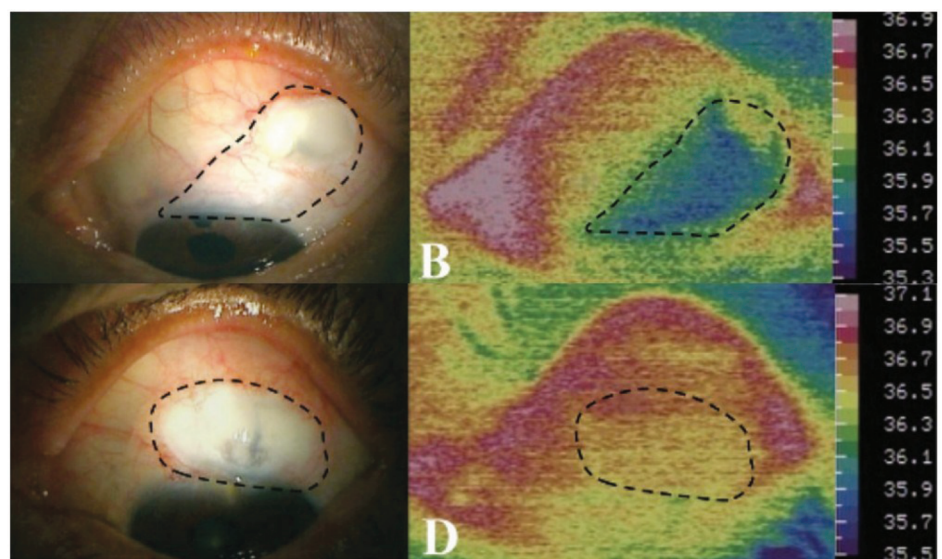




# BULGARIAN FORUM GLAUCOMA

БЪЛГАРСКИ ФОРУМ  
ГЛАУКОМА



# BULGARIAN FORUM GLAUCOMA

Edition of the „National Academy Glaucoma” Foundation, Sofia, Bulgaria

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# Pachymetry and visual fields in the diagnosis and prognosis of glaucoma

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## Abstract

**Purpose:** Studies of the cornea, show that corneal thickness is an important factor influencing the accuracy of measuring intraocular pressure. A pachymetry test is a simple, quick, painless test to measure the thickness of the cornea. With this measurement, we can better understand the IOP reading and develop a treatment plan that is right for the condition. Several techniques are available to reliably and reproducibly measure corneal thickness. The methodologies used in these techniques are based on either ultrasonic or optical principles. While each of the methods have a peculiarity of their own, all have been described as reliable.

**Material and methods:** A retrospective analytical study of the medical records of primary open-angle glaucoma patient, that visited the Glaucoma department of the University Eye Clinic between January 2014 and December 2014. All subjects underwent a complete eye examination. Central corneal thickness (CCT) measurement and various other eye tests were performed, including best-corrected visual acuity (CVA), intraocular pressure (IOP), cup-to-disc ratio (C/D), visual fields by automated perimetry and RNFL thickness.

**Results:** Thinner baseline CCT was associated with more advanced damage at presentation, correlated with mean deviation (MD) ( $r=0.17$ ,  $p=0.02$ ) and neuroretinal rim area (NRR) ( $r=0.20$ ,  $p=0.02$ ). Glaucomatous eyes had significantly thinner ( $p=0.01$ ) baseline CCT compared to non-glaucomatous eyes. The slope of visual field change was significantly greater ( $p=0.05$ ) for eyes with thinner ( $<540 \mu\text{m}$ ) as compared to thicker corneas. A significant CCT reduction ( $12.78 \pm 13.35 \mu\text{m}$ ,  $p<0.0001$ ) was noted in glaucomatous eyes. CCT change was in correlation with visual field MD. A thinner CCT (Odds ratio=1.80,  $p=0.02$ ), was a significant risk factor for glaucoma.

**Conclusion:** In our study, CCT correlated significantly with the amount of glaucomatous damage at presentation. Thinner corneas may be associated with increased risk of visual field progression.

**Key words:** glaucoma, pachymetry, visual fields.

## Introduction

Until recently, pachymetric measurement of central corneal thickness (CCT) has been the exclusive territory of corneal specialists. It is an important tool to evaluate the health of the cornea, measuring its thickness to assess the capacity to pump out excess fluid and maintain clarity [1, 2].

