



How AI-driven tools can simplify personalized surgical planning and predict spectacle free vision outcomes to improve access to premium outcomes.

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AI holds the potential to improve the precision and personalization of ophthalmic care, enhancing patient outcomes. Barriers to AI adoption include a steep learning curve and concerns about complexity and reliability.

As AI transitions from research laboratories into clinical practices, surgeons encounter numerous challenges. Ensuring responsible AI integration in health care hinges on addressing key factors such as validity, generalizability, interpretability, durability, and liability. These considerations form the foundation of what is known as *responsible AI*—a concept growing in importance as AI systems, such as expert systems, supervised and unsupervised learning models, and deep learning techniques, expand into various medical specialties, including ophthalmology. Despite the theoretical promise of these technologies, their practical application remains complex and challenging.

In ophthalmology, AI has shown promise in narrow applications such as diabetic retinopathy and age-related macular degeneration, where image classification algorithms have achieved impressive results. In cataract and refractive surgery, AI offers exciting possibilities, such as IOL power calculations, keratoconus detection, and preoperative sizing and vault prediction for phakic IOLs.

Spectacle independence after cataract surgery is readily achievable with current technology. Effectively implementing this technology, however, remains complex and resource-intensive. For more than 25 years, specialist surgeons have consistently delivered spectacle-free outcomes for nearly all their patients. Despite this, only a small fraction of surgeons employ these techniques to benefit their patients. This underutilization of available technology represents the primary unmet need in cataract surgery today.

DUAL BARRIERS TO ADVANCED REFRACTIVE CATARACT SURGERY

Cataract surgery, one of the most commonly performed procedures worldwide, can provide spectacle-free visual outcomes for most patients when performed by specialist refractive cataract surgeons. Of the estimated 30 million cataract procedures performed globally each year, however, only around 15% utilize advanced IOL technologies to achieve this goal. Consequently, more than 20 million patients continue to rely on spectacles or contact lenses postoperatively.¹

The limited adoption of advanced refractive cataract surgery technologies can be attributed to two primary barriers:

► No. 1: Complex Surgical Planning

Optimizing patients' visual outcomes after cataract surgery requires highly individualized surgical planning, an intricate and time-intensive process. Ophthalmologists must consider numerous factors, including spherical, toric, and presbyopic corrections, while tailoring calculations to the specific needs of each patient. This level of customization demands expertise in optics and familiarity with advanced mathematical models, presenting a challenge even for seasoned practitioners.

► No. 2: Managing Patients' Expectations

Setting realistic expectations for

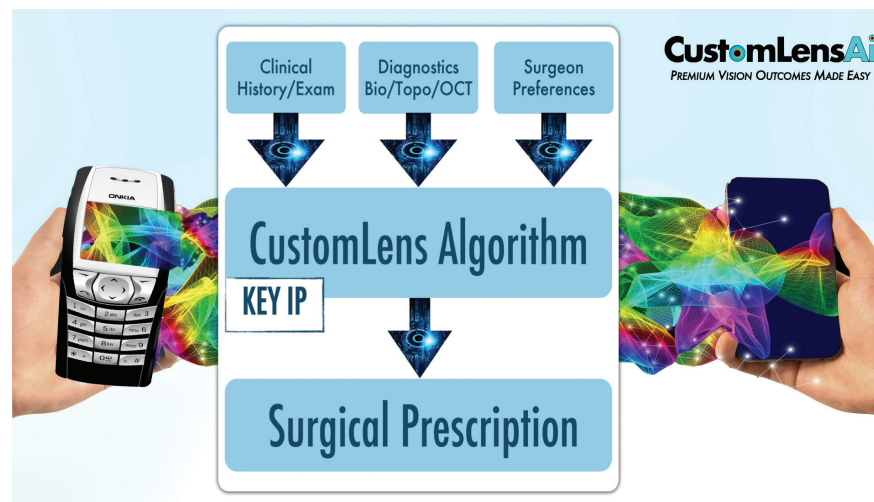


Figure 1. The CustomLens algorithm integrates clinical data and surgeon preferences to generate a personalized surgical prescription.

spectacle-free visual outcomes can be complex because patients often have varied expectations and a limited understanding of what constitutes spectacle independence. Many surgeons find it difficult to predict and communicate the potential range of visual acuity and functional vision that will allow spectacle-free performance in various lifestyle activities in a way that patients can easily understand. This communication gap is a major contributor to patient dissatisfaction.

Although ophthalmic surgeons are proficient in performing cataract procedures, few receive specialized training in the optics, IOL designs, and predictive models necessary to achieve consistent postoperative spectacle independence. Consequently, many ophthalmologists opt to offer simpler surgical options, limiting the availability of premium vision surgery primarily to patients treated by expert surgeons who have invested considerable time in developing custom planning and communication processes.

AI AS A CATALYST FOR OVERCOMING BARRIERS

Expanding access to premium vision outcomes in cataract surgery requires solutions that reduce the complexity of surgical planning and improve

surgeon-patient communication. AI-driven tools, such as CustomLens AI, aim to address these challenges by assisting surgeons in providing more personalized and consistent refractive outcomes for patients who may benefit from advanced technology cataract surgery.

