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Central corneal thickness in primary open angle glaucoma, pseudoexfoliative glaucoma, ocular hypertension, and normal population

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PURPOSE. This study was designed to determine the relationship between central corneal thickness (CCT) and intraocular pressure (IOP) measured by applanation tonometer in glaucomatous, ocular hypertensive, and normal eyes.

METHODS. A total of 125 subjects were included in the study. Twenty-six had primary open angle glaucoma (POAG), 25 had pseudoexfoliative glaucoma (PXG), 24 had ocular hypertension (OHT), and 50 of them were normal. IOP values were measured by Goldmann applanation tonometer whereas CCT values were measured by ultrasonic pachymeter.

RESULTS. CCT values in the OHT group (595.75±22.52 µm) were greater than the CCT values of the POAG group (539.92±21.50 µm), the PXG group (526.28±31.73 µm), and the normal group (533.96±29.25 µm) ($p<0.05$). Eight patients who were diagnosed with OHT showed IOP values of 21 mm Hg or lower with corrected IOP values according to CCT.

CONCLUSIONS. Increased CCT may lead to falsely high values of IOP measured with Goldmann applanation tonometer. In this study, when IOP values of the OHT group were redefined according to the formulae regarding the CCT, the authors noted that one third of them were normal. Determination of the CCT in OHT cases is crucial since it has great impact on IOP values, measured with applanation tonometer, which is the main parameter in the diagnosis and follow-up of glaucoma. (Eur J Ophthalmol 2005; 15: 324-8)

KEY WORDS. Central corneal thickness, Glaucoma, Intraocular pressure, Ocular hypertension

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INTRODUCTION

Goldmann applanation tonometry is the international gold standard method for measurement of intraocular pressure (IOP). The measured values with Goldmann applanation tonometer may be regarded as correct when ocular factors like corneal thickness and curvature diameter are assumed to have no effect on this measurement. However, many factors influence the measurements with applanation tonometer (1), central corneal thickness (CCT) being the most commonly reported one (2). Goldmann defined a standard CCT (520 µm) for calibration of applanation tonometer, and also he had mentioned that CCT influences the IOP measurement (3). Treatment modalities that make cornea thinner, such as excimer photorefractive keratectomy (4, 5) and laser in situ keratomileusis (LASIK) (6, 7), are known to cause lower tonometric values. Hansen and Ehlers showed the positive linear relationship between CCT and IOP (8). It was shown that IOP values measured with applanation tonometer were greater than the values measured with manometry in subjects with high CCT values (9-11). Recent studies showed that ocular hypertensive subjects have thicker corneas when compared to normal subjects (12-15) and normotensive glaucomatous patients have thinner corneas than normal subjects (14, 15). In this study, we measured mean CCT of patients with primary open angle glaucoma (POAG), pseudoexfoliative glaucoma (PXG),

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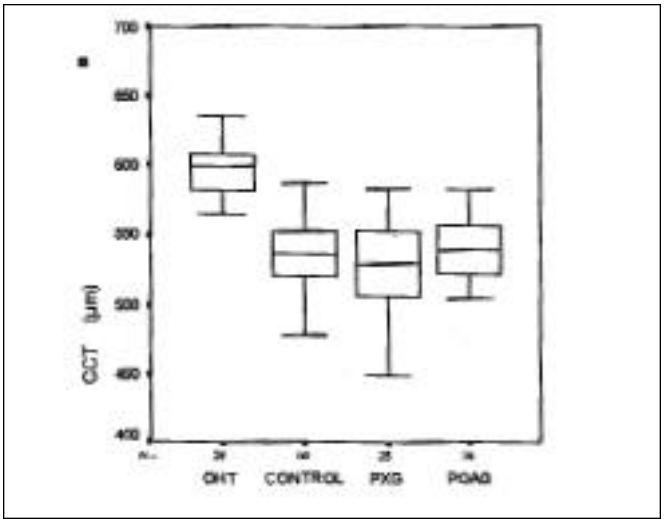

Fig. 1 - Distribution of central corneal thickness (CCT) values in different groups (distribution and mean values are given as box-and-whiskers plot). OHT = Ocular hypertension; PXG = Pseudoexfoliative glaucoma; POAG = Primary open angle glaucoma.

and ocular hypertension (OHT) and normal subjects by ultrasonic pachymeter, and tried to define the number of patients who had been falsely diagnosed with OHT.

