



THE ORIGINS OF INTRAOPERATIVE ABERROMETRY



From concept to clinical tool.

BY WILLIAM F. WILEY, MD

The introduction of intraoperative aberrometry about 15 years ago coincided with the early adoption of femtosecond lasers for cataract surgery. Suddenly, ophthalmologists had two new tools designed to improve the refractive outcomes of cataract surgery.

I began using the ORA System (Alcon) for nearly every case to learn the technology's nuances.

There were so many potential use cases. I would create a laser arcuate incision, obtain ORA measurements, and decide whether to open the incision to increase its effect.

The development of an intraoperative aberrometer and femtosecond laser cataract system marked the beginning of packages that group advanced

technologies together to achieve specific refractive outcomes. This gave rise to a pivotal shift in refractive cataract surgeons' mindset.

One of the pioneers in intraoperative aberrometry I learned from was William F. Wiley, MD. In this installment of *CRST's* Origins column, Bill traces the technology's history.

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Intraoperative aberrometry was not originally conceived as a routine refractive adjunct. The technology's earliest purpose was far more pragmatic: to help surgeons determine IOL power in situations where reliable preoperative biometry measurements could not be obtained.

The first conceptual applications of intraoperative aberrometry were in pediatric cataract surgery, where traditional optical biometry was often impossible. Soon, attention shifted to other challenging scenarios, particularly eyes with a history of refractive surgery and cases involving astigmatism measurements and IOL alignment. These needs reflected well-recognized limitations in IOL formulas and corneal power assessment at the time.¹

EARLY ADOPTION AND TECHNOLOGICAL LIMITATIONS

I was an early adopter of the first commercially available system, the ORange Intraoperative Wavefront Aberrometer, which later evolved into the ORA System available today. Although ORange represented a significant conceptual leap forward, important limitations impeded its widespread adoption.

Most notably, in its earliest form, the device lacked a predictive algorithm. Surgeons relied primarily on measurements taken after the IOL had been implanted, with an

IOL exchange considered if the reading was significantly off target. Although aphakic measurements were eventually introduced, the early algorithms struggled, particularly in post-refractive surgery eyes—one of the primary reasons many surgeons were interested in intraoperative aberrometry. At the time, ORange could perform reasonably well in anatomically normal eyes but frequently missed the target in those that had a history of LASIK or PRK, limiting the technology's usefulness in the most challenging cases.²

FROM ORANGE TO ORA: THE POWER OF DATA

The transformation of ORange into the commercially successful ORA System was driven less by hardware improvements and more by data.

ORA was one of the first ophthalmic technologies to systematically aggregate pre-, intra-, and postoperative refractive data on a large scale. Surgeons entered outcomes data, allowing the system to learn and evolve. Over time, the growing database permitted refinement of the underlying algorithms and, critically, the development of more reliable post-refractive surgery IOL formulas. This data-driven evolution changed intraoperative aberrometry from a reactive tool into a predictive one.³

COMPETITION AS A DRIVER OF PROGRESS

Competition played a meaningful role in the evolution of intraoperative aberrometry. The Holos IntraOp system (Clarity Medical Systems), although short-lived, introduced the important concept of real-time streaming data. Unlike early intraoperative aberrometry systems (ORange), Holos allowed surgeons to view live aberrometry measurements as they were acquired. The immediate feedback helped ophthalmologists better understand and control intraoperative variables and highlighted how sensitive intraoperative aberrometry measurements are to surgical conditions. Holos, however, emphasized streaming data without robust image capture, limiting the device's ability to build large datasets and refine algorithms over time.

Despite its commercial failure, Holos helped shape the design philosophy of later intraoperative aberrometers.²

REFINEMENT OF INDICATIONS OVER TIME

In the early days, some surgeons used intraoperative aberrometry in nearly every case to gain familiarity with and confidence in the technology. As traditional biometry formulas improved, however, it became clear that intraoperative aberrometry had less value in routine cataract surgery for anatomically normal eyes.

► ORIGINS

Where intraoperative aberrometry continued to demonstrate a benefit—and still does today—was in post-refractive surgery eyes and astigmatism management. Despite advances in preoperative diagnostics, posterior corneal astigmatism remains difficult to measure accurately, and anterior keratometry alone is insufficient to determine the magnitude of true corneal astigmatism.⁴

No preoperative device can account for surgically induced astigmatism. Intraoperative aberrometry remains the only technology capable of measuring total corneal power after incisions are made but before IOL selection, making it uniquely valuable.^{4,5}

THE ART OF INTRAOPERATIVE ABERROMETRY

Technological advances notwithstanding, the accuracy of intraoperative aberrometry remains highly surgeon dependent. To illustrate this point, I often make the following analogy: Owning a high-end camera does not guarantee great photographs; technique, experience, and control of variables matter. A traditional biometer will produce nearly identical measurements in the hands of many surgeons, whereas intraoperative aberrometry measurements can vary widely if conditions are not carefully controlled.

Surgeons' judgment remains essential. They must recognize when a measurement is reliable, understand when to trust or discount the data, and integrate intraoperative aberrometry results with preoperative planning.

THE FUTURE OF INTRAOPERATIVE ABERROMETRY

One of the greatest challenges in intraoperative aberrometry is determining whether conditions are sufficiently controlled to produce a trustworthy measurement. Future systems may provide better real-time feedback regarding image quality and reliability.

Additionally, whereas modern biometry benefits from dozens of formulas, intraoperative aberrometry currently relies on a single primary algorithm. This may present an opportunity. The integration of AI and the development of multiple formulas specifically for intraoperative aberrometry could refine outcomes and produce the next evolution of this technology.⁵ ■

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