CustomLens AI incorporates advanced algorithms to guide surgeons through the complexities of cataract surgery planning, enabling precise, individualized surgical plans.

The CustomLens Algorithm

At the core of the AI-assisted expert system is the CustomLens algorithm (Figure 1). This tool considers the surgeon's preferences and patient-specific clinical data—such as medical history, diagnostic test results, and examination findings—to generate a comprehensive surgical plan. The algorithm offers detailed recommendations for IOL selection, spherical and toric power, presbyopia correction, incision placement, toric lens orientation, anesthesia, and additional case-specific insights. The output serves as a decision-support tool, empowering surgeons to either implement the recommendations or modify the plan based on their own clinical judgment. This ensures that AI

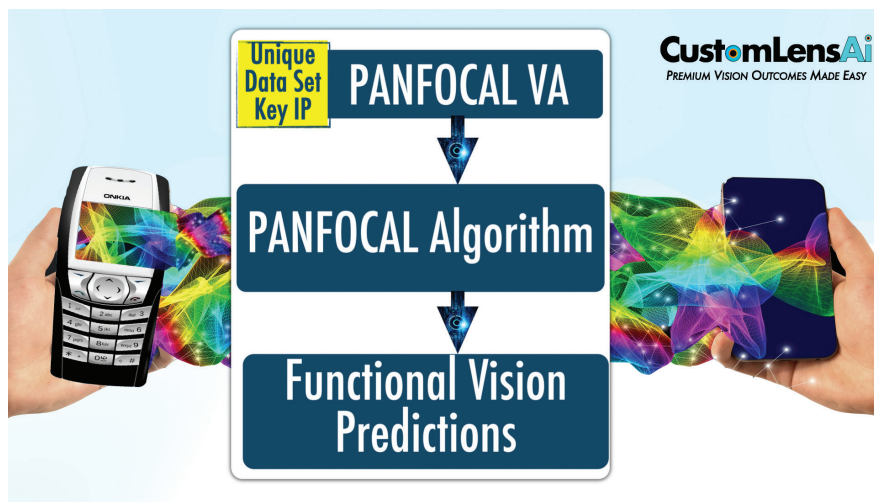


Figure 2. The Panfocal algorithm uses pre- and postoperative data to predict functional vision outcomes, enhancing patients' understanding of expected visual performance.

supplements, rather than replaces, the surgeon's expertise.

The Panfocal Algorithm

The Panfocal algorithm (Figure 2) is designed to improve patients' understanding of anticipated surgical outcomes. This algorithm analyzes data on pre- and postoperative visual acuity, objective assessments of task performance, and postoperative patient feedback to generate predictive outcomes. These predictions include expectations for spectacle-free vision at distance, intermediate, and near ranges under both photopic and mesopic conditions. Additionally, the algorithm offers realistic insights into the range of daily tasks patients may be able to perform without spectacles and comparative feedback based on outcomes reported by previous patients. This information is presented in an interactive, user-friendly format within the CustomLens AI application.

The algorithm addresses key challenges that have limited the adoption of advanced cataract surgery and offers solutions to streamline planning and support realistic patient expectations.

SCALING PRECISION: MASS CUSTOMIZATION FOR UNIVERSAL ACCESS

A significant advantage of AI lies in its ability to scale complex processes that would otherwise require extensive time and expertise. CustomLens AI enables mass customization, offering personalized surgical plans at scale, which allows surgeons in diverse practice settings to provide advanced technology cataract surgery for more patients. By reducing reliance on surgeon expertise in optics and complex calculations, the platform democratizes access to refractive cataract surgery, expanding the potential reach of advanced vision care worldwide.

As CustomLens AI enters beta testing and regulatory approval is pursued, the focus remains on integrating the CustomLens platform with existing diagnostic tools and electronic health records. The goal is to establish a seamless workflow that enhances both the efficiency and effectiveness of cataract surgery, positioning AI as an essential component of surgical planning.

THE FUTURE OF AI IN OPHTHALMOLOGY

The continuous evolution of machine learning algorithms, driven by growing global surgical data, presents exciting opportunities for the future of ophthalmic care. As data from surgeries around the world are integrated, algorithms like those used in CustomLens will be refined, further improving patient outcomes over time.

Fully realizing this potential requires close collaboration among ophthalmic surgeons, AI technologists, and industry stakeholders. Surgeons should be actively involved in AI system design and development to ensure these tools address the practical needs of the OR. At the same time, AI developers must remain attentive to ethical and legal considerations and prioritize patient safety, transparency, and regulatory compliance.

Contrary to misconceptions, AI is not intended to replace human judgment or skills but to enhance the surgeon's ability to provide precise, individualized care. By automating complex aspects of surgical planning, AI enables surgeons to focus on delivering high-quality patient care and achieving the best possible outcomes. ■

1. European Society of Cataract and Refractive Surgeons. ESCRS Clinical Trends Survey 2023 Results. *EuroTimes* Supplement. September 2024;7. Accessed October 9, 2024. https://www.es CRS.org/media/21nhm3yl/final_escrs_clinical-trendssurvey2023_sept24.pdf

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