# Intraocular Pressure Measurements After Conductive Keratoplasty

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**ABSTRACT**

**PURPOSE:** To determine the possible impact of conductive keratoplasty (CK) on intraocular pressure (IOP) measurements.

**METHODS:** A prospective, single-center, noncomparative interventional case series was performed. Baseline and postoperative IOPs were measured by Goldmann applanation tonometry in 32 eyes of 18 patients who underwent CK for hyperopia correction. Mean follow-up was 11.9 months (range: 8 to 18 months).

**RESULTS:** After CK, a statistically significant decrease in the measured IOP was observed (before CK: $14.22 \pm 1.64$ vs after CK: $12.66 \pm 2.21$, $P < .001$). The change in IOP readings postoperatively was not correlated with age, sex, keratometric readings, or attempted correction.

**CONCLUSIONS:** Despite the limitations due to the small number of patients enrolled in this study, the applanation tonometer appears to underestimate the true IOP after CK. [*J Refract Surg*. 2005;21:171-175.]

As corneal refractive surgery enters its maturity period, ophthalmologists are beginning to take a greater interest in its side effects. Induced alterations in the intraocular pressure (IOP) measurements by applanation tonometry in eyes that have undergone refractive surgery have been reported.[1,2] It has been postulated that post-refractive surgery IOP readings might be inaccurate as a consequence of the induced changes in corneal parameters such as central corneal thickness and curvature.[3-5] Therefore, it is crucial in post-refractive surgery patients to detect the possible induced alterations in IOP measurements and apply a correction for systematic errors whenever possible to detect and manage ocular hypertension or glaucoma.

One of the latest refractive surgical treatment modalities for low to moderate hyperopia correction with promising results is conductive keratoplasty (CK) (Refractec Inc, Irvine, Calif).[6,7] During the procedure, a 450-µm keratoplasty tip is inserted directly into the peripheral cornea at 6-, 7-, and 8-mm treatment zones, which delivers radiofrequency (350 kHz). The induced-thermokeratoplasty collagen contraction at CK-treated spots results in steepening of the central cornea. The concept of this minimally invasive hyperopic correction approach is to increase the curvature of the central cornea (and thereby correct hyperopic refractive error) by thermokeratoplasty collagen contraction into the peripheral cornea.

Preliminary results have demonstrated that CK is a safe, minimally invasive, and predictable method for the correction of low to moderate hyperopia without serious complica-

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tions.[8-14] No reports in the literature directly study the effect of CK on IOP measurements measured by Goldmann applanation tonometry (Haag-Streit, Koniz, Switzerland). In this study, we prospectively evaluated the effect of CK on Goldmann applanation tonometry readings in healthy hyperopic patients.

## PATIENTS AND METHODS

### PATIENT POPULATION

In this prospective, single-center, clinical study, 32 eyes of 18 patients who underwent CK for hyperopia correction (in the Department of Ophthalmology, Vardinoyannion Eye Institute of Crete, University of Crete, Greece) were enrolled. All treatments were performed with a ViewPoint CK system (Refractec) and by the same surgeon (I.G.P.).

Patients were excluded if any of the following criteria applied after the preoperative examination: active anterior segment pathology; residual, recurrent, or active ocular disease; previous intraocular or corneal surgery in the eye undergoing CK; glaucoma; history of herpes keratitis; diagnosed autoimmune disease, systemic connective tissue disease, or atopic syndrome; and eyes with ultrasound pachymetry readings <550 µm at the 6-mm zone. Contact lens users were advised to discontinue their lenses 1 month prior to the preoperative evaluation and procedure.

All patients were appropriately informed before their participation in the study and gave their written informed consent in accordance with institutional guidelines, according to the Declaration of Helsinki.

Mean patient age was 53.5±7.5 years (range: 42 to 68 years). Fourteen patients had bilateral treatments, and four had unilateral treatments. All patients had minimum 8-month follow-up (mean follow-up: 11.9±3.3 months [range: 8 to 18 months]).