Corneal specialists and general ophthalmologists continue to rely on accurate corneal pachymetry readings to manage patients with corneal ectasias (keratoglobus, pellucid degeneration, keratoconus, Fuchs' endothelial dystrophy, bullous keratopathy, corneal rejection post - penetrating keratoplasty, and other causes of corneal edema).

However, an increasing number of ophthalmologists are now obtaining CCT measurements on patients with (or suspected to have) glaucoma. Studies about the cornea, show that corneal thickness is an important factor in accurately diagnosing intraocular pressure. The report summarizing the five-year results from the Ocular Hypertension Study (OHTS) was released in 2002. The study's goal was to determine if early intervention with pressure lowering medications could reduce the number of ocular hypertensive (OHT) patients who develop glaucoma. During the study, a critical discovery was made regarding the relationship between corneal thickness and its correlation with intraocular pressure and the glaucomatous process.

### *A Thin Cornea - The Danger of Misreading Eye Pressure*

Patients with thin corneas (less than  $555 \mu\text{m}$  central corneal thickness) show artificially low IOP readings. This is dangerous because if the actual IOP is higher than the reading shows, the patient may be at risk of developing glaucoma. Left untreated, high IOP can lead to glaucoma and vision loss. It is important that ophthalmologists have an accurate IOP reading to diagnose the risk and decide upon a treatment plan [3-5].

### *A Thicker Cornea - May Mean Less Reason to Worry About Glaucoma*

Those patients with thicker CCT may show a higher reading of IOP than actually exists. However, it is still important to have regular eye exams to monitor eye pressure and stay aware of changes.

### *Pachymetry - A Simple Test to Determine Corneal Thickness*

A pachymetry test is a simple, quick, painless test to measure the thickness of the cornea. With this measurement, we can better estimate the true IOP reading, and develop a treatment plan that is right for the condition. Several techniques are available to reliably and reproducibly measure corneal thickness. The methodologies used in these techniques are based on either ultrasonic or optical principles. While each of the methods have a peculiarity of their own, all have been described as reliable [6, 7]. Systematic differences exist between the different techniques



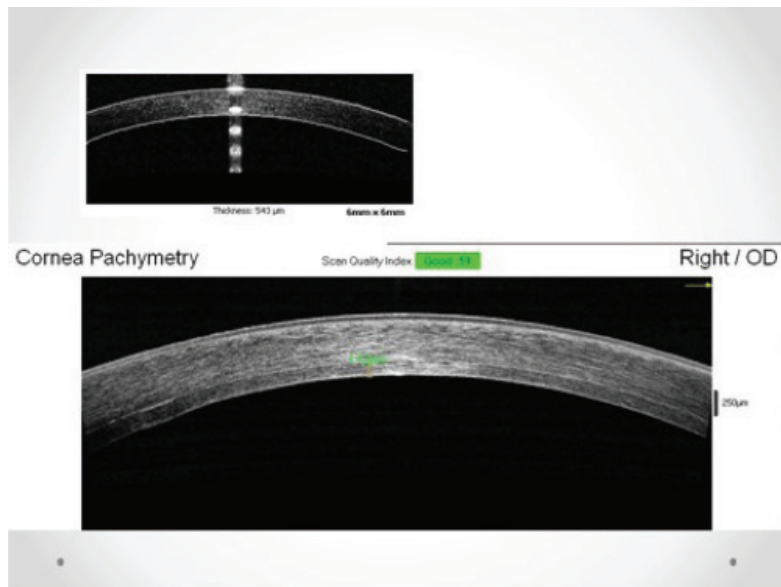


Fig. 1. Cornea pachymetry.

and result in different values [8]. As a result, the measurements cannot simply be substituted between the different modalities.

- **Traditional ultrasound** (10-20 MHz)
- **Ultrasound biomicroscopy** (50 MHz) and very-high-frequency ultrasound (70 MHz) have the disadvantage of requiring a water bath, but allow for determination of corneal sublayers details and pachymetry.
- **Specular microscope** (Topcon Corp.) is a non-contact optical instrument that provides pachymetry and specular microscopy simultaneously.
- **Orbscan** is a non-contact optical scanning-slit instrument that provides pachymetry in addition to topographic analysis.
- **Optical coherence tomography (OCT)** non-contact techniques that acquire pachymetry measurements based on optical interferometry.
- **Confocal microscopy** is a contact technique that acquires measurements by thorough focusing a confocal microscope through the thickness of the cornea.
- **The Pentacam Scheimpflug Camera** is a non-contact

technique that uses a rotating Scheimpflug camera to rapidly capture images of the anterior segment of the Laser Doppler interferometry is a non-contact technique that uses a dual-beam infrared laser Doppler interferometry to measure corneal thickness.

