Traditionally, biomechanical properties of the cornea have been assessed in vitro by measuring stress-strain and Young modulus on corneal strips. In 2005, the Ocular Response Analyzer (ORA; Reichert Technologies, Depew, New York) was launched as the first commercial device claiming to provide in vivo measurements of corneal biomechanics. It utilizes a dynamic bi-directional applanation process in which two applanation pressure measurements are recorded: one while the cornea is moving inward, and the other as the cornea returns. The primary output measurements are Goldmann-correlated intraocular pressure (IOPg), and a new parameter called corneal hysteresis (CH), defined by Reichert as the difference between the two pressure values of the inward and outward applanations. The ORA provides two additional new parameters: corneal-compensated intraocular pressure (IOPcc) and corneal resistance factor (CRF), which was thought to be an indicator of the overall “resistance” of the cornea.

Given the promising nature of the possibility of measuring biomechanics in vivo, many studies covering a wide range of topics have been performed and published using the ORA in the past 5 years. The majority of articles addressed the following topics: 1) IOP, CH, and CRF measurements in patients with glaucoma, 2) changes in CH and CRF after corneal refractive surgery, and 3) changes in CH and CRF in keratoconic patients and the possibility of using CH and CRF for assisting in the detection of early keratoconus.

With this initial body of articles published, we can now start to evaluate the clinical utility of the ORA in refractive surgery. This editorial reviews the use of the ORA for measuring IOP, CH, CRF, and future parameters and discusses the commonly used terminology.

IOP MEASUREMENTS

Corneal-compensated IOP has been shown to be comparable to IOP measured with dynamic contour tonometry, and IOPcc has also been shown to be independent of central corneal thickness. Therefore, as the proportion of patients electing to have corneal refractive surgical procedures continues to increase, IOPcc will remain a valid and powerful tool to diagnose and monitor patients with glaucoma after corneal surgery.

CORNEAL HYSTERESIS, CORNEAL RESISTANCE FACTOR, AND FUTURE PARAMETERS

It is our assessment that CH and CRF are relatively weak parameters for measuring ocular biomechanical properties. These two parameters decrease after corneal refractive surgery, as reported by Ryan et al in this issue of the Journal, and have lower values in keratoconus. However, the difference between normal eyes and keratoconic eyes, although statistically significant, remains relatively small with a large standard deviation, resulting in a large overlap between groups and a low sensitivity and specificity for diagnosing keratoconus. Several studies have recently concluded that CH and CRF are poor parameters for discriminating between mild keratoconus and normal corneas and that CH and CRF alone cannot be used to identify keratoconus suspect corneas. With a procedure such as corneal cross-linking (CXL), where the cornea is stiffened, biomechanical properties of the cornea are expected to be modified. In vitro studies have demonstrated this by measuring an increase in Young modulus after CXL. However, using the ORA, no studies have been able to show a sustainable change in CH and CRF to correlate with increased stiffness as clinically predicted.

So, is the ORA just a very expensive tonometer essential in corneal refractive surgery practice because of the increasing penetrance of corneal refractive surgery in the population? Or, does it have the potential to provide better parameters than CH and CRF to also describe biomechanical properties of the eye? Several groups have been working on developing new parameters based on more complex analysis of the wave-
form signal with the goal of improving sensitivity and specificity in diagnosing keratoconus. In 2008, Fry et al.\textsuperscript{11} presented a study on 24 new parameters derived from analysis of the waveform signal and found improved classification of various degrees of keratoconus compared with CH and CRF alone. This work has recently been incorporated into the ORA software so that a total of 37 new parameters and an overall keratoconus risk score are now available. In this issue of the Journal, Spoerl et al.\textsuperscript{12} report an analysis of ORA toconus risk score are now available. In this issue of the Journal, Spoerl et al.\textsuperscript{12} report an analysis of ORA waveform signal analysis. Qazi et al.\textsuperscript{14} compared biomechanical metric changes after myopic LASIK and laser epithelial keratomileusis. Mikielewicz et al.\textsuperscript{15} demonstrated that these parameters were able to distinguish between normal and keratoconic eyes. Avetisov et al.\textsuperscript{16} used the ORA waveform signal to estimate the elasticity coefficient of the cornea and found large statistically significant differences among normal eyes, keratoconus eyes, and postoperative LASIK eyes.

These recent publications seem to indicate that the new parameters derived from waveform signal analysis represent a significant improvement over CH and CRF alone. However, more research based on these new parameters is needed to confirm the sensitivity and specificity of keratoconus detection. Given the wealth of studies reporting CH and CRF already in the literature and the work being done with ORA waveform signal analysis, it seems appropriate for the Journal to be more selective over future submissions that report ORA data; new submissions will need to include more parameters than simply CH and CRF.

**TERMINOLOGY**

The terms “corneal biomechanics,” “corneal biomechanical parameters,” “corneal biomechanical properties,” or “corneal biomechanical characteristics” have been used in publications. Despite measurements on the cornea, there is no proof that CH and CRF actually represent only corneal biomechanics. It is likely that ORA measurements represent biomechanics of the whole eye. For example, patients with scleroderma had higher CRF and IOPg values compared to normal controls.\textsuperscript{17} Another study showed an increased in CH after deep sclerectomy.\textsuperscript{18} Until we can specify exactly what each parameter represents, authors should avoid using the adjective “corneal” and simply refer to measures of “ocular biomechanics.”

**REFERENCES**


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