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Tzu Chi Medical Journal

Original Article

Measurements of Intraocular Pressure with Tono-Pen and Goldmann Applanation Tonometers in Subjects with Systemic Illness

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Article info

Article history:
Received: April 19, 2007
Revised: May 19, 2007
Accepted: June 15, 2007

Keywords:
Corneal thickness
Intraocular pressure
Tonometer

Abstract

Objective: The purpose of this preliminary study was to compare differences in the measurement of intraocular pressure (IOP) between Tono-Pen tonometry and Goldmann applanation tonometry (GAT) in healthy individuals and those with coexisting illnesses.

Patients and Methods: This prospective study included 42 individuals who were further categorized into two groups. Group 1 consisted of 20 healthy individuals and group 2 contained 22 participants who had various systemic illnesses such as congestive heart failure, chronic bronchitis, uremia, liver cirrhosis and cerebral ischemia stroke. One eye of each of the 42 participants was randomly selected and the IOP was measured with the Tono-Pen and GAT. In addition, the central corneal thickness (CCT), axial length (AL) and keratometric power (K) were measured in the same eyeball of each participant.

Results: There was no significant difference in the IOP values between the Tono-Pen and GAT in these two groups ($p>0.05$). The average IOP values in the healthy individuals were 14.5 ± 3.5 and 13.7 ± 3.4 mmHg with the Tono-Pen and GAT, respectively. The IOP values in the subjects with coexisting systemic illnesses were 13.8 ± 2.9 and 13.1 ± 3.2 mmHg with the Tono-Pen and GAT, respectively. The IOP values were positively correlated with CCT with both the Tono-Pen (group 1, $p=0.042$; group 2, $p=0.039$) and GAT (group 1, $p=0.020$; group 2, $p=0.015$). There were no significant differences in the age of subjects, AL or K ($p>0.05$) in these two groups.

Conclusion: In our preliminary study, the IOP values were positively correlated with the CCT with Tono-Pen tonometry and GAT in these two groups. The IOP values were not significantly different between the Tono-Pen and GAT in the subjects with systemic illness. (*Tzu Chi Med J* 2007;19(4):241–244)

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1. Introduction

Intraocular pressure (IOP) measurement is a regular and important part of ocular examinations. Goldmann applanation tonometry (GAT) is a commonly used tool for IOP measurement [1–3], although there is still some controversy in factors such as axial length (AL) and keratometric power (K) when measuring IOP with a tonometer [4–7].

Precision IOP measurement requires cooperation from subjects. Sometimes, a patient is not able to cooperate with GAT procedures because of a coexisting illness. Tono-Pen tonometry, utilizing a small-size transducer tip, gently makes contact with the cornea, and displays the average IOP measurements quickly and easily. It might be considered a suitable tool for IOP measurements in patients who cannot cooperate properly with the GAT method. Therefore, in this preliminary study, we compared the differences in IOP measurements between the Tono-Pen and GAT in a group of healthy individuals and a group with coexisting systemic illnesses.

2. Patients and methods

This prospective study included 42 individuals who were further categorized into two groups. Group 1 (the control group) consisted of 20 healthy individuals and group 2 (the experimental group) contained 22 participants who had various coexisting systemic illnesses. In group 2, four participants had congestive heart failure, four had chronic bronchitis, four had uremia with regular hemodialysis, four had liver cirrhosis and six had cerebral ischemic stroke. None of the patients in group 2 were bedridden. Individuals with dry eye syndrome, collagen disease, allergy, glaucoma, or previous intraocular inflammation and those who took medication such as anticholinergics or β2-antagonists were excluded from the study. All 22 participants in group 2 had been regularly followed-up in the internal medicine clinic of Buddhist Tzu Chi General Hospital, Hualien, for at least 3 months.

One eye of each of the 42 participants was randomly selected, and the IOPs were measured with the Tono-Pen and GAT. In addition, an experienced technician was assigned to measure the central corneal thickness (CCT), AL and K in the same eyeball.

The IOP measurements with the Tono-Pen (Tono-Pen® XL applanation tonometer; Medtronic, Jacksonville, FL, USA) and GAT (Goldmann AT 900/870, Haag-Streit, Switzerland) were further analyzed and the influence of subject age, CCT and K were also investigated. The study was approved by the institute's committee on human research.

