# The Impact of Central Corneal Thickness on Intraocular Pressure Measured by Non-Contact Tonometry

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***Objective:*** *To investigate the impact of central corneal thickness (CCT) on the intraocular pressure (IOP) measurement by non-contact tonometry (NCT).*
***Material and Method:*** *Eye examination data of normal volunteers aged between 18-96 years and intraocular pressure less than 22 mmHg were retrospectively reviewed. Subjects with possible conditions that affected the results of CCT and IOP measurement by NCT were excluded. The data of CCT and IOP measurements by NCT were obtained. Linear and multiple regression analysis were used to evaluate the influence of CCT and age on IOP measurement by NCT.*
***Results:*** *Four hundred and thirty seven eyes of 437 subjects were enrolled. The mean age was 49.05 ± 18.84 years. The average CCT was 524.56 ± 32.40 microns and the mean IOP measurement by NCT was 13.85 ± 2.81 mmHg. Linear regression model showed a significant negative correlation between CCT and subject age ($p < 0.001$), but had a positive correlation between CCT and IOP measurement by NCT ($p = 0.006$).*
***Conclusion:*** *CCT has a significant impact on IOP measurement by NCT. The finding suggests that CCT is an important parameter for interpretation of IOP measurement by NCT.*

***Keywords:*** *Central corneal thickness, Non-contact tonometry, Intraocular pressure*

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Glaucoma is a chronic eye disease characterized by loss of neural rim of the optic disc and retinal nerve fiber layer that usually has a corresponding visual field defect. The results from the Ocular Hypertension Treatment Study (OHTS) demonstrated that a central corneal thickness of less than 555 microns was one of the important risk factors for ocular hypertension patients developing primary open angle glaucoma[1]. Nevertheless, some studies have reported that glaucoma patients with thin central corneal thickness (CCT) were at a higher risk of developing glaucoma progression[2-4].

Goldmann applanation tonometry (GAT) has been the gold standard for intraocular pressure (IOP) measurement for decades. Many studies have demonstrated the influence of CCT on IOP measurement by GAT[5-10]. The impact of CCT on IOP measurement is a concern for glaucoma diagnosis and management. Non-contact tonometry (NCT) is an alternative IOP measurement method because it is easy to use and does not need special training. Thus, it is widely used as a screening tool for glaucoma. Nevertheless, NCT can decrease the potential risk of ocular infection and the transmission of prion proteins. The IOP measurements by NCT are highly correlated with GAT in both normal and glaucoma patients[8,10,11]. However, there are little data about the influence of CCT on IOP measurement by NCT.

The authors aimed to investigate the impact of CCT on IOP measurements by NCT. The finding should be valuable for glaucoma diagnosis and management.

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## Material and Method

Data of normal volunteers who had eye examinations between June 1, 2005 and May 31, 2006 of the Ophthalmology clinic, Songklanagarind Hospital were reviewed. The protocol of the present study was approved by the Hospital Ethic Committee. The inclusion criteria were normal patients aged between 18 and 96 years with a history of CCT and NCT examination. The exclusion criteria were intraocular

pressure over 21 mmHg, contact lens wearer, previous ocular surgery, glaucoma, corneal diseases, active ocular inflammation, and diabetes mellitus.

The subjects who were eligible for the present study underwent a complete eye examination. IOP was measured using NCT (Nidek NT 3000, Gamagori, Japan). The NCT had automatic alignment and focusing. When exact alignment was accomplished, the tonometer measured the IOP three times automatically and reported the IOP with an average value. CCT was measured by an experienced examiner using ultrasound pachymeter (Tomey SP-3000; Tomey Corp., Nagoya, Japan). Before measuring CCT, a drop of 0.5% tetracaine hydrochloride (Alcon, Fort Worth, Texas, USA) was applied. With the patient fixating on a distant object, the probe was gently applied to the corneal surface over the central pupillary area. The test was repeated five times and the pachymeter automatically calculated the mean CCT value.

Statistical analyses were performed to right eyes only to ensure independent observations. Linear regression and multiple regression analyses were performed with SPSS Version 13.0 (SPSS, Chicago, IL, USA) for Macintosh to explore the relationship between IOP measurement by NCT, CCT and subject age.