Data obtained from the case records included patient age and sex; preoperative IOP, refraction, spherical equivalent refraction, best spectacle-corrected visual acuity (BSCVA), and keratometry; intraoperative complications; and uncorrected visual acuity (UCVA), refraction, spherical equivalent refraction, BSCVA, and IOP at each 3-month postoperative visit.

### SURGICAL TECHNIQUE

A drop of propocaine 0.5% was used in the operative eye 15 minutes prior to the procedure followed by the second application immediately before surgery. Eyes were prepared with povidone-iodine (Betadine; Lavipharm, Greece) and lids were retracted with a ViewPoint CK speculum.

Patients were advised to fixate on the microscope light and cornea was marked at the 6-, 7-, and 8-mm optical zones with a CK ViewPoint marker, centered on the corneal light reflex. According to the marks, spots were applied to the cornea starting with a cycle at the 6-mm optical zone and followed, when necessary, with circles of spots at the 7- and 8-mm zones, as per the manufacturer's nomogram (8 to 32 spots—all for spherical hyperopia). The treatment spots were applied to the cornea with a Keratoplast tip (Refractec) placed perpendicular to the corneal surface. All eyes were treated with the standard setting of 350 kHz, 60% power for 0.6 seconds per spot. As soon as the procedure was completed, drops of tobramycin 0.3% (Tobrex, Alcon-Couvreur NV, Puurs, Belgium) as well as a drop of flubiprofen sodium 0.03% (Ocuflur, Allergan, Wesport, Ireland) were applied. After surgery, patients received tobramycin four times per day for 1 week combined with flubiprofen sodium 0.03% four times per day for the first 2 days after surgery. Patients were encouraged to use artificial tears five to six times per day for the first 2 weeks after surgery.

Applanation tonometry measurements were obtained before treatment and at each visit thereafter using Goldmann applanation tonometry (Haag-Streit tonometer using sodium fluorescein solution). The same tonometer, calibrated once monthly, was used throughout the study, and tonometry was performed between 11:00 a.m. and 2:00 p.m. by a masked observer to minimize the effect of diurnal variations. The median of three consecutive measurements was used for analysis. Tonometry readings obtained within >2 hours difference were excluded from the study. The tonometry measurements before surgery and at the last follow-up visit were included in the statistical analysis.

### STATISTICAL ANALYSIS

Results are presented as mean±standard deviation. Paired-sample *t* test was used to correlate pre- and postoperative CK IOP measurements whereas independent-sample *t* test was used to compare the change in IOP readings postoperatively with sex of the patients. Linear regression analyses were used to test the influence of continuous variables such as patient age, change in spherical equivalent refraction, and keratometric values. A *P* value <.05 was regarded as statistically significant.

## RESULTS

Mean preoperative spherical equivalent refraction was +2.18±0.86 diopters (D) (range: +0.75 to +4.00 D); mean keratometry was 43.39±1.75 D (range: 40.12 to 47.40 D); and mean central corneal pachymetry was 556.53±31.08 µm (range: 480.00 to 640.00 µm). The mean attempted correction was 1.65±0.47 D (range: +0.75 to +2.75 D).