Complete ocular examination included anterior segment and anterior vitreous examination by slit-lamp biomicroscopy and posterior vitreous, disc, and macula examination by slit-lamp biomicroscopy with a 90-D lens. Patients with abnormal anterior segments, significant macular lesions or abnormal disc morphology were excluded from this study. The K (3 times), AL (10 times) and CCT (5 times) were measured by the AutoRefractoKeratometer (ARK-700; Nidek, Gamagori, Japan), the A-scan (OcuScan RxP; Alcon, Fort Worth, TX, USA), and an ultrasonic pachymeter (OcuScan RxP; Alcon), respectively. The mean values were recorded and statistically examined.

The IOP values were measured three times and averaged for each eye for both the Tono-Pen and GAT. We used a Tono-Pen first and then GAT. Prior to the measurement, the cornea was anesthetized with one drop of 0.5% proparacaine hydrochloride (Alcaine; Alcon Pharma, Puurs, Belgium) instilled in each eye and the subject asked to close the eye for 5 minutes. The same ophthalmologist took the IOP measurements with the Tono-Pen and GAT, and an experienced operator measured the K, AL and CCT.

During IOP measurement, a disposable tip diaphragm was used with the Tono-Pen; 70% isopropyl alcohol was used to clean the probe, which was then dried properly when using GAT. The portable, handheld Tono-Pen, utilizing a 1.5-mm transducer tip, gently made contact with the cornea, and displayed the average of four independent measurements. When using GAT, a fluorescein strip was stained on the ocular surface of the inferior fornix and the patient was asked to blink several times before measurement to ensure a proper thickness of fluorescein rings.

Statistical analyses were performed using SPSS (SPSS Inc., Chicago, IL, USA). The subjects' age, CCT, AL and K were entered as independent variables, and the measurements from the Tono-Pen and GAT as dependent variables. The correlations were analyzed by regression analysis and a p value lower than 0.05 was considered significant. Variability was described by assessing the coefficient of variation. The IOP values between Tono-Pen tonometry and GAT were evaluated by the Wilcoxon two-sample test; a p value lower than 0.05 was considered significant.

3. Results

The mean age in group 1 was 59.2±15.8 years (range, 22–76 years). The average values of CCT, AL, K were 536.4±37.6 μm (range, 475–580 μm), 23.80±0.45 mm (range, 21.72–25.50 mm), and 43.32±1.88 diopters (D) (range, 41.50–46.50 D), respectively. The average IOP values in group 1 were 14.5±3.5 mmHg (range, 8.7–20.0 mmHg) with the Tono-Pen and 13.7±3.4 mmHg (range, 7.0–19.5 mmHg) with GAT (Table 1). The data in group 2 are also shown in Table 1.

Table 1 — Age, central corneal thickness (CCT), axial length (AL), keratometric power (K) and intraocular pressure (IOP) in the two groups

	Group 1 (healthy subjects)	Group 2 (various coexisting diseases)	p^*
Age (yr)	59.2±15.8 (22–76)	61.3±16.5 (28–85)	0.214
CCT (μm)	536.4±37.6 (475–580)	531.0±34.2 (472–576)	0.322
AL (mm)	23.80±0.45 (21.72–25.50)	23.44±0.36 (21.75–25.20)	0.246
K (D)	43.32±1.88 (41.50–46.50)	43.45±1.93 (42.00–46.50)	0.462
IOP (mmHg)			
Tono-Pen	14.5±3.5 (8.7–20)	13.8±2.9 (8.7–18.0)	0.232
GAT	13.7±3.4 (7.0–19.5)	13.1±3.2 (8.8–17.5)	0.448

*Wilcoxon two-sample test. GAT = Goldmann applanation tonometer.

Table 2 — Correlations between intraocular pressure (IOP) and age, central corneal thickness (CCT), axial length (AL) and keratometric power (K) in group 1

IOP	p^*			
	Age	CCT	AL	K
Tono-Pen	0.441	0.042†	0.216	0.385
GAT	0.568	0.020†	0.248	0.389

*Regression analysis; †$p<0.05$. GAT=Goldmann applanation tonometer.

Table 3 — Correlations between intraocular pressure (IOP) and age, central corneal thickness (CCT), axial length (AL) and keratometric power (K) in group 2

IOP	p^*			
	Age	CCT	AL	K
Tono-Pen	0.409	0.039†	0.208	0.306
GAT	0.576	0.015†	0.252	0.288

*Regression analysis; †$p<0.05$. GAT=Goldmann applanation tonometer.

The IOP values were not significantly different between Tono-Pen tonometry and GAT in both group 1 ($p=0.378$) and group 2 ($p=0.245$). Furthermore, there were no significant differences in age ($p=0.214$), CCT ($p=0.322$), AL ($p=0.246$) and K ($p=0.462$) between groups. The IOP values were not significantly different between groups with the Tono-Pen ($p=0.232$) or GAT method ($p=0.448$) (Table 1).