## Results

Four hundred and thirty-seven eyes of 437 subjects were enrolled in the present study. All subjects were Thai and 286 of the 437 (65.4%) subjects were female. The mean age was 49.05 $\pm$ 18.84 years (range 18-96 years). The mean intraocular pressure measured by a non-contact tonometer was 13.85 $\pm$ 2.81 mmHg (range 6-21 mmHg). The average central corneal thickness was 524.56 $\pm$ 32.40 microns (range 419-625 microns). There were no significant differences of mean age, IOP and CCT between genders ($p > 0.05$).

The linear regression analysis showed a significant negative correlation between subject age and CCT ($p < 0.001$) but no significant correlation between subject age and IOP measurement by NCT ($p = 0.127$). However, CCT was significantly correlated to IOP measurement by NCT. The equations are as follows:

$$CCT = 549.49 - 0.51 \times Age \text{ (Fig. 1)}$$
$$(\text{adjusted } R^2 = 0.09;\ p < 0.001)$$

$$IOP_{NCT} = 7.87 + 0.01 \times CCT \text{ (Fig. 2)}$$
$$(\text{adjusted } R^2 = 0.02;\ p = 0.006)$$

These equations implied that CCT decreased by 5.1 microns (95% CI -6.63, -3.53) for each 10-year increase in subject age and the IOP measurement by NCT changed by 0.1 mmHg (95% CI 0.03, 0.2) for every 10 microns of CCT change.

When multiple regression analysis was applied to evaluate the effect of CCT and subject age on IOP measurement by NCT, it showed a significant correlation. The equation is as follow:

$$IOP_{NCT} = 5.33 + 0.02 \times CCT + 0.02 \times Age$$
$$(\text{adjusted } R^2 = 0.03;\ p = 0.001, 0.013 \text{ respectively})$$

The equations demonstrated that IOP measurement by NCT changed by 0.2 mmHg (95% CI 0.06, 0.23) for every 10 microns of CCT change and

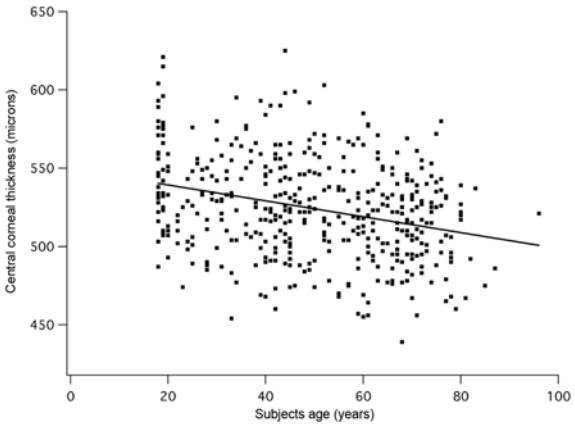


**Fig. 1** Scatter plot between CCT and subjects age, showing negative correlation

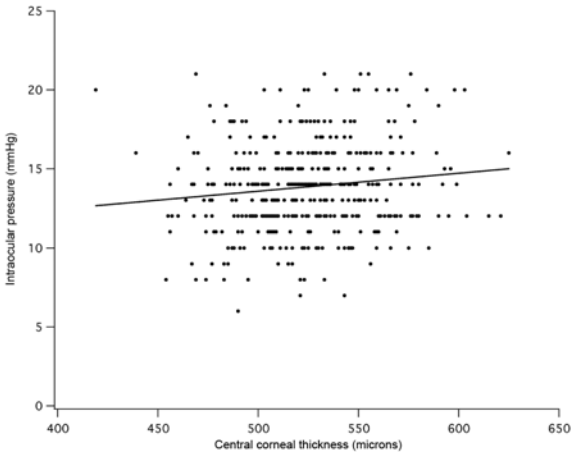


**Fig. 2** Scatter plot between IOP measured by NCT and CCT, showing positive correlation

changed by 0.2 mmHg (95% CI 0.04, 0.33) for every 10 years of change in the subjects' age.

## Discussion

There are several reports on the relationship between CCT and IOP measurements by GAT[5-10]. Some studies have also reported the relationship between CCT and IOP measurements by NCT. They found that IOP measurement by NCT changed by 0.22-0.63 mm Hg for every 10 microns of CCT change[8,10-12]. These numbers are greater than the authors' result (0.1 mm Hg for every 10 microns of CCT). The difference between the authors' result and previous studies may be affected by different NCT instruments and studied subjects. The understanding about the impact of CCT on IOP measurement by NCT can be beneficial for IOP determination for glaucoma screening and management.

