Original Article

Comparison of Intraocular Pressure Measurement between Non-Contact and Goldmann Applanation Tonometry among Glaucoma Patients in Ratchaburi Hospital

Supaporn Trakanwitthayarak, MD[1]

[1] Department of Ophthalmology, Ratchaburi Hospital, Ratchaburi, Thailand

Objective: To compare the intraocular pressure (IOP) values acquired from the non-contact tonometers and a Goldmann applanation tonometer in glaucoma patients.

Materials and Methods: The present study included 300 eyes from 150 participants that attended the glaucoma outpatient clinic. The IOP was measured using both non-contact tonometry (NCT) and Goldmann applanation tonometry (GAT). The differences in IOP readings between the two techniques were evaluated.

Results: The mean IOP as measured by NCT was 16.26±6.95 mmHg, when that of measured by GAT was 16.11±8.43 mmHg. The mean difference between the two techniques of measurement was 0.147±3.01 mmHg. The values acquired from NCT were slightly higher than those acquired by GAT in 49% of patients, and this difference was more distinct when the IOP as measured by GAT more than 21 mmHg.

Conclusion: There was no statistically significant correlation in the measurement of IOP between non-contact and GAT tonometers. NCT is a proper method for mass screenings of IOP even if the IOP measurement by NCT is slightly higher than by GAT.

Keywords: Tonometry, Comparison, Glaucoma, Non-contact tonometry, Goldmann applanation tonometer

Received 18 Jun 2019 | Revised 16 Sep 2019 | Accepted 18 Sep 2019

J Med Assoc Thai 2020;103(8):819-23
Website: http://www.jmatonline.com

Glaucoma is a chronic, progressive optic neuropathy, which is characterized by ganglion cell loss, cupping of the optic disc, and visual field defects[1]. Glaucoma is the second leading cause of irreversible blindness worldwide[2]. The global prevalence of glaucoma for population aged 40 to 80 years is 3.54% in 2020[3]. In 2013, the number of people with glaucoma worldwide was estimated to be 64.3 million, increasing to 76.0 million in 2020, and 111.8 million in 2040[3]. Screening for glaucoma is based on an intraocular pressure (IOP) of more than 21 mmHg[4]. Higher IOP levels are associated with the progression of damage the optic nerve and irreversible visual loss[5]. Therefore, IOP is the most important and only modifiable risk factor[6]. Reduction of IOP is the best, and only evidence-based, treatment modality[7]. IOP measurement by tonometry is essential in ophthalmological assessment[8]. The accurate IOP measurement has a very important role in diagnosis and management of glaucoma. The Goldmann applanation tonometry (GAT) is still the gold standard for the measurement of IOP and is used in all major randomized glaucoma clinical trials[9,10]. Applanation tonometry is based on the Imbert-Fick principle and is performed with the patient seated at the slit lamp[11,12].

Air-puff tonometry is an applanation method using a standardized puff of air to flatten the cornea. This method has the advantages that no topical anesthetic or risk of corneal abrasion is involved[13], the risk of transmitting infectious agents from one eye to another via the tonometer tip is eliminated,

Correspondence to:

Trakanwitthayarak S.

Department of Ophthalmology, Ratchaburi Hospital, 85 Somboon Kun Road, Na Muang, Muang, Ratchaburi 70000, Thailand.

Phone: +66-32-719600

Email: toonoph@gmail.com

How to cite this article:

Trakanwitthayarak S. Comparison of Intraocular Pressure Measurement between Non-Contact and Goldmann Applanation Tonometry among Glaucoma Patients in Ratchaburi Hospital. J Med Assoc Thai 2020;103:819-23.

doi.org/10.35755/jmedassocthai.2020.08.10279

and it is either non-portable or portable[14]. This study aimed to compare the IOP measurements by means of the two different tonometers that are routinely used in glaucoma clinic, the GAT and the non-contact tonometry (NCT).

