Correlation between Central Corneal Thickness, Intraocular Pressure and Retinal Nerve Fiber Layer Thickness in Glaucoma Suspects


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Abstract

Background: The measurement of Central Corneal Thickness (CCT) by pachymetry has been an essential part of the contemporary glaucoma work-up. Corneal thickness (along with other hysterics) may hold significant influence on accurate measurement of Intraocular Pressure (IOP). However, 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 FD-OCT offers comprehensive glaucoma evaluation by providing assessment of RNFL thickness and optic disc morphology. In this study, we studied the correlation between central corneal thickness, IOP and RNFL thickness in glaucoma suspects.

Methods: 31 eyes of glaucoma suspects were included in the study. Glaucoma suspects were classified as those with: IOP >21mmHg or ONH changes, such as an optic rim notch, vertical cup/disc diameter ratio asymmetry and reliable Humphrey SITA central 24-2 standard visual field that is normal or showing changes not fulfilling the minimal criteria for glaucoma diagnosis. All subjects underwent complete ophthalmic examination, gonioscopy, Goldmann applanation tonometry, OCT corneal pachymetry, Visual field examination using standard automated perimetry performed with a Humphrey Field Analyzer using the Swedish Interactive Threshold Algorithm (SITA) standard strategy, program central 24-2 and imaging using FD-OCT; the RTVue-100 glaucoma protocol.

Results: The study showed significant correlation between CCT and IOP. However the correlation between average RNFL thickness and CCT and between average RNFL thickness and IOP was not statistically significant.

Conclusions: CCT is a significant glaucoma predictor in glaucoma suspects.

Key Words: Glaucoma – IOP – Central corneal thickness – Peripapillary RNFL.

Introduction

CENTRAL corneal thickness has been shown to be an important risk factor for the development and severity of glaucoma [1].

It is unclear whether risk attributed to CCT is only the result of inaccuracies in measurement of IOP or whether there are additional related factors, such as properties of the posterior sclera and lamina cribrosa, which may significantly influence the development and progression of glaucoma [2].

Several reports have focused on the concern that thinner than average corneas may underestimate the true IOP whereas thickener than average corneas may overestimate the true IOP. This effect has been found to be in the order of 1 mmHg correction for every 25 gm deviation from a CCT of 550gm [3].

Central corneal thickness has been recognized as a significant risk factor for progression of ocular hypertension to primary open-angle glaucoma in the ocular hypertension treatment study. This study was the first to prospectively demonstrate that a thinner CCT predicts the development of POAG. They found that a decrease in CCT of 40 gm added a 70% increase in risk [4].

In OAG and OHT, a thin cornea is more strongly associated with disease severity than IOP [1]. However, CCT has a significant effect on IOP measured by applanation tonometry. The potential for these concepts to lead to such new horizons in glaucoma treatment is especially exciting in the presence of conditions such as normal-tension glaucoma, in which IOP plays a role, but perhaps less of a role [8].
Glaucma diagnosis and follow-up involves visual field testing, Intraocular Pressure (IOP) and morphologic assessment of the Optic Nerve Head (ONH) and the Retinal Nerve Fiber Layer (RNFL). It is known that structural damage precedes detectable visual field loss measured with the standard automatic perimetry. Early detection is therefore essential to stop or delay progressive loss of visual function [6].

In recent years, new technologies for the early detection of structural damage have been developed and OCT provides real-time, objective, and reproducible measurements [6].

In the current study, we studied the correlation between central corneal thickness, RNFL thickness, measured by spectral domain OCT and IOP measured by applation tonometry in glaucoma suspects.

Material and Methods

This study was carried out from March 2012 to June 2013 in Kasr Al-Ainy Hospital, Cairo University to study the correlation between central corneal thickness, intraocular pressure and retinal nerve fiber layer thickness in glaucoma suspects.

Study design:
Observational cross sectional study.