The average CCT in the present study is 524.56 $\pm$ 32.40 microns, which is close to the result from a previous study in the Thai population by Ruangvaravate et al (529.58 $\pm$ 32.83 microns)[13] but slightly smaller than the result from a study by Lekskul et al (535.2 $\pm$ 29.9 microns)[14]. The result may be due to the difference of the subjects' ages between the present study and previous studies and the ethnicity of the subjects. The relationship between CCT and age is inconsistent. It depends on the age group studied, underlying diseases, and race[15-19]. Some of those reported a CCT increase with increased age in Caucasians[15,16,18]. Other studies found an association between increased CCT and diabetes mellitus[17,19]. On the other hand, the present study showed that CCT decreased with increased age, the result is similar to the previous studies especially those that studied subjects in the Asian population[14,20-22]. Although the linear regression analysis did not demonstrate a significant correlation between subject age and IOP measurement by NCT, a multiple regression model showed a significant correlation of CCT and subject age on IOP measurement by NCT. The finding might occur due to the influence of the subjects' age on CCT.

The limitation of the present study is that it is a retrospective study, lack of data in high IOP range (over 21 mmHg) and no glaucoma patient enrollment. These may affect the results.

## Conclusion

Although the present study enrolled subjects who had IOP in the normal range, the results showed a significant correlation between CCT and IOP measurement by NCT. The finding is an important implication for glaucoma diagnosis and management. It is essential for clinicians to know how much central corneal thickness affects the IOP measurement by NCT, thus clinicians can make an appropriate IOP determination.

## Potential conflicts of interest

None.

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## *ผลกระทบของความของหนาตรงกลางกระจกตาต่อความดันลูกตาโดยเครื่องวัดความดันลูกตาแบบไม่สัมผัส*

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***วัตถุประสงค์****: เพื่อศึกษากระทบของความหนาตรงกลางกระจกตาต่อความดันลูกตาโดยเครื่องวัดความดันลูกตาแบบไม่สัมผัส*

***วัสดุและวิธีการ****: ศึกษาย้อนหลังการตรวจตาในอาสาสมัครปกติอายุระหว่าง 18 ถึง 96 ปี และความดันลูกตาน้อยกว่า 22 มม.ปรอท คัดผู้มีภาวะผิดปกติซึ่งมีผลต่อการวัดความหนาตรงกลางกระจกตาและความดันลูกตาออก วิเคราะห์ข้อมูลความหนาตรงกลางกระจกตาและความดันลูกตาด้วยวิธี linear และ multiple regression ประเมินอิทธิพลของความหนาตรงกลางกระจกตาและอายุต่อความดันลูกตาวัดโดยเครื่องวัดความดันลูกตาแบบไม่สัมผัส*

***ผลการศึกษา****: 437 ตาของอาสาสมัคร 437 คน อายุเฉลี่ย 49.05 ± 18.84 ปี ความหนาตรงกลางกระจกตาเท่ากับ 524.56 ± 32.40 ไมครอน และค่าเฉลี่ยความดันลูกตาวัดโดยเครื่องวัดความดันลูกตาแบบไม่สัมผัสเท่ากับ 13.85 ± 2.81 มม.ปรอท linear regression แสดงความสัมพันธ์เชิงลบอย่างมีนัยสำคัญระหว่างความหนาตรงกลางกระจกตาและอายุ ($p < 0.001$) แต่มีความสัมพันธ์เชิงบวกอย่างมีนัยสำคัญระหว่างความหนาตรงกลางกระจกตาและความดันลูกตา ($p = 0.006$)*

***สรุป****: ความหนาตรงกลางกระจกตามีผลกระทบอย่างมีนัยสำคัญต่อการวัดความดันลูกตาโดยเครื่องวัดความดันลูกตาแบบไม่สัมผัส ผลการศึกษานี้เสนอแนะว่าความหนาตรงกลางกระจกตาเป็นปัจจัยสำคัญในการแปลผลค่าความดันลูกตาโดยเครื่องวัดความดันลูกตาแบบไม่สัมผัส*