### Material and methods

A retrospective analytical study of the medical records of primary open-angle glaucoma patients, between January 2014 to December 2014, were reviewed in the Glaucoma Department of the University Eye Clinic in Skopje, Macedonia.

All subjects underwent a complete eye examination. Central corneal thickness (CCT) measurement and various other eye tests were performed, including best-corrected visual acuity (CVA), intraocular pressure (IOP), cup-to-disc ratio (C/D), visual fields by automated perimetry and RNFL thickness by OCT in each patient.

The participants underwent a standardized protocol with a comprehensive questionnaire; ophthalmic examination (slit-

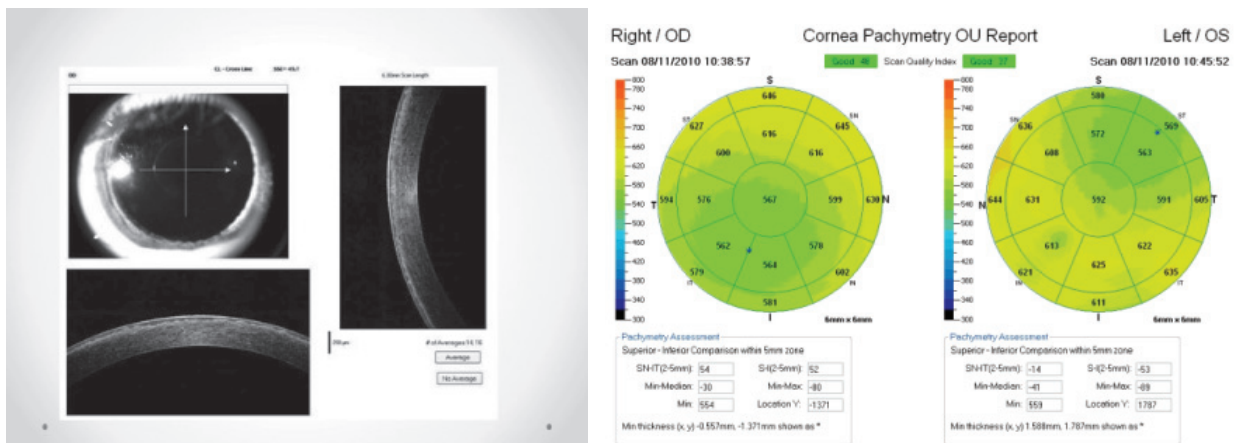


Fig. 2. Results of cornea pachymetry.

lamp biomicroscopy; autorefractometry; noncontact tonometry; fundus photography; CCT measurements (optical pachymetry); visual field testing).

The gender distribution was 65% male and 35% female. The average age was 62.5 years.

The results showed that in 32 patients there were no glaucomatous visual field defects and they were treated as ocular hypertension, while in 18 patients we have found pachymetric, visual field and OCT positive signs of glaucoma and they were treated with the appropriate therapy.

Discrepancies between tonometry and CCT readings were evaluated after stratification into thin, intermediate, and thick CCT groups.

## Results

Thinner baseline CCT was associated with more advanced damage at presentation, with greater mean deviation (MD) depression ( $r=0.17$ ,  $p=0.02$ ) and larger neuroretinal rim area (NRR) ( $r=0.20$ ,  $p=0.02$ ).

Glaucomatous eyes had significantly thinner ( $p=0.01$ ) baseline CCT compared to non-glaucomatous eyes.

In addition, the Ocular Hypertension Treatment Study (OHTS), a large-scale longitudinal study, clearly demonstrated a thin CCT value as a substantial and independent risk factor for the development of primary open-angle glaucoma (POAG).

The reasons for the correlation between thin CCT and POAG development are presently unclear, and there are few studies regarding CCT as correlated with POAG risk factors such as IOP [9, 10].