Population of the study and disease condition:
31 eyes of glaucoma suspects were included in the study. Glaucma suspects were defined as those with: IOP >2 1 mmHg or ONH changes, such as an optic rim notch, vertical cup/disc diameter ratio asymmetry and reliable Humphrey SITA central 24-2 standard visual field that is normal or showing changes not fulfilling the minimal criteria for glaucoma diagnosis.

Background and demographic characteristics:
Patients between 30 and 65 years old with no sex prediliction.

Inclusion criteria: Normalopen anterior chamber angle, clear media, refractive errors in the spherical equivalent not exceeding 6 or +3 diopters, and cylindrical correction within 3.0 diopters.

Exclusion criteria: Age <30 or >65 years, concomitant corneal or retinal diseases, diseases that could cause visual field loss or optic disc abnormalities, history of intraocular surgery, unreliable visual field tests and scans with poor signal strength.

Interventions: Each patient underwent a comprehensive ophthalmologic examination, including review of medical history, best-corrected visual acuity, slit-lamp biomicroscopy, IOP measurement using Goldmann applation tonometry, gonioscopy, automated perimetry using Humphrey 24-2 visual field analyzer, CCT measurement using RTVue-100 OCT pachymetry, and RNFL thickness Imaging using FD-OCT; the RTVue-100.

Statistics:
Data were statistically described in terms of mean ± standard deviation (±SD), median and range, or frequencies (number of cases) and percentages when appropriate. Statistical significance was determined using unpaired student- t-test for comparing means of quantitative data. Pearson correlation (r) was used for correlation coefficient. Ap-value of <0.05 was considered to be statistically significant.

All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

Results

Subjects' characteristics:
A total of 34 eyes were examined. Two eyes were excluded because of poor OCT images. In addition, one eye was excluded because of unreliable VF. Finally, a total of 31 eyes of glaucoma suspects were included in the study.

The mean age of the glaucoma suspects was 46.03± 14.24 years. 60% of the participants were females and 40% were males. Family history of glaucoma was positive in 15% of the eyes.

The mean IOP measured by applation tonometry was 16± 3.37mmHg.

RNFL measurements: Fig. (1).

The mean average RNFL thickness was 106.9 ± 11.66 microns.

The mean superior average RNFL thickness was 106.15±15.38 microns while the mean inferior average RNFL thickness was 107.67 ± 10.14 microns.

29% of the suspects showed one or more affected NFL sector and 10% showed one or more affected NFL sector despite having NFL parameters within normal values.

Among the suspects with NFL defect, 44.4% had an affected inferior quadrant and 5.6% had an affected superior quadrant, most of them (75%) above the age of 55.
Optic disc measurements: Fig. (1).

The mean rim volume was $0.09 \pm 0.05 \text{mm}^3$, mean CD area ratio was $0.54 \pm 0.14$ and mean rim area was $0.91 \pm 0.3 \text{mm}^2$.

The study showed significant correlation between CCT and IOP. However the correlation between average RNFL thickness and CCT and between average RNFL thickness and IOP was not statistically significant. (Table 1), Fig. (2).

Table (1): Correlation between central corneal thickness, intraocular pressure and retinal nerve fiber layer thickness in glaucoma suspects.

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<tr>
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<th>PACHY</th>
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<tr>
<td>PACHY:</td>
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<td>$p$-value</td>
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<td>N</td>
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| IOP:     | .845  | 1    |
| $p$-value| $<0.001$ |      |
| N        | 31    | 31   |

| RNFL:    | -.007- | -.116- |
| $p$-value| .972   | .536  |
| N        | 31    | 31   |

Discussion

Glaucoma is a progressive optic neuropathy in which morphological changes that occur at the optic nerve head and retinal nerve fiber layer are associated with functional deficit. Examining and monitoring the optic nerve head and the RNFL, structurally and functionally, is important for diagnosis and treatment. It has been proved by Li et al., that RTVue-OCT may provide objective, quantitative, and reproducible images of the ONH and RNFL thickness in glaucoma [7].