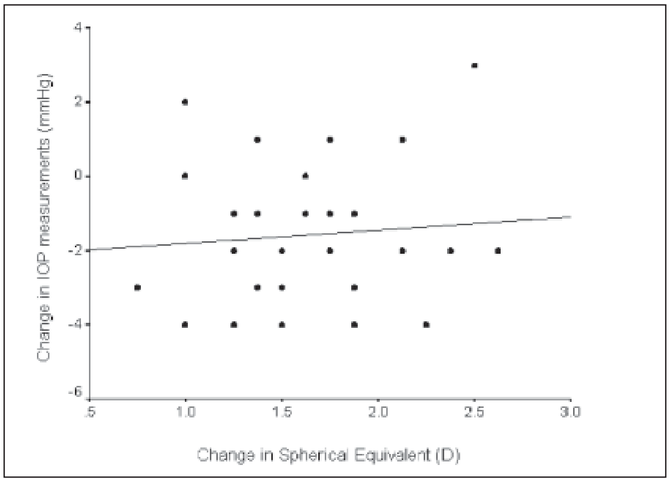


**Figure 1.** Correlation between change in intraocular pressure measurements and spherical equivalent refraction ($P$=.64, $r^2$=0.01) in 32 eyes of 18 patients who underwent CK for hyperopia correction.

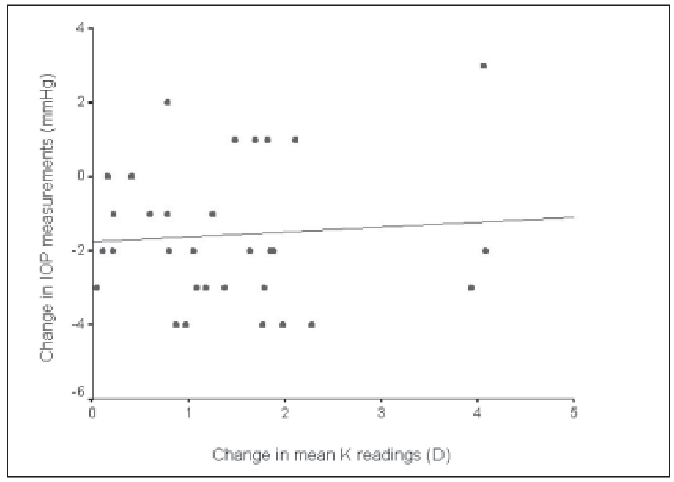


**Figure 2.** Correlation between change in intraocular pressure measurements and keratometric values ($P$=.69, $r^2$=0.01) in 32 eyes of 18 patients who underwent CK for hyperopia correction.

A statistically significant reduction of IOP measurements after CK was noted (before CK: 14.22±1.64 mmHg [range: 11 to 18 mmHg] to after CK: 12.66±2.21 mmHg [range: 10 to 18 mmHg] [$P$<.001]). The mean reduction of IOP measurements was −1.56±1.88 mmHg (range: −4 to 3 mmHg).

The change in IOP readings postoperatively was not correlated with patient age ($P$=.62, $r^2$=0.02) and sex ($P$=.80). Furthermore, no statistically significant correlation was found between changes in IOP measurements and change in spherical equivalent refraction ($P$=.64, $r^2$=0.01) (Fig 1) or keratometric values ($P$=.69, $r^2$=0.01) (Fig 2).

### Uncorrected Visual Acuity

Before the CK treatment, no eye had UCVA of ⩾20/20, 4 (13%) eyes had ⩾20/25, 9 (28%) eyes had ⩾20/40, and 18 (56%) eyes had ⩾20/80. Postoperatively, UCVA improved at the final postoperative CK examination. At the final postoperative CK examination, 13 (41%) of the 32 eyes had UCVA of ⩾20/20, 19 (59%) eyes had ⩾20/25, 29 (91%) eyes had ⩾20/40, and 31 (97%) eyes had ⩾20/80.

### Predictability

At the final postoperative CK follow-up examination, 21 (66%) of 32 eyes were within ±0.50 D of plano, 26 (81%) were within ±1.00 D, and 31 (97%) eyes were within ±2.00 D.

### Safety and Best Spectacle-corrected Visual Acuity

At the final postoperative CK follow-up examination, all eyes were within ±1 line of the preoperative BSCVA. Two (6%) eyes lost 1 line of BSCVA, 28 (88%) eyes had no change in BSCVA, and 2 (6%) eyes gained 1 line of BSCVA.

No intraoperative complications or adverse events occurred during CK procedures.

