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Original Article

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Comparing intraocular pressures with different types of tonometers and its correlation with central corneal thickness in patients presenting in a tertiary care centre

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Abstract

***Background & Aims*:** Glaucoma usually undiagnosed in general population. People usually ignores the symptoms and came late when disease already get worsened. This study aimed to compare intraocular pressures in general population having inclusion criteria with different types of tonometers and its correlation with central corneal thickness in patients presenting in OPD at Ophthalmology Department of Sir T hospital, Bhavnagar, Gujarat.

Materials & Methods: In this Hospital based cross-sectional observational study with 9-month duration, 72 patients between the ages of 30–75 years were evaluated, after taking into consideration the inclusion and exclusion criteria. Detailed history taken including chief complaints, past history, family history, personal history followed by general and systemic examination. 72 patients having inclusion exclusion criteria were analyzed with three different tonometers (Goldmann applanation, Non-contact tonometer (NCT), Schiotz tonometer), and the correlation between each other were measured. Then central corneal thickness is measured with OCT Tomography, and the results were compared to intraocular pressure (IOP).

***Results*:** When compared to the non-contact tonometer, we found that the Schiotz tonometer had the highest correlation. These associations were also seen in people with diabetes and hypertension. Nonetheless, as patients age, there is a corresponding rise in the correlation between the gold standard approach and the tonometer.

***Conclusion*:** All the tonometer showed significant correlation with the gold standard technique (Goldmann applanation tonometer), over a range of intra ocular pressure, between the ages of 30 -75 years, in diabetics and hypertensive patients, and in the patients with different CCT values.

***Keywords*:** Central Corneal Thickness, Diabetes Mellitus, Hypertension, Goldmann Applanation Tonometer, Intra Ocular Pressure, Non-Contact Tonometer

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Introduction

The most common cause of permanent blindness worldwide is glaucoma. According to 1995 estimates from the WHO, glaucoma is the cause of blindness in 5.1 million individuals (1). Glaucoma, which affects 70 million people globally, is the second most common cause of blindness (2). The global prevalence of glaucoma in persons between the ages of 40 and 80 is 3.54 percent, and experts predict that by the year 2040, there will be 111.8 million cases worldwide (3,4).

One of the main causes of irreversible bilateral blindness is glaucoma. Its prevalence in India is thought to be between 3 and 4 percent (5). There have been efforts to develop screening techniques for the early diagnosis of the condition since early detection and therapy may delay the rate of visual field loss and subsequent blindness (6,7).

Ocular health and illness are fundamentally influenced by intraocular pressure. In addition to helping with glaucoma diagnosis and treatment, intraocular pressure is crucial for gauging how all intraocular surgical procedures will progress postoperatively.

The primary goal of glaucoma treatment is to reduce intraocular pressure (IOP). The target IOP is frequently established at a level of 20–30% IOP reduction, with significant IOP reductions of more than 30–40% necessary in situations of advanced glaucoma.[8] The only known modifiable risk factor that has been shown to reduce both glaucoma and ocular hypertension progression is IOP. IOP monitoring is crucial for primary open angle glaucoma diagnosis and treatment (1,6,7).

From the first computerized tension measurements to indentation tonometry, applanation tonometry, and noncontact tonometry, clinical measurement of IOP has seen a number of technological advancements (NCT).

IOP measures are known to be affected by central corneal thickness (CCT) assessments. Conversely, a thinner cornea is simpler to flatten than a thicker one, and thicker corneas take more force to applanate. It is not yet known whether the significant glaucoma risk associated with a thin cornea is a result of CCT's influence on IOP readings or if it is a separate effect.

The normal range for central corneal thickness in humans is 490 to 560 μm. While the Goldmann Applanation Tonometry, the gold standard method, bases its measurement of intraocular pressure on the premise that CCT is 520 μm. The Goldmann applanation tonometer has been the industry standard for measuring intraocular pressure for nearly 50 years.

When the corneal thickness is 500 to 525 microns, the Goldmann applanation tonometer produces accurate results (8).

Non-contact tonometers have been proven to be adequate for screening, although their values should always be linked with corneal thickness in clinical practice.

Indentation (Schiotz) tonometry determines IOP by measuring how much of the cornea is indented by a fixed-weight plunger (9-12).