The cornea and sclera form the continuous collagen coat of the eye. In the posterior segment, the sclera perforates to form the lamina cribrosa through which retinal ganglion cell axon exit the eye. Changes in the sclera may be highly relevant in glaucoma, and scleral properties, such as elasticity and thickness may mirror those in the lamina. In experimental glaucoma there is acquired regional thinning in the posterior sclera that increase eye wall stress [8].

That is why many investigators have focused on the role of CCT in glaucoma. In other words, it may be that a thin central cornea is associated with a thin sclera, which in turn, is associated with a thin lamina and a higher risk from glaucomatous damage. A thin central cornea is emerging as a major risk factor for severity of OHT and OAG [1,5].

Anatomic and biometric evaluations of the optic disc and corneal thickness with correlation to various parameters, including sex, age, race, height, iris color, keratometry, anterior chamber depth, lens thickness, refraction, axial length, IOP, and various types of glaucoma have been made [9].

The study was performed on 31 eyes of glaucoma suspects.
29% of the suspects had NFL defect despite their normal visual fields.

10% of the suspects showed one or more affected NFL sector despite having NFL parameters within normal values.

Among the suspects with NFL defect, 44.4% had an affected inferior quadrant respecting ISNT rule. 55.6% had an affected superior quadrant, most of them (75%) above the age of 55. This is consistent with age-related retinal nerve fiber layer loss which is maximum in the superior quadrant, and seems to reach a maximum after the age of 50 years [10].

In the current study, there was a significant correlation between CCT and IOP in glaucoma suspects.

Low CCT in glaucoma suspects has clinical as well as statistical significance, since a patient’s glaucoma risk assessment may be directly affected by this decrease. The Early Manifest Glaucoma Trial demonstrated that glaucoma progression was lessened by 10% for every millimeter of mercury decrease in IOP, so adjusting IOP for decreased CCT may in fact alter glaucoma patient’s risk profile for progression [9].

In another study to correlate the Retinal Nerve Fiber Layer (RNFL) thickness and Optic Nerve Head (ONH) parameters measured by Optical Coherence Tomography (OCT) with Central Corneal Thickness (CCT) measurements in patients with Ocular Hypertension (OHT) they concluded that Ocular hypertensives with CCT $\leq 555 \mu m$ may represent patients who have either very early undetected glaucoma or an inherent structural predisposition to glaucomatous damage [11].

The current study, however, showed no significant correlation between average RNFL and CCT or between average RNFL and IOP.

Another study by Henderson et al., concluded that ocular hypertension patients with thinner corneas had significantly thinner RNFL than OHT patients with thicker corneas and healthy control subjects [12].

Most of our glaucoma suspects had suspicious discs and within normal values of IOP and CCT which explains the study results. Further studies on ocular hypertensives are recommended.

**Conclusion:**

Studying the structural changes in glaucoma suspects can allow early glaucoma diagnosis and management and aim for a better outcome.

**References**


الملخص العربي

مقدمة: بعد قياس سمك القرنية جربًا هامًا في تشخيص مرض الجلوكوما، وقد نشأت دراسات عديدة في هذا الصدد، ومن المهم دراسة العلاقة بين سمك القرنية وضغط العين وتأثيرهما على سمك طبقة الآلياف العصبية بالشبكة.

طريق البحث: تم البحث على 31 حالة من مشتبهى مرض الجلوكوما حيث تم إجراء فحص كامل للعين وقياس ضغط العين، وقياس سمك القرنية، وتحديد مجال الإصار، والتصوير باستخدام الماسح الضوئي المقطعي الطيفي.

النتائج: أثبتت الدراسة وجود ارتباط بين سمك القرنية وضغط العين بينما كان الارتباط بين سمك الآلياف العصبية وكل من (سمك القرنية وضغط العين) ليس ذو أهمية إحصائية.