



The future of vault prediction and patient satisfaction in vision correction.

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AI is transforming nearly every field, and ophthalmology is no exception. In refractive surgery—particularly with Implantable Collamer Lenses (ICLs; STAAR Surgical)—AI has the potential to improve precision, outcomes, and patient satisfaction. AI-driven innovations in ICL sizing and vault prediction could establish a new standard of care in vision correction.

SAFETY, PREDICTABILITY, AND PATIENT SATISFACTION

For many patients, phakic IOLs such as the ICL offer a safe, reversible alternative to LASIK that preserves the eye's natural anatomy. The latest iteration of the ICL, the EVO model, features a central port (Aquaport) that allows continuous aqueous flow through the lens, greatly reducing the risk of cataract formation, which has been a concern with earlier ICL models. Cataract formation in eyes with the EVO ICL is rare, with global complication rates approaching zero.¹

The ICL offers refractive predictability rivaling that of LASIK. According to data my colleagues and I have collected, 98.4% of ICL patients achieved outcomes within 0.50 D of their target spherical equivalent. Additionally, ICL patients, especially those with high myopia, often gained lines of BCVA. Around 20% of patients with moderate to high myopia achieved a postoperative UCVA that exceeded their best preoperative BCVA.²

THE CHALLENGE OF VAULT PREDICTABILITY

One of the most critical factors in achieving ICL success is maintaining an appropriate vault³⁻⁵—the distance between

ZALDIVAR N:238				MAE	MAX ERROR
VAULT Prediction Error Stratified by Size and Magnitude of Prediction Error					
ICL Size	Percent of Predictions within Error Range				
	≤ 250 μm	≤ 325 μm	≤ 500 μm		
12.6	100.00%	100.00%	100.00%	88	240
13.2	99.21%	100.00%	100.00%	68	307
13.7	100.00%	100.00%	100.00%	46	145

Figure 1. Vault prediction error stratified by ICL size and magnitude of prediction error using the ICL Guru platform. Abbreviations: MAE, mean absolute error.

the ICL and the crystalline lens. A proper vault is crucial to preventing complications such as cataract formation and angle-closure glaucoma. Although the introduction of the Aquaport improved vault stability with the ICL, natural variations in ocular anatomy can lead to unpredictable outcomes.

Historically, surgeons have relied on anatomic measurements and their experience to estimate the correct ICL size. Differences in patients' anterior chamber depth, sulcus-to-sulcus distance, and ocular tissue elasticity, however, can cause vault variability.⁶ Patients whose vault measurements fall outside the ideal range may not experience complications, but their long-term postoperative outcomes may be suboptimal. These outliers are a concern for surgeons aiming to optimize predictability and precision in ICL implantation.

AI-POWERED SOLUTIONS FOR PRECISE VAULT PREDICTION

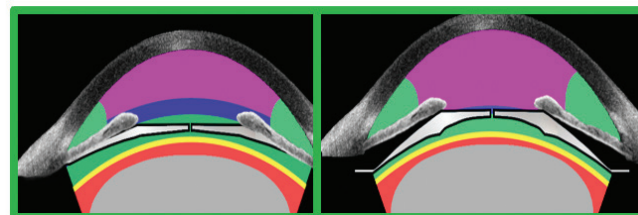
The AI-powered ICL Guru platform (www.revaicare.com) was designed to address the challenges of ICL sizing and vault stability. The system leverages a dual deep learning algorithm trained on a dataset of 12,730 ultrasound biomicroscopy images obtained from 350 eyes to predict ICL vault behavior based on each eye's unique anatomic features.

The ICL Guru utilizes a multistep AI-driven process. The platform analyzes full ultrasound biomicroscopy video sequences rather than single images. An AI frame selector isolates the highest-quality frames for analysis, ensuring the accuracy of anatomic data. Key measurements such as internal structure configuration, anterior chamber depth, and angle morphology are evaluated. These data are cross-referenced with OCT images to define "safety bands" that predict the ideal vault outcome for each ICL size and power.

The ICL Guru provides a customized *safe vault* range for each patient based on their specific eye anatomy, a step forward from the traditional generalized sizing approach (Figure 1). With a mean absolute error in vault prediction that keeps all patients within 332 μm of the target range, this level of precision reduces the likelihood of an unpredictable vault and minimizes outliers.

REAL-TIME SIMULATION AND INTRAOPERATIVE INSIGHT

A groundbreaking feature of the ICL Guru is its ability to simulate ICL behavior within the eye in real time. Using advanced predictive modeling, the platform visualizes expected postoperative ICL performance based on each eye's anatomic characteristics (Figure 2). This real-time, AI-driven preview of ICL positioning and vault dynamics can assist surgeons both pre- and intraoperatively.



Results

IOL overall diameter	Central vault	Peripheral vault	Angle
12.1 mm	0.412 mm	0.170 mm	34 °
12.6 mm	0.719 mm	0.477 mm	30 °
13.2 mm	HYPERVAULT	1.155 mm	22 °
13.7 mm	HYPERVAULT	HYPERVAULT	0 °

Figure 2. Real-time simulation of ICL positioning and vault dynamics using the ICL Guru platform. The images show predicted ICL positioning for different lens diameters, with resulting central and peripheral vault measurements and angles.

The ICL Guru can be particularly valuable for complex cases, such as young patients with narrow anterior chamber angles. By allowing surgeons to predict vault behavior in anatomically challenging eyes, the platform can help them make informed decisions on how to prevent complications associated with vault instability. Intraoperative guidance from the ICL Guru allows surgeons to confirm that the predicted vault aligns with real-time observations, helping to optimize lens positioning and reduce the need for postoperative adjustment.

ICL ADVANTAGES

Improvements in the ICL platform and the development of AI-powered sizing could make this lens the preferred option for vision correction in a broader patient population. These procedures do not require expensive capital equipment, involve a minimal learning curve, and can often be performed in an office setting.

In the coming decade, it is likely that a growing number of refractive surgery candidates, especially those with moderate to high myopia, will be offered ICL implantation as a primary treatment option. As AI-powered algorithms refine vault prediction and procedural outcomes, surgeons can anticipate delivering vision correction with unparalleled confidence and precision. ■

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