Several recent investigations have demonstrated that thinner-than-average corneas underestimate genuine intraocular pressure while thicker-than-average corneas exaggerate it. When compared to a center corneal thickness of 550 microns, this effect was found to be 1 mm Hg corrected for every 25-micron change. Gold standard tonometer values are influenced by the central corneal thickness, corneal curvature, axial length, previous corneal procedures including lasik and keratoplasty, astigmatism, and corneal anomalies (8).

When measured on thicker or thinner corneas, respectively, the estimated intraocular pressure becomes incorrectly high or falsely low. The center corneal thickness must therefore be taken into account when adjusting IOP (8).

In the management of all types of glaucoma, tonometry, or the measurement of IOP, the pressure of the fluid inside the eye, is typically the only controllable component. Numerous investigations have demonstrated that differences in central corneal thickness have an impact on the precision of applanation tonometry's determination of intraocular pressure (8). The current study compares the intraocular pressure measured by the applanation tonometer, indentation

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tonometer, and non-contact tonometer and examines their correlations with central corneal thickness in patient coming in OPD at Ophthalmology Department of Sir T Hospital, Bhavnagar, Gujarat.

Materials & Methods

In this hospital-based cross-sectional observational study with 9-month duration, 72 patients were evaluated based on the following inclusion and exclusion criteria:

- **Inclusion Criteria:**
- ✓ All patients giving written and informed consent for the study.
- ✓ Patients between the ages of 30 – 75 years
- **Exclusion Criteria:**
- ✓ Patients with corneal edema
- ✓ Patients with corneal ulcer
- ✓ Patients with corneal opacity
- ✓ Patients with high myopia
- ✓ Patients with the history of any intraocular surgery and refractive surgery**.**
- **Patient Selection:**

After taking into consideration the inclusion and exclusion criteria, patients whose eyes had their intraocular pressure and central corneal thickness measured using various tonometer.

- **Methodology**

A detailed history was taken, including chief complaints, past history, family history, and personal history, followed by a general and systemic examination and slit lamp examination. After the history was taken, the near and far visual acuities were assessed using the Snellen and Jaeger charts, respectively, and the amount of refractive error was checked. A slit lamp examination was done to rule out any anterior segment pathology like corneal high myopia, edema, ulcer, acute uveitis, corneal opacities, and corneal perforations. Then all the patients were analyzed with three different tonometers (Goldmann applanation, NCT, and Schiotz tonometers) and measured the correlation between each other. Then central corneal thickness is measured with OCT Tomography was used to measure the central corneal thickness for each patient, and the results were compared to IOP.

Statistical Analysis:

Data was collected, compiled and tabulated in excel sheet. Qualitative data were represented as number with percentage. Quantitative data were represented as mean with standard deviation. Statistical analysis was done by SPSS 26.0 version software (IBM, SPSS, Inc.). P values below 0.05 considered as statistically significant.

Results

We enrolled prospectively 73 patients, all of whom had their intraocular pressure measured with different types of tonometers and correlate with their central corneal thickness. Out of 73 patients, 51 subjects were within 41-60 years (69.9 %), 19 patients were within >60 years (26 %) and 3 patients were within ≤ 40 years (4.1 %), 44 patients (60.3%) were females and 29 patients (39.7%) were males.

In patients of central corneal thickness (<520), the Goldmann applanation tonometer was significantly as well as weakly correlated with the non-contact tonometer (r = 0.371, $p =< 0.0001$), whereas it was significantly as well as moderately correlated with the Schiotz tonometer (r = 0.442, $p =<0.0001$). In patients of central corneal thickness (521–540), the Goldmann applanation tonometer was significantly and strongly correlated with the non-contact tonometer (r = 0.926, $p =<0.0001$) and the Schiotz tonometer (r = 0.911, $p =<0.0001$). In patients of central corneal thickness (>540), the Goldmann Applanation Tonometer was significantly and strongly correlated with the non-contact Tonometer (r = 0.732, $p =<0.0001$) and Schiotz Tonometer (r = 0.685, $p =< 0.0001$) (Table:1). We were observed graphical representation based on <520, 521-540 and >540 of CCT with IOP measured by different tonometer. According to observation, Schiotz tonometer was lower deviating compared to the other tonometers (Figure 1).