PATIENTS AND METHODS

Twenty-six patients with POAG, 25 patients with PXG, 24 patients with OHT, and 50 control subjects who had been admitted to the glaucoma department of Ankara Training and Research Hospital between January and August 2003 were included in this study. Patients with POAG had no angle pathology in gonioscopic examination and their angles were open. All had glaucomatous damage in optic nerve and defect in visual field and IOP values were 22 mmHg or above. IOP values of PXG patients were 22 mmHg or above, with open angle, typical pseudoexfoliative material on angle and lens, glaucoma-

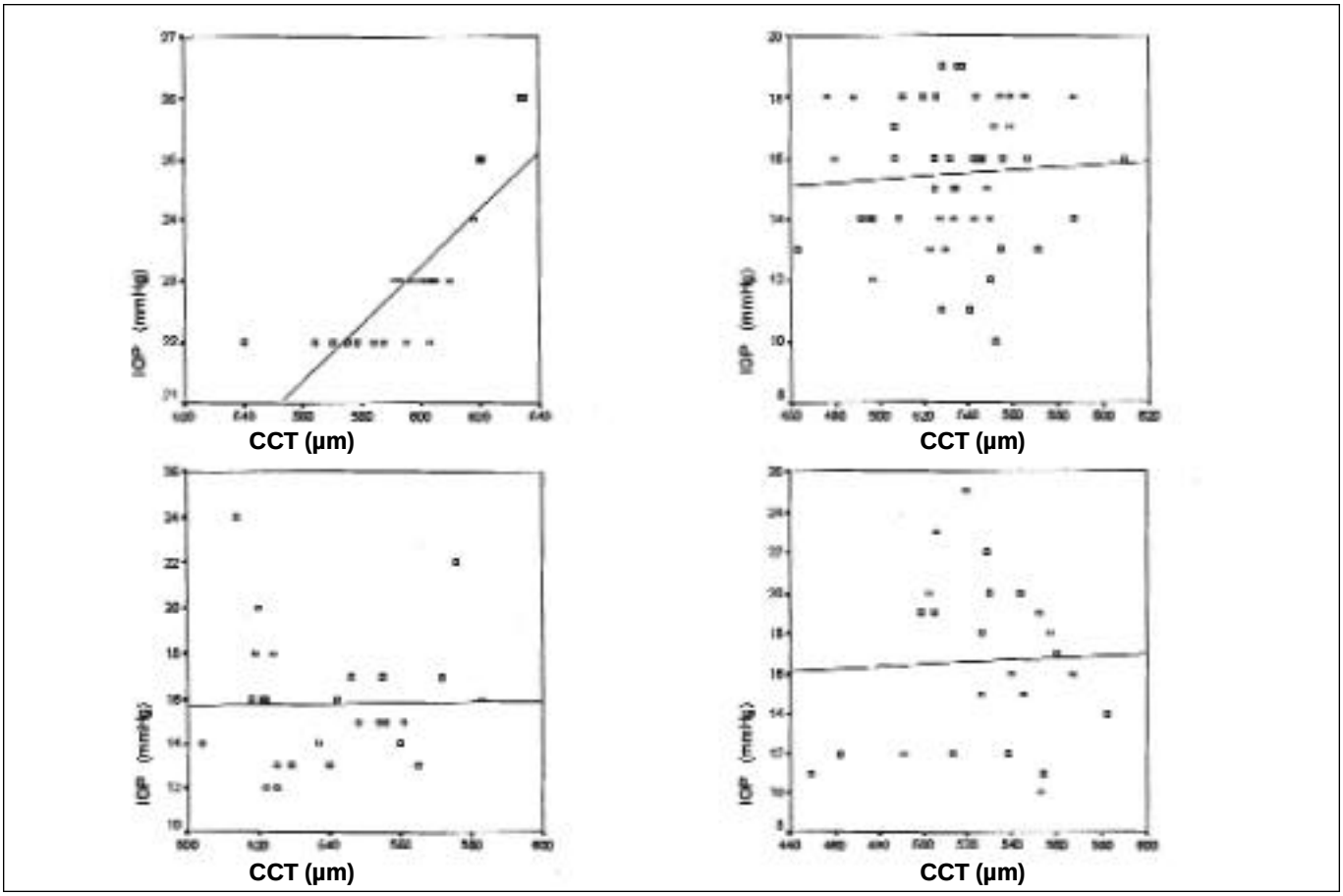

Fig. 2 - Assessment of the association between central corneal thickness (CCT) and intraocular pressure (IOP) with regression analysis in ocular hypertension (OHT), control, primary open angle glaucoma (POAG), and pseudoexfoliative glaucoma (PXG) groups, respectively.

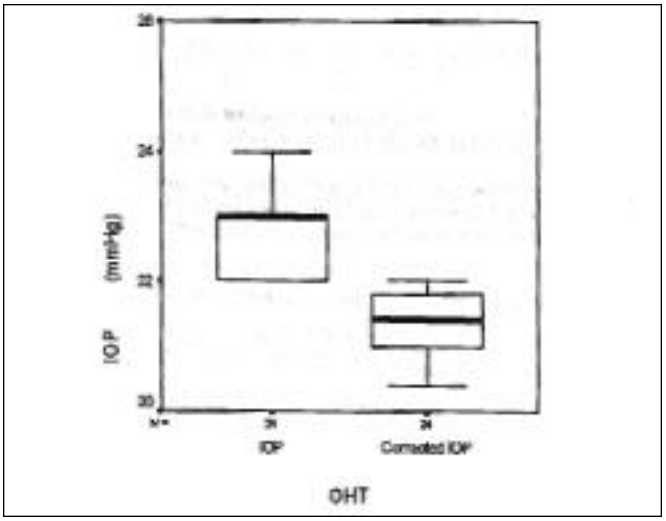

Fig. 3 - IOP and corrected IOP values in ocular hypertension group (Distribution and mean values are given as box-and-whiskers plot). OHT= Ocular hypertension; IOP= Intraocular pressure.

tous optic disc, and visual field changes. The OHT group had IOP values of 22 mmHg or above, normal optic disc, and visual field with open angle. Patients with contact lenses, corneal disease, trauma or ocular surgery history, unknown diagnosis, or myopic or hypermetropic refractive error over 3 diopters (D) or astigmatism over 1 D were excluded from the study.

Corrected visual acuity levels and ages of all patients were recorded and all of the patients underwent biomicroscopic examination. IOP values were measured by standard Goldmann applanation tonometer. CCT was measured by regularly calibrated ultrasonic pachymeter (Sonomed, Sonoscan, model 4000 AP). After application of local anesthetic agent, CCT was measured from the center of the pupilla without any dilatation and holding the probe perpendicular to the cornea, in forward sight and sitting position of patient.