## DISCUSSION

Intraocular pressure is a crucial parameter in the diagnosis and management of ocular hypertension, various forms of glaucoma, and postoperative management of ocular diseases. Misleading tonometry could lead to late diagnosis or inappropriate follow-up. It is therefore essential to identify parameters (ie, surgery, diseases, instrumental technique) that could affect IOP measurements and apply a correction for systematic errors.

Several studies have reported changes in IOP measurements after refractive surgery.[3-5] One of the recently developed minimally invasive refractive techniques for low to moderate hyperopia correction is CK.[6-9] The concept of this technique is to increase the curvature of the central cornea (and thereby correct hyperopic refractive error) by collagen contraction in the peripheral cornea. Preliminary results have demonstrated that CK is a safe and predictable method for the correction of low to moderate hyperopia without significant evidence of regression or significant postoperative complications.[6-14]

McDonald et al,[9] in a multi-center prospective study, reported that CK has predictability, stability, and safety similar (or better) to that obtained with other techniques used to correct hyperopia. In this article, the authors did not state any induced alterations in IOP after CK. The previous study was based on a single IOP measurement by different observers using several applanation instruments (Goldmann, Perkins, Draeger tonometries), leading to increased variability of the results, which cannot be compared.

In our study, a statistically significant reduction in IOP measurements after CK was found. The mean reduction of IOP measurements was $-1.56\pm1.88$ mmHg (range: $-4$ to 3 mmHg).

Several speculations exist regarding the post-refractive surgical effect in IOP measurements.[2,3,15-18] It has been suggested that the reported decrease in IOP is an artifact caused by the induced alterations in the virgin preoperative cornea, with the true IOP remaining similar to preoperative levels. For example, in laser refractive surgeries such as photorefractive keratectomy (PRK) and laser in situ keratomileusis (LASIK), the induced alterations in central corneal thickness have been implicated as the main cause for IOP measurement changes.[2,3,15,16] Studies in patients with low-tension glaucoma that reported decreased central corneal thickness in addition to studies in patients with presumed ocular hypertension that found increased central corneal thickness[18] contribute data that support the implication of central corneal thickness in the IOP measurements. On the contrary, Zadok et al[4] found that the applanation tonometer underestimates the true IOP after hyperopic LASIK whereas Munger et al[1] found a statistically significant decrease in IOP measurements after hyperopic PRK that was not directly linked to changes in central corneal thickness. Because central corneal thickness in hyperopic LASIK and CK corrections remains almost unchanged, the possibility that induced reduction of central corneal thickness could affect IOP measurements is weakened.

Other theories implicate changes in corneal integrity during refractive surgery as a possible cause of the reduced IOP measurements.[19,20] Postoperative changes in Bowman's layer and the stromal structure may render local tissue more pliable by altering the biomechanical parameters of the cornea, namely, rigidity and elasticity. Ocular rigidity is a measurable physical parameter of the eye, which expresses the elastic properties of the eye globe. In 1937, Friedenwald[21] described the coefficient of ocular rigidity as a "measure of the resistance, which the eye exerts to distending forces" and he developed a formula for ocular rigidity. Induced stromal alterations (collagen contraction) after CK could affect the cornea and finally ocular biomechanical properties, resulting in reduced rigidity and less resistance to deformation.[20]

There is still, however, a possibility that the drop in IOP is a response of aqueous humor dynamics to the surgery (increase in outflow from the effect on the trabecular meshwork) or an unknown effect of the thermal corneal stromal constriction. Other factors, such as improved patient cooperation or relaxation at applanation tonometry during follow-up, should also be considered. Despite the limitations due to the small number of patients enrolled in this study, CK seems to affect the IOP measurements. Whatever the etiology (it remains possible that the etiology of this process is multifactorial), preoperative IOP levels (used as baseline IOP), peripheral[22] (out of CK-treated spots), or Tono-pen IOP measurements[15] should be taken into account in CK-treated patients, especially if glaucoma is suspected.

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