It is noteworthy that in both groups, the IOP values were positively correlated with CCT when using the Tono-Pen (group 1, $p=0.042$; group 2, $p=0.039$) and GAT (group 1, $p=0.020$; group 2, $p=0.015$). No significant correlation existed between the IOP values and other variables including age, AL and K with either the Tono-Pen or GAT in both group 1 and group 2 ($p > 0.05$) (Tables 2 and 3).

4. Discussion

It has been suggested that the portable Tono-Pen technique might be a simple, alternative tool for IOP measurement in a select population. The reliability and validity of the Tono-Pen technique in comparison to GAT in measuring IOP in certain populations have not been examined critically. Therefore, this study was conducted to analyze potential differences between the Tono-Pen and GAT in the measurement of IOP in patients with coexisting illnesses.

IOP measurements, whether using the Tono-Pen or GAT, all cause a defined amount of deformation of the cornea (8). In other words, the thicker the cornea the higher the force needed to bend it. However, the influence of corneal thickness on the accuracy of IOP values has been reported previously and those studies proved a positive correlation between IOP measurements and CCT (9–10). In our study, the IOP values were also positively correlated with CCT with both the Tono-Pen and GAT and in both groups.

The relationships among the IOP measurements, AL values and K values still remain controversial, as in previous reports (4–6). In this study, the IOP value was not significantly influenced by the subject's age, AL or K with either the Tono-Pen or GAT. There was a bigger difference in the variability when applying GAT (coefficient of variation, CV: 24.4%) to measure the IOP in the group with coexisting diseases than when applying the Tono-Pen (CV: 21.0%).

In this preliminary study, we found no significant differences between the two tonometers, in group 1 or group 2. In general, the Tono-Pen might be considered an alternative tool to measure the IOP in a certain population who cannot cooperate and sit properly during the GAT procedure because of physical rigidity or a poor performance status caused by coexisting systemic illnesses. In our study, we used the Wilcoxon two-sample test to analyze the difference in IOP measurement between tonometers and between groups due to the limited case numbers. Further investigation of this issue is warranted.

Acknowledgments

The authors wish to thank Barry Lee Reynolds, a native English-speaking editor (Lecturer, Department of Foreign Languages, National Chiayi University, Chiayi, Taiwan) for English revision.

References

1. Bhan A, Browning AC, Shah S, Hamilton R, Dave D, Dua HS. Effect of corneal thickness on intraocular pressure measurements with the pneumotonometer, Goldmann applanation tonometer and Tono-Pen. *Invest Ophthalmol Vis Sci* 2002;43:1389–92.
2. Brandt JD, Beiser JA, Kass MA, Gordon MO. Central corneal thickness in the Ocular Hypertension Treatment Study (OHTS). *Ophthalmology* 2001;108:1779–88.
3. Pache M, Wilmsmeyer S, Lautebach S, Funk J. Dynamic contour tonometry versus Goldmann applanation tonometry: a comparative study. *Graefe's Arch Clin Exp Ophthalmol* 2005;243:763–7.
4. Sihota R, Tuli D, Dada T, Gupta V, Sachdeva MM. Distribution and determinants of intraocular pressure in a normal pediatric population. *J Pediatr Ophthalmol Strabismus* 2006;43:14–8.
5. Lee AJ, Saw SM, Gazzard G, Cheng A, Tan DT. Intraocular pressure associations with refractive error and axial length in children. *Br J Ophthalmol* 2004;88:5–7.
6. Morgan AJ, Harper J, Hosking SL, Gilmartin B. The effect of corneal thickness and corneal curvature on pneumatonometer measurements. *Curr Eye Res* 2002;25: 107–12.
7. Goldmann H, Schmidt T. Uber applanationstonometrie. *Ophthalmologica* 1957;134:221–42.
8. Liu J, Roberts CJ. Influence of corneal biomechanical properties on intraocular pressure measurement: quantitative analysis. *J Cataract Refract Surg* 2005;31: 146–55.
9. Zadok D, Tran DB, Twa M, Carpenter M, Schanzlin DJ. Pneumotonometry versus Goldmann tonometry after laser *in situ* keratomileusis for myopia. *J Cataract Refract Surg* 1999;25:1344–8.
10. Hsu SY, Hsu YC, Tsai RK, Lin CP. Intraocular pressure change after laser *in situ* keratomileusis (LASIK). *Kaohsiung J Med Sci* 2005;21:149–52.