Materials and Methods

The retrospective study was done in the outpatient glaucoma clinic of Ratchaburi Hospital. The study received approval by the Ethical Committee of the Director of Ratchaburi Hospital. Three hundred eyes of 150 patients (72 females, 78 males) between July and December 2018 were included. All patients were diagnosed with glaucoma on the basis of disc appearance and visual field change by a glaucoma specialist, with the majority diagnosed with primary open-angle glaucoma (OAG), narrow-angle glaucoma, neovascular glaucoma (NVG), and normal tension glaucoma. The present research was performed according to the Declaration of Helsinki, The Belmont Report, the Council for International Organizations of Medical Sciences (CIOMS) Guideline, and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP).

Inclusion criteria included patients aged 18 years or older, diagnosis of glaucoma (OAG, angle closure glaucoma [ACG], NVG, or secondary glaucoma), no use of contact lenses, no ocular surface disease, no significant degree of corneal astigmatism, no ocular pathology such as retinal disease and no connective tissue disease, no uncooperative patients in the measurement of IOP by either method, and no history of refractive surgery.

Technique

Each patient's IOP was measured in a sitting position using both NCT and GAT tonometer, and the difference in IOP values via the two techniques was calculated. The NCT were performed by an experienced technician and the GAT were performed in another room by an ophthalmologist in a masked fashion (GAT calibration was confirmed prior to the study). The NCT tonometer used was a Tomey FT-1000 (Tomey Corporation, Japan). The IOP assessment with the GAT was regularly following with the Tomey FT-1000 (Tomey Corporation, Japan) to prevent bias from decreasing of measured IOP caused by applanation. The observer was masked to the measured IOP acquired by NCT. For the GAT, the applanation tonometry is based on the Imbert-Fick principle, which states that a perfect sphere has its internal pressure equally distributed and that the external force needed to flatten a known area of that sphere is directly proportional to the internal pressure of the sphere. The applanation diameter was 3.06 mm and performed with the patient seated at the slit lamp[11,12]. The applanation tonometry was performed with the Goldmann applanation device fixed on slit-lamp biomicroscope and the eyes were anesthetized using 0.5% tetracaine hydrochloride eye drops and fluorescein strip was applied to the inferior conjunctival fornix for a few seconds. The ophthalmologist took measured GAT using the cobalt blue adjust the biomicroscope. The tonometer was dialed to the '1' position and the knob adjusted until the usual end point was applanating the cornea. One 'best' reading was taken to reduce the effect of multiple applanations causing disruption of the ocular surface and the potential for GAT to displace aqueous from the anterior chamber, falsely lowering IOP values[15]. The collected data were classified into two groups according to the IOP measurements by GAT and NCT tonometer with group 1 having an IOP of less than 21 mmHg, and group 2 having an IOP of 21 or greater. The different IOP values between the two methods was assessed for each patient in each group. The data were classified according to the patients' laterality (right and left eyes)[16].

Table 1. Demographic data of glaucoma patients (n=150)

Characteristic	Mean±SD (range)
Age (years)	64.56±11.57 (33 to 87)
Sex: male/female; n (%)	78 (52)/72 (48)
Central corneal thickness (μm)	513.15±28.63 (414 to 572)
Diagnosis; n (%)	
Primary open angle glaucoma	74 (49.3)
Normal tension glaucoma	31 (20.7)
Primary angle closure glaucoma	26 (17.3)
Secondary glaucoma	19 (12.7)

SD=standard deviation

Statistical analysis

The data were analyzed using PASW Statistics software, version 18.0 (SPSS Inc., Chicago, IL, USA). The paired t-test was used and a p-value less than 0.05 was considered statistically significant.