Five measurements with standard deviation of 5 µm or less were made through central cornea and mean value of them were calculated and recorded as CCT value. We corrected IOP values according to CCT values in OHT group as described by Whitacre et al (11). The same investigator (R.Y.), who was blind to the diagnosis of the patients, had done all measurements. A single eye of each patient was randomly selected for analysis, Student t-test was used for comparing the mean values between the groups, and all statistical tests were conducted at the 5% significance level.

RESULTS

Demographic properties of patients are given in Table I. There were 17 women and 9 men in the POAG group, 16 women and 9 men in the PXG group, 18 women and 6 men in the OHT group, and 27 women and 23 men in the control group. There was no difference between the groups when refraction values were compared. The patients in PXG (69.12±7.90) and POAG (60.38±9.65) groups were older when compared with the OHT and control groups (50.37±11.47 and 47.98±13.81) ($p<0.05$) (Tab. I). CCT values were significantly higher in OHT group when compared to POAG, PXG, and control groups ($p<0.05$). CCT values were relatively lower in PXG group than the normal group but this was not statistically significant ($p=0.239$). Distribution of CCT values among different groups is shown in Figure 1. With regression analysis, a strong linear correlation between CCT and IOP was found in OHT group ($r=0.83$, $p=0.00$). No significant correlation was found in other groups ($p>0.05$ for each group) (Fig. 2, A–D). With correction of IOP values according to CCT values as described by Whitacre et al (11), 8 patients (33%)

