 2024;72(5):613-614. doi:10.4103/IJO.IJO_888_24. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11168568/
34. Salgado R, Torres P, Marinho A. Update on femtosecond laser-assisted cataract surgery: a review. Clin Ophthalmol. 2024;18:459-472. doi:10.2147/OPTH.S453040. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10875176/
35. O'Brart D. The future of cataract surgery. Eye (Lond). 2025;39:1451-1456. doi:10.1038/s41433-025-03745-x. Available from: https://www.nature.com/articles/s41433-025-03745-x
36. Luo Y, Guangcan Xu, Hongyu Li, Tianju Ma, Zi Ye, Zhaohui Li. Application of the active-fluidics system in phacoemulsification: A Review. J Clin Med. 2023;12(2):611. doi:10.3390/jcm12020611. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC9863491/
37. Do Young Kim, Ella Seo Yeon Park, Hyunjin Park, Bo Yi Kim, Ikhyun Jun, Kyoung Yul Seo, Ahmed Elsheikh, Tae-im Kim. Comparative Outcomes of the Next-Generation Extended Depth-of-Focus Intraocular Lens and Enhanced Monofocal Intraocular Lens in Cataract Surgery. Clin Ophthalmol. 2025;19:2147-2158. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12295884/
38. Figure 6. Optical principle and range of vision provided by EDOF intraocular lenses [Internet]. Dr Kashish Gupta. Available from: https://drkashishgupta.com/edof-lenses-dr-kashish-gupta/
39. Figure 7. Femtosecond laser-assisted cataract surgery procedure and laser-created capsulotomy [Internet]. In: StatPearls. Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK554036/
40. Figure 8. Phacoemulsification after automated femtosecond laser pretreatment showing nuclear fragmentation [Internet]. ResearchGate. Available from: https://www.researchgate.net/figure/A-and-B-Phacoemulsification-performed-in-the-usual-manner-after-using-the-automated_fig5_381858459
41. Rao SK, Safran SG, Gatinel D, Nanavaty MA, Ang M, Vajpayee RB, et al. International consensuses and guidelines on multifocal intraocular lenses (IOLs) by the Academy of Asia-Pacific Professors of Ophthalmology (AAPPO). Asia Pac J Ophthalmol (Phila). 2025;14(2):100138. Available from: https://www.sciencedirect.com/science/article/pii/S2162098925001410
42. Miller KM, Oetting TA, Tweeten JP, Carter K, Lee BS, Lin SR, et al. Cataract in the adult eye preferred practice pattern. Ophthalmology. 2022;129(1):P1-P126. doi:10.1016/j.ophtha.2021.10.006. Available from: https://www.aao.org/education/preferred-practice-pattern/cataract-in-adult-eye-ppp-2021-in-press
43. Jingyao Dai, Yiting Hua, Yijie Chen, Jiali Huang, Xiaoxian Zhang, Yiwen Sun, Chen Chen, Yanyan Chen, Kaijing Zhou. Current Status of Shared Decision-Making in Intraocular Lens

Selection for Cataract Surgery: A Cross-Sectional Study. 2024;18:1489-1498. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11212811/

44. Zhu MM, Choy BNK, Lam WWT, Shum JWH. Randomized control trial of the impact of patient decision aid developed for Chinese primary open-angle glaucoma patients. Ophthalmic Res. 2023;66(1):846-853. doi:10.1159/000530071. Available from: https://karger.com/ore/article/66/1/846/836830/Randomized-Control-Trial-of-the-Impact-of-Patient
45. Cindy Yue Tian, Eliza Lai-Yi Wong, Hong Qiu, Shi Zhao, Kailu Wang, Annie Wai-Ling Cheung, Eng-Kiong Yeoh. Patient experience and satisfaction with shared decision-making: A cross-sectional study among outpatients. Patient Educ Couns. 2024;130:108543. doi:10.1016/j.pec.2024.108543. Available from: https://www.sciencedirect.com/science/article/pii/S0738399124002775
46. Figure 9. ESCRS recommendations for intraocular lens selection and patient counselling in cataract surgery [Internet]. European Society of Cataract and Refractive Surgeons. Available from: https://www.escrs.org/escrs-guideline-for-cataract-surgery
47. Figure 10. Conceptual model of the relationship between patient knowledge, shared decision-making, and satisfaction with intraocular lens selection [Internet]. Patient Prefer Adherence. 2024. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11212811/#s0004
48. Olena Al-Shymali, Mario Cantó-Cerdán, Jorge L. Alió del Barrio, Colm McAlinden, Pilar Yebana, Jorge L. Alio. Managing dissatisfaction after multifocal intraocular lens implantation through lens exchange using monofocal or alternative multifocal IOLs. Acta Ophthalmol [Internet]. 2025. Available from: https://onlinelibrary.wiley.com/doi/10.1111/aos.16720
49. Stopyra W, Grzybowski A. Innovations in intraocular lens power calculation - A review. J Clin Med [Internet]. 2025 Sep 25;14(19):6421. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12470778/
50. Review of Ophthalmology. A look down the premium IOL pipeline [Internet]. Review of Ophthalmology; 2025. Available from: https://www.reviewofophthalmology.com/article/a-look-down-the-premium-iol-pipeline
51. Lee JH, Moon SY, Chung HS, Park SY, Lee H, Kim JY, et al. Clinical outcomes of a monofocal intraocular lens with enhanced intermediate function compared with an extended depth-of-focus intraocular lens. J Cataract Refract Surg [Internet]. 2022;48:61-66. Available from: https://europepmc.org/article/med/34117177