Moreover, the definitive answer to the question of a causal vs. correlative relationship of CCT and POAG remains somewhat elusive. The study published in the Am J Ophthalmol [17] may help to shed some light on this intriguing feature of glaucoma connected with the oxygen levels of the anterior chamber. In this cross-sectional study, 124 patients had the oxygen levels of their anterior chambers measured directly by means of paracentesis and a fiber optic oxygen sensor at three different and distinct locations: just posterior to the central corneal endothelium, midway through the anterior chamber, and at the anterior chamber angle. The results of the study showed that oxygen levels were higher in patients with thinner CCT values. However, this result was isolated to the anterior chamber angles

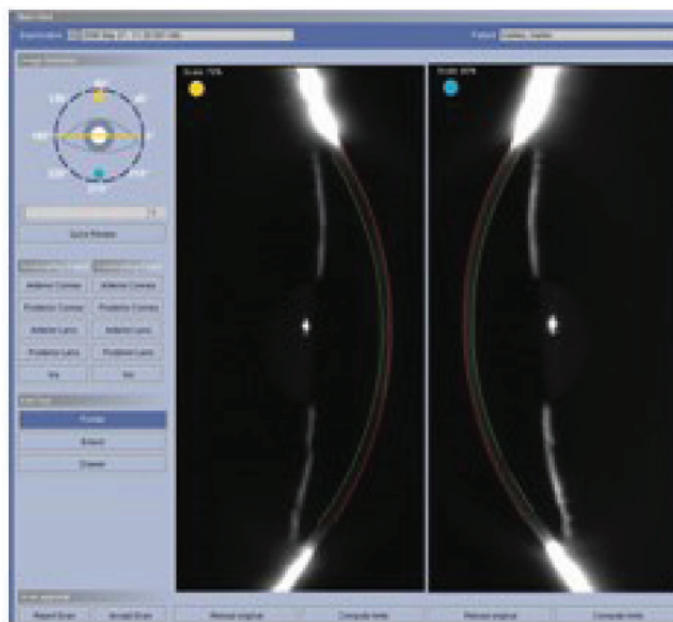


Fig. 3. Corneal pachymetry of both eyes.

The slope of visual field change over time was significantly greater ( $p=0.05$ ) for eyes with thinner ( $<540 \mu\text{m}$ ) as compared to eyes with thicker corneas.

A significant CCT reduction ( $12.78 \pm 13.35 \mu\text{m}$ ,  $p<0.0001$ ) was noted in glaucomatous eyes.

CCT change was correlated with the visual field MD. A thinner CCT (Odds ratio=1.80,  $p=0.02$ ), was a significant risk factor for glaucoma.

## Discussion

Corneal thickness (along with other parameters) may hold significant influence on accurate measurement of intraocular pressure (IOP).

and not the other ocular sites in these patients.

Such a specific correlation is particularly intriguing due to the fact that the trabecular meshwork is located within the anterior chamber angle and provides some evidence for such a scenario. Could it be that oxygen and/or reactive oxygen species damage the trabecular meshwork at a molecular level, thus affecting its structural, and therefore, functional integrity? The authors of the study are among those who suggest this very possibility.

It has been shown that oxidative stress plays a significant role in damage to the trabecular meshwork in glaucoma models [11, 12].

Since the trabecular meshwork and the lamina cribosa share common developmental origin from the neuro-ectoderm, there may be a good reason to believe that oxidative stress would damage the lamina cribosa in a similar fashion, thus exposing and predisposing the retinal ganglion cells and their axons that fenestrate through it to damage and eventual premature cell death (which happens in glaucoma).

So, with the potential relationship between CCT values and oxidative stress (and the OHTS study) in mind, pachymetry values are important and essential to an accurate glaucoma work-up and could be considered a tipping point for treatment even more than monitoring for change.

Further, the suggested inverse relationship between CCT values and oxygen levels in the anterior chamber angle acts as another check in the box that we, as clinicians, are truly on the verge of being able to treat glaucoma in ways other than lowering IOP.

The potential for these concepts to lead to new horizons in glaucoma treatment is exciting, especially in the presence of conditions such as normal-tension glaucoma, in which IOP increase plays less of a role.

Thinking about glaucoma variables other than IOP as risk factors also helps us, as clinicians, to move beyond the "gold standard" of 21 mmHg as an IOP upper normal limit. The future of glaucoma therapy is likely to be highly personalized. We will likely be able to not only modify variables other than IOP (such as oxidative stress), but we will also be able to identify patients in which one or more variables matters more than the others. This is all still somewhat conceptual, but not off the radar. Moreover, with the possible CCT-oxidative stress relationship in mind, pachymetry may provide at least a partial insight into such concepts [13-16].

Therefore, in the modern age of big and colorful OCT printouts that quantify retinal nerve fiber and ganglion cell layer thickness down to just a few microns, it's surprising that old pachymetry test is still so important.

## Conclusions

Pachymetry in relation with visual field examination are important diagnostic procedures for the right diagnosis and prognosis of newly diagnosed glaucoma patients.

In our study CCT correlated significantly with the amount of glaucomatous damage at presentation. Thinner corneas may be associated with increased risk of visual field progression.

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