TABLE I - DEMOGRAPHIC PROPERTIES, CCT, IOP VALUES AND REFRACTIVE STATUS OF THE STUDY POPULATION

	Control	OHT	PXG	POAG
CCT, µm	533.96±29.25	595.75±22.52	526.28±31.73	539.92±21.50
IOP, mmHg	15.58±2.40	23.04±1.27	17.55±4.87	15.88±3.53
No. (female/male)	50 (27/23)	24 (18/6)	25 (16/9)	26 (19/7)
Spherical equivalent, D	0.48±2.04	-0.23±1.93	-0.55±2.01	-0.49±2.03
Age, yr	47.98±13.81	50.37±11.47	69.12±7.90	60.38±9.65

Values are given as mean±SD.
CCT = Central corneal thickness; IOP = Intraocular pressure; OHT = Ocular hypertension; PXG = Pseudoexfoliative glaucoma; POAG = Primary open angle glaucoma; D = Diopters

who were diagnosed with OHT in our study showed IOP values 21 mmHg or lower. Graphically we have shown the mean IOP values in OHT group before and after correction of IOP according to the CCT (Fig. 3). Two of the patients falsely diagnosed with OHT, without any findings of optic nerve damage, had been treated for high IOP values measured by Goldmann applanation tonometer.

DISCUSSION

OHT is a cumbersome disease that may lead to loss of eye that should be followed up properly. Measurement of CCT is important in diagnosis and follow-up of OHT patients. Goldmann and Schmidt showed the effect of CCT on IOP values (3). However, significant changes in CCT were thought to occur solely in patients with keratoconus, keratoplasty, and scarred corneas. Johnson et al reported a case with CCT of 900 µm and IOP of 30 to 40 mmHg measured with Goldmann applanation tonometer, in whom IOP was 11 mmHg with manometric measurement (16). Ehlers et al accepted CCT of 520 µm as normal and assumed IOP measurements with Goldmann applanation tonometer at that CCT value to be accurate. In this regard, they found that each 10 µm deviation of CCT value from 520 µm leads to 0.7 mmHg deviation in the IOP value measured with applanation tonometer (9). According to this calculation, Copt et al, Shah et al, and Sobottka et al reclassified 56%, 35%, and 50% of OHT patients as normal (14, 15, 17). With cannulation study, Whitacre et al found that each 10 µm change in CCT causes a change of 0.18 to 0.23 mmHg in IOP measured with applanation tonometer (11). On the basis of this calculation, Sobottka et al reclassified 42% of patients with OHT as normal (17). By using this formula, we reclassified 8 of our 24 (33%) patients with OHT as normal. Doughty and Zaman found normal CCT to be 544 µm in a meta-analysis of 80 ultrasonic pachymeter studies. They concluded that every 10 µm deviation of CCT leads to 0.5 mmHg deviation of IOP (18).

Copt et al and Sobottka et al deduced that OHT patients had significantly higher CCT measurements than POAG patients and normal subjects. They measured CCT as 583 µm and 563 µm in OHT group and 552 µm and 524 µm in controls, respectively (14, 17). In our study, the OHT group had greater CCT values when compared to POAG, PXG, and control groups. The mean values of CCT in our OHT and control groups were 596 µm and 534 µm, respectively.

As we have shown in our study, normal subjects thought to have OHT due to their thick corneas may take treatment. The OHT study group found that higher IOP and thinner CCT measurement were important factors that predicted the development of POAG in OHT group. They concluded that CCT is a powerful predictor of POAG development in OHT patients (19).

In conclusion, IOP is an important parameter for diagnosis, follow-up, and treatment of glaucoma. CCT is a well-known parameter that affects IOP measurement, so CCT values should be measured in all patients with suspicion of OHT and glaucoma.

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