Results

The data were collected from the 300 eyes (150 patients) (Table 1) in the present study. The mean IOP value as measured by NCT tonometer was 16.26±6.95

Table 2. Mean intraocular pressure values for study participants, as measured by non-contact tonometer and Goldmann applanation tonometer

IOP measure	IOP Mean±SD
GAT (mmHg)	16.11±8.43
NCT (mmHg)	16.26±6.95
p-value	0.399

IOP=intraocular pressure; GAT=Goldmann applanation tonometer; NCT=non-contact tonometer; SD=standard deviation

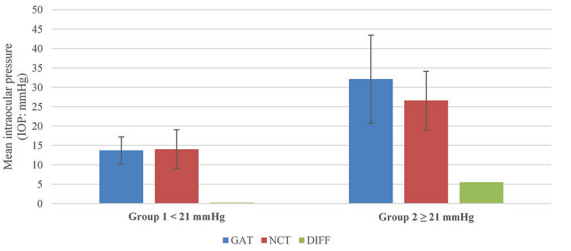
Table 3. Intraocular pressure values measured by non-contact tonometer as related to those measured by Goldmann applanation tonometer

IOP measurement by NCT	Patients (%)	Right eyes (%)	Left eyes (%)
Below GAT measurement	13	10.7	16
Equal GAT measurement	38	40.7	34.7
Above GAT measurement	49	48.6	49.3

IOP=intraocular pressure; GAT=Goldmann applanation tonometer; NCT=non-contact tonometer

mmHg (range 5 to 55 mmHg) (Table 2). The mean IOP value for all patients as measured by GAT was 16.11±8.43 mmHg (range 7 to 56 mmHg) (Table 2). The mean difference of IOP readings between GAT and NCT tonometer measurements was 0.147±3.01 mmHg (range 0.195 to 0.488 mmHg). The difference in IOP values between the two methods was not statistically significant (p=0.399) (Table 2). In 49% of the patients, the measured IOP by NCT tonometer was higher than that measured by GAT (Table 3).

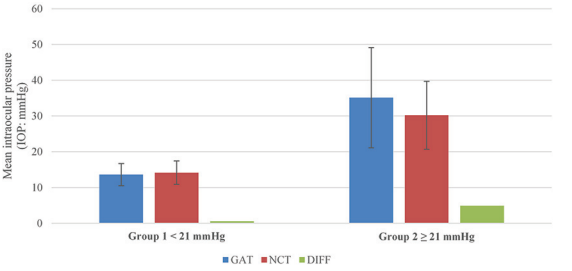
The study showed that IOP values measured with an NCT tonometer were slightly higher than those measured with GAT in Group 1 where the IOP were less than 21 mmHg (Figure 1, 2), and this difference in IOP values was not statistically significant (p=0.151). However, the measured IOPs by NCT were lower than those measured with GAT in Group 2 where the IOP values were 21 mmHg or more. This difference in IOP values was statistically significant (p=0.016).



	Group 1	Group 2
GAT	13.74±3.47	32.10±11.37
NCT	14.03±5.05	26.58±7.54
DIFF	0.29	5.52

Figure 1. Right eyes: mean intraocular pressure (IOP; ±SD) as measured by GAT. Mean intraocular pressure (IOP) as measured by NCT. The difference (DIFF) between two values according to two groups: Group 1 <21 mmHg, Group 2 ≥21 mmHg.

Group 1 IOP <21 mmHg, this difference IOP values was not statistically significant (p=0.151); Group 2 IOP ≥21 mmHg, this difference in IOP values was statistically significant (p=0.016).



	Group 1	Group 2
GAT	13.60±3.10	35.12±14.03
NCT	14.14±3.27	30.21±9.51
DIFF	0.54	4.91

Figure 2. Left eyes: mean intraocular pressure (IOP; ±SD) as measured by GAT. Mean intraocular pressure (IOP) as measured by NCT. The difference (DIFF) between two readings according to two groups: Group 1 <21 mmHg, Group 2 ≥21 mmHg.

Group 1 IOP <21 mmHg, this difference IOP values was not statistically significant (p=0.151); Group 2 IOP ≥21 mmHg, this difference in IOP values was statistically significant (p=0.016).

