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Does Corneal Hysteresis Correlate with Endothelial Cell Density?

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Statistical Analysis C
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Source of support: Departmental sources**Background:** Our aim was to determine if there is a correlation between corneal biomechanical properties, endothelial cell count, and corneal pachymetry in healthy corneas.**Material/Methods:** Ninety-two eyes of all subjects underwent complete ocular examination, including intraocular pressure measurement by Goldmann applanation tonometer, objective refraction, and slit-lamp biomicroscopy. Topographic measurements and corneal pachymetry were performed using a Scheimpflug-based (Pentacam, Oculus, Germany) corneal topographer. Corneal hysteresis (CH) and corneal resistance factor (CRF) were measured with an Ocular Response Analyzer (ORA, Reichert Ophthalmic Instruments, Buffalo, NY). Endothelial cell count measurement was done using a specular microscope (CellChek, Konan, USA).**Results:** Right eye values of the subjects were taken for the study. The mean CH was 11.5 ± 1.7 mmHg and the mean CRF was 11.2 ± 1.4 mmHg. Mean intraocular pressure was 15.3 ± 2.3 mmHg. The mean endothelial cell count was 2754 ± 205 cells/mm². No correlation was found between biomechanical properties of cornea and endothelial cell count. There was a significant positive correlation between CH, CRF, and corneal thickness ($p < 0.001$; $r = 0.79$).**Conclusions:** The corneal biomechanical properties significantly correlated with corneal thickness. We found no correlation between CH and CRF with the endothelial cell density in normal subjects.**MeSH Keywords:** **Cornea • Corneal Stroma • Endothelium, Corneal****Full-text PDF:** <http://www.medscimonit.com/abstract/index/idArt/893589>

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Background

In vivo measurement of corneal biomechanics on clinical basis has become available with the Ocular Response Analyser (ORA, Reichert Ophthalmic Instruments, Buffalo, NY). The ORA measures corneal biomechanical properties using an applied force-displacement relationship [1]. During the ORA measurement based on non-contact tonometer principles, the cornea resists the dynamic air pulse, causing delays in the inward and outward applanation states. Finally, 2 pressure values are obtained at the end of the 20-millisecond measurement period. The corneal hysteresis (CH) is the difference of the 2 measurements, reflecting the energy adsorption capacity of the cornea. The average of the 2 pressure measurements gives the Goldmann-correlated intraocular pressure. The corneal resistance factor (CRF) is also derived from these measurements, reflecting the resistance of the cornea. The corneal-compensated intraocular pressure is the given pressure value, which is relatively less affected by corneal properties such as central corneal thickness (CCT). Corneal biomechanical properties have recently assumed a greater clinical importance because they may have an influence on progression of glaucoma and keratectasia, and outcome of corneal refractive surgery [2–6]. These numerous reports on different corneal pathologies such as keratoconus, several clinical conditions such as post-laser *in situ* keratomileusis, and glaucoma suggest that the biomechanics of the cornea may be related to intrinsic structural and cellular properties of the cornea. In this study, we aimed to determine if there is a relationship between corneal biomechanical properties and endothelial cell count or corneal thickness in healthy subjects.

Material and Methods

Forty-six volunteers with healthy corneas were enrolled in this study. The study was conducted according to the tenets of the Declaration of Helsinki, and approved by the institution. All participants gave informed consent. The endothelial cell count measurement was performed using a specular microscope (CellChek, Konan, USA) at the Sevket Yilmaz Training and Research Hospital by 1 physician. The results were evaluated by the 2 authors at the Department of Ophthalmology, Uludag University. All the subjects involved in the study were Caucasians. The exclusion criteria were any history of ocular surgery, ocular inflammation or infection, glaucoma, application of topical ocular medication, and history of soft or rigid contact lens wear. Ninety-two eyes of these 46 subjects underwent complete ophthalmologic examination, including objective refraction, visual acuity measurement, slit-lamp biomicroscopy, and undilated funduscopy. Before intraocular pressure (IOP) measurement, the anterior segment of the right eye of each subject was imaged with a rotating Scheimpflug camera

(Pentacam, Oculus, Germany) without application of any eye-drops. One of the authors performed all the measurements with Pentacam. The measurements were repeated until values with an “OK” reading were obtained. With the Pentacam, central corneal thickness (CCT) was measured and taken from “OK” reading values. The IOPs were measured with a Goldmann applanation tonometer. For endothelial cell density measurement, the images of the corneal endothelial cells of the right eye were captured by the instrument. The endothelial cell density was calculated by automatic analysis from the best frame. Four consecutive ORA measurements were performed on the right eye and the average of the measurements were taken. The high-quality readings defined by the manufacturer, because the force-in and force-out applanation signal peaks on the ORA waveform are fairly symmetrical in height, were accepted and recorded. The statistical analyses were performed using the statistical package SPSS 22. The correlation between corneal biomechanical properties, corneal thickness, and endothelial cell count were examined with Pearson correlational analysis.

Results

Forty-six eyes of 46 healthy volunteers with a mean age of 28.7 ± 8.9 years (range: 17–55 years) were eligible for the analysis. Mean IOP was 15.3 ± 2.3 mmHg. The mean CH was 11.5 ± 1.7 mmHg (range: 6.4–17.6 mmHg), and the mean CRF was 11.2 ± 1.4 mmHg (range: 7.0–17.2 mmHg). CRF correlated strongly with IOP measured by Goldmann applanation tonometry ($r=0.54$, $p<0.0001$), whereas CH had only a weak correlation with IOP ($r=0.25$, $p=0.042$).

