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Intraoperative Refractive Biometry

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Keywords

• Intraoperative aberrometry • Wavefront sensor • Biometry • Cataract surgery • Refractive surgery

Key points

- Intraoperative aberrometry aims to reduce refractive surprises following cataract surgery and optimize refractive outcomes.
- Wavefront sensors allow for intraoperative autorefraction to guide intraocular lens power selection and astigmatic correction.
- Refractive outcomes results using this technology are limited.

INTRODUCTION

Cataract surgery is refractive surgery. The drive toward perfecting refractive outcomes is not only propelled by the collective aspiration of cataract surgeons but also the increasing demands of patients undergoing cataract surgery. These patient expectations are shaped by the steadily improving optical outcomes of cataract surgery coupled with the increasing acceptance and occurrence of refractive surgery over the preceding decades.

Ninety-four percent of eyes are within plus or minus 0.50 diopter (D) of the intended optical target after laser vision correction [1]. This stands in contrast to the benchmark refractive outcome following cataract surgery established by the National Health Service of the United Kingdom that states 55% of eyes should be within plus or minus 0.50 D [2]. Recently, Hahn and colleagues [3] found that 80% of cataract surgeons are within plus or minus 0.50 D of the intended refractive target. Patients expect laser vision correction-like results from cataract surgery but these results are not yet attainable to the same degree with cataract surgery.

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In addition, there is an ever-growing cohort of individuals with a history of prior refractive surgery who will subsequently require cataract surgery. These patients are accustomed to the quality of postrefractive surgery vision, making it imperative to avoid refractive surprises. However, it is in these patients that the refractive target following cataract surgery is less likely to be achieved [4].

Intraoperative aberrometry is intended to reduce refractive surprises and optimize refractive outcomes. These wavefront sensors attempt to avoid residual refractive error through intraoperative aphakic and pseudophakic refraction, which allows the cataract surgeon to confirm or revise the intraocular lens (IOL) power choice reached via preoperative biometry, optimize the lens alignment in the case of toric IOL, and tailor arcuate corneal incisions. In astigmatic correction, evaluating the emanating wavefront from the eye intraoperatively allows this technology to determine the net power of the anterior cornea, the posterior cornea, and the toricity of the IOL within the capsular bag. Intraoperative aberrometry proposes to build on the current standard of care of preoperative biometry alone by augmenting astigmatism management, and IOL selection and placement at the time of surgery.

AVAILABLE WAVEFRONT SENSORS

When used to analyze the entire optical system of the eye, wavefront sensors are able to detect both lower-order and higher-order aberrations, ranging from sphere and cylinder to irregular astigmatism [5,6]. Although widely used in optimizing treatment algorithms for laser keratorefractive surgery, wavefront analysis can also be used to guide IOL selection to optimize postoperative visual outcome [7,8]. Currently, the 3 main available wavefront sensors used in ophthalmology practice are the Hartmann-Shack, Talbot-Moiré, and sequential wavefront sensors.

Hartmann-Shack wavefront sensor

A Hartmann-Shack wavefront sensor is capable of measuring the wave aberrations of the human eye by sensing the wavefront emerging from the eye [9]. It projects an array of light onto the retina and captures reflected light as it travels back through the pupil, after being focused by an array of lenslets. A charge-coupled device (CCD) camera captures the array of spot images focused by the lenslet array, and those images are processed against correlated aberration-free images to generate a wavefront aberration map [5,6].

If the eye were a perfect optical system, the wavefront at the lenslet array plane would be perfectly flat and the video sensor located at the focal plane of the lenslet array would record a uniformly distributed array of image spots [5,6]. However, the eye is not a perfect optical system and, therefore, the wavefront at the lenslet array will not be perfectly flat and will have irregular, curved shapes. As a result, the spot images detected by the CCD camera will depart from the location corresponding to the aberration-free image. After processing of the image spot position, both lower-order and higher-order aberrations of the eye can be determined.