Discussion

IOP is the most important and only modifiable risk factor in glaucoma patients[6]. Therefore, IOP measurement by tonometry is essential in assessment. NCT and GAT tonometers are the most common devices for IOP measurement in daily practice. GAT consists of a double prism fixed on a slit lamp, while NCT tonometers are easier to use, portable, and more convenient for both the patient and the examiner than GAT. Therefore, NCT is a proper device for mass IOP screenings. Nowadays, there is an increasing use in the medical community, especially in outpatient clinics. The IOP measurement by NCT were slightly higher than by GAT. So, there were suspicion regarding the acceptance of all NCT tonometer readings.

This study showed there was no significant difference in measurements of IOP between GAT and NCT tonometers. NCT false-high readings are common if patients tighten their eyelids[17]. Yildiz et al showed that the mean GAT (16.08±3.00, range 10 to 24), NCT (16.42±2.80, range 10 to 24), and both IOP values were similar to the present study[17].

The IOP readings derived from NCT tonometer were higher than those acquired from GAT in 49% of the patients in the present study. Farhood found 74% of the patients were measured higher by NCT tonometry[15]. Martinez-de-la-Casa et al[18] compared IOP measurements obtained by GAT and non-contact tonometer and found that the mean GAT measurement was lower than the mean non-contact tonometer measurement[18]. The difference in readings between the two instruments increased when the GAT measurement of IOP exceeded 21 mmHg[15], which correspond to the present study. Rao et al, found that the IOP readings were more accurately measured by NCT when the IOP was less than 20 mmHg[19]. Lagerlöf showed that measurements by a non-contact tonometer were found to be unreliable between 20 and 30 mmHg[20]. Tonnu et al[21] showed that the mean difference in IOP between GAT and NCT tonometer measurements was 0.7 mmHg, which was different with the present study (0.3 to 0.4 mmHg).

From the present study, the difference in IOP values between the two techniques increased when the GAT measurement of IOP exceeded 21 mmHg, while the NCT readings were mostly lower than GAT in the high IOP patients group. The previous studies did not mention that the NCT readings were lower than GAT in the high IOP patients group. The present study showed that the lower the IOP as measured by GAT, the more reliable the corresponded readings made with NCT tonometer[15].

The main advantages of non-contact tonometers are non-invasive and easier to use than GAT since there is no need for topical anesthesia or fluorescein. Hence, there is minimum risk of infection, no risk of corneal abrasion, and more comfortable than GAT tonometers. When the examiner repeated the measurements, NCTs did not reduce IOP (unlike the corneal pressure effect that occurs with GAT tonometers). The IOP screening with a non-contact tonometer may be performed by an ophthalmic assistant without supervision of an ophthalmologist. A disadvantage is that when readings by NCT tonometer are abnormally high, the readings should be rechecked and repeated with another tonometry device before giving an opinion or a final diagnosis.

Conclusion

There was no statistically significant correlation in the measurement of IOP between non-contact and GAT tonometers. NCT is a proper method for mass screenings of IOP. Although IOP measurements by NCT are slightly higher than by GAT.

What is already known on this topic?

NCT can be used as a screening tool for community practices.

What this study adds?