The mean central corneal pachymetry measured by Pentacam was 553.2 ± 30.5 μm (range: 508–627 μm). Both CH and CRF correlated significantly with central corneal pachymetry ($r=0.79$, $P<0.001$). The mean endothelial cell count was 2754 ± 205 cells/ mm^2 . No significant correlation was found between CH or CRF with endothelial cell density ($r=0.20$, $P>0.05$) (Figures 1 and 2).

Discussion

The biomechanical response in close relation with the viscoelasticity of the cornea may vary according to intrinsic corneal factors. One of these factors intensively studied is the central corneal thickness (CCT). Measurement of corneal thickness is essential in many ocular disorders such as glaucoma, keratoconus, and atopic keratoconjunctivitis [2,4,6,7]. In several studies concerned with the corneal biomechanical factors, a strong correlation has been demonstrated between CH and CRF with CCT [8–10], in accordance with our findings. However, Touboul et al. did not report a significant relationship between CH and

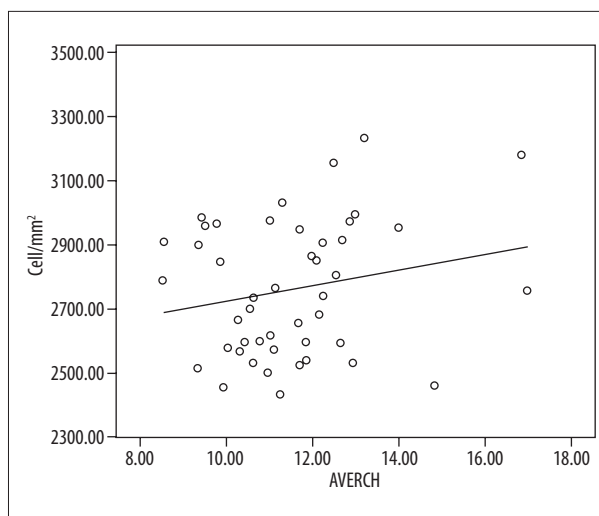


Figure 1. The graph showing the relationship of CH with endothelial cell count.

CCT [11]. Aging was also shown to affect the corneal hysteresis. While some contradictory results have been reported [12,13], other studies have revealed an age-related decrease in CH [10,14–17]. This age-related change is mostly attributed to the increased stiffness by increased collagen cross-linking in the cornea [10,14–16]. As one may expect, alterations in tissue composition and structure may also contribute to differences in corneal biomechanical response. The biomechanical properties may be related to corneal stromal hydration [18,19]. Corneal hydration is kept at a constant level by a fluid pump mechanism that is located predominantly on the corneal endothelium [20]. In Fuchs' corneal dystrophy, characterized by decreased endothelial cell density and progressive failure of endothelial pump function, CH and CRF were found to be lower compared to normal eyes, and CH and CRF had an inverse relationship with CCT [21]. A recent study revealed that CH and CRF are reduced in Fuchs' endothelial dystrophy, consistent with the study of del Buey et al., as well as after posterior lamellar keratoplasty [22]. They thought that the added stroma and Descemet's membrane did not contribute to the biomechanical rigidity because they were not integrated as part of the recipient cornea, although the endothelium seemed to function well.

There is evidence that corneal hydration control is also compromised in diabetic patients [23]. However, diabetes appears to influence corneal material properties, as exhibited by the higher CRF in the eyes of diabetic patients [24]. Thus, we hypothesized that the endothelial cell count may affect CH in normal eyes, but we did not find a correlation between CH and CRF with the endothelial cell density in normal subjects. Our study is limited by its small sample size and a larger sample size with a broader range of age groups may reveal different

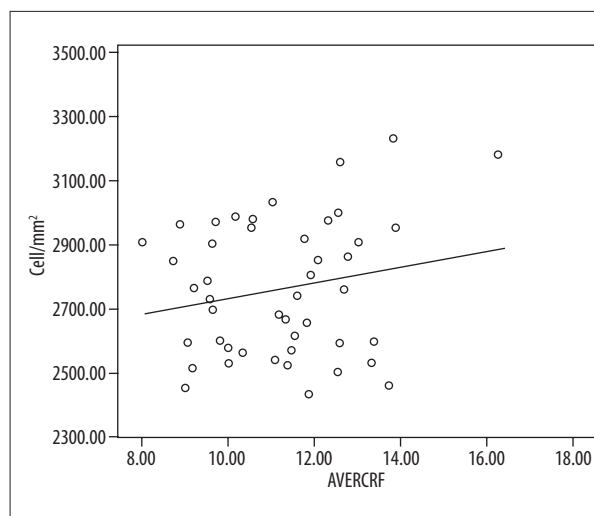


Figure 2. The graph showing the relationship between CRF and endothelial cell count.

results. Also, our healthy population with a very narrow range in endothelial density may not reflect a relationship with corneal hysteresis, but such a correlation may exist in eyes with pronounced endothelial defects.

In a study concerned with the relationship of corneal biomechanical properties with confocal microscopy findings, the authors reported that the keratocyte density of the posterior half of the stroma had been significantly related with CRF in healthy eyes, suggesting the cellular structure of the cornea may affect corneal elasticity [25]. This study suggests that cellular component, apart from endothelial cell density, may affect corneal hysteresis.

Conclusions

We did not show a correlation between CH and CRF with the endothelial cell density in normal subjects, suggesting that endothelium alone may not contribute to the biomechanical properties of the cornea. The corneal biomechanical properties significantly correlated with corneal thickness in healthy corneas.

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Conflict of interest

The authors do not have any conflict of interest.

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