NCT can be used instead of GAT in normotensive population but is unreliable in the patient with higher IOP range.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Quigley HA, Hohman RM, Addicks EM, Massof RW, Green WR. Morphologic changes in the lamina cribrosa correlated with neural loss in open-angle glaucoma. Am J Ophthalmol 1983;95:673-91.
2. Quigley HA. Number of people with glaucoma worldwide. Br J Ophthalmol 1996;80:389-93.
3. Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence of glaucoma and projections of glaucoma burden through 2040: a systematic review and meta-analysis. Ophthalmology 2014;121:2081-90.
4. Simmons ST. 2007-2008 Basic and clinical science course. Section 10. Glaucoma: Practicing ophthalmologists curriculum. San Francisco, CA: American Academy of Ophthalmology; 2007.
5. Fernandes P, Diaz-Rey JA, Queiros A, Gonzalez-Meijome JM, Jorge J. Comparison of the ICare rebound tonometer with the Goldmann tonometer in a normal population. Ophthalmic Physiol Opt 2005;25:436-40.
6. Kass MA, Heuer DK, Higginbotham EJ, Johnson CA, Keltner JL, Miller JP, et al. The Ocular Hypertension Treatment Study: a randomized trial determines that topical ocular hypotensive medication delays or prevents the onset of primary open-angle glaucoma. Arch Ophthalmol 2002;120:701-13.
7. Nakamura Y, Ishikawa S, Nakamura Y, Sakai H, Henzan I, Sawaguchi S. 24-hour intraocular pressure in glaucoma patients randomized to receive dorzolamide or brinzolamide in combination with latanoprost. Clin Ophthalmol 2009;3:395-400.
8. Topouzis F, Founti P. Weighing in ocular perfusion pressure in managing glaucoma. Open Ophthalmol J 2009;3:43-5.
9. Kniestedt C, Punjabi O, Lin S, Stamper RL. Tonometry

through the ages. Surv Ophthalmol 2008;53:568-91.
10. Goldmann H, Schmidt T. Applanation tonometry. Ophthalmologica 1957;134:221-42.
11. Fleming J. Anterior segment evaluation: Applanation tonometrics. In: Benjamin WJ, Borish IM, editors. Borish's clinical refraction. 2nd ed. St. Louis, MO: Butterworth- Heinemann; 2006. p. 501-3.
12. Jampel H. Intraocular pressure and tonometry. In: Morrison JC, Pollack IP, editors. Glaucoma science and practice. New York, NY: Thieme Medical Publishers; 2003. p.57-69.
13. Crick RP, Khaw PT. Disorders associated with the level of intraocular pressure. In: Crick RP, Khaw PT, editors. A textbook of clinical ophthalmology: A practical guide to disorders of the eyes and their management. 3rd ed. Singapore: World Scientific; 2003. p. 547-84.
14. Kanski JJ, Bowling B. Clinical ophthalmology: A systematic approach. 7th ed. Edinburgh: Elsevier Saunders; 2011.
15. Farhood QK. Comparative evaluation of intraocular pressure with an air-puff tonometer versus a Goldmann applanation tonometer. Clin Ophthalmol 2013;7:23-7.
16. Vincent SJ, Vincent RA, Shields D, Lee GA. Comparison of intraocular pressure measurement between rebound, non-contact and Goldmann applanation tonometry in treated glaucoma patients. Clin Exp Ophthalmol 2012;40:e163-70.
17. Yildiz A, Yasar T. Comparison of Goldmann applanation, non-contact, dynamic contour and tonopen tonometry measurements in healthy and glaucomatous eyes, and effect of central corneal thickness on the measurement results. Med Glas (Zenica) 2018;15:152-7.
18. Martinez-de-la-Casa JM, Jimenez-Santos M, Saenz-Frances F, Matilla-Rodero M, Mendez-Hernandez C, Herrero-Vanrell R, et al. Performance of the rebound, noncontact and Goldmann applanation tonometers in routine clinical practice. Acta Ophthalmol 2011;89:676-80.
19. Rao BS. Clinical evaluation of the non-contact tonometer and comparison with Goldmann applanation tonometer. Indian J Ophthalmol 1984;32:432-4.
20. Lagerlöf O. Airpuff tonometry versus applanation tonometry. Acta Ophthalmol (Copenh) 1990;68:221-4.
21. Tonnu PA, Ho T, Sharma K, White E, Bunce C, Garway-Heath D. A comparison of four methods of tonometry: method agreement and interobserver variability. Br J Ophthalmol 2005;89:847-50.