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Table 1: Correlation of CCT with IOP measured with different tonometer (all P values <0.0001)

CCT	Goldmann	NCT	Schiotz
<520	1	0.371**	0.442**
521-540	1	0.926**	0.911**
>540	1	0.732**	0.685**

**indicates p <0.0001

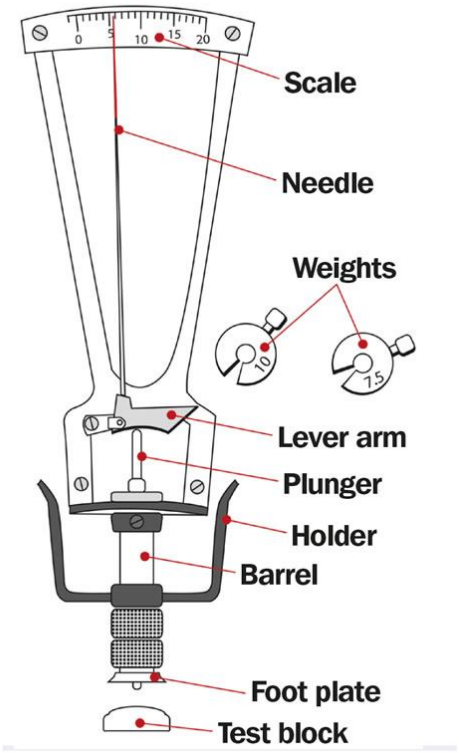

Fig. 1. Schiotz tonometer

In diabetic patients, Goldmann applanation tonometer was significantly as well as strongly correlated with non-contact tonometer (r = 0.804 , *p =<0.0001*) and Schiotz tonometer (r = 0.806 , *p =<0.0001*) (Table:2).

In hypertensive patients, Goldmann applanation tonometer was significantly as well as moderately correlated with non-contact tonometer (r = 0.422, *p =<0.0001*) and Schiotz tonometer (r = 0.537, *p =<0.0001*) (Table:2).

In hypertensive patients, Goldmann applanation tonometer was significantly as well as strongly positive correlated with non-contact tonometer (r = 0.843, *p =<0.0001*) and Schiotz tonometer (r = 0.686, *p =<0.0001*) (Table:2).

In hypertensive patients, Goldmann applanation tonometer was significantly as well as strongly correlated with non-contact tonometer (r = 0.631, *p =<0.0001*) and moderately correlated with Schiotz tonometer (r = 0.403, *p =<0.0001*). (Table:2).

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Table 2: Correlation of systemic illness with IOP measured with different tonometer (all *P values <0.0001*)

Systemic illness	Goldmann	NCT	Schiotz
Only DM	1	0.804**	0.806**
Only HTN	1	0.422**	0.537**
DM+ HTN	1	0.843**	0.686**
No systemic illness	1	0.631**	0.403**

**indicates p <0.0001

We were observed graphical representation of probability plot based on IOP measured by different tonometer. According to probability, Schiotz tonometer highly accurate compared to NCT and then Goldmann applanation tonometer.

Discussion

Although multiple risk factors can account for the susceptibility to glaucomatous damage, the IOP is the only risk factor that is amenable to treatment by pharmacological and surgical measures (9). Baseline values of the IOP will help the clinician in monitoring the progress of the disease and response to treatment. While a number of tonometers are available for measuring the IOP, each has its own advantages and disadvantages. The Goldmann applanation tonometer (GAT) is regarded as the gold standard. The accuracy of measurement is dependent on the amount of fluorescein in the cul-de-sac, other factors such as the CCT, corneal curvature, axial length and the structural rigidity of the cornea are well-known sources of error in conventional applanation tonometry (10-13). And finally, the GAT does not permit its use in the rural mass screening programs that are required in a country like India.

In seeking to evaluate a new instrument for clinical physiological measurement, it is necessary to compare its accuracy with that of the current standard and to determine in what manner of operation such accuracy is obtained.

The Noncontact tonometer (NCT) is a user-friendly instrument that lends well to use by the ophthalmology trainee as well as by the optometrist. The NCT has the potential advantage that it uses an air puff to indent the cornea thereby reducing the possible risk of epithelial trauma and cross infection which can be of tremendous advantage while in use in mass screening camp setting (14).

The Schiotz tonometer is another user-friendly instrument available for use by both the ophthalmology trainee and the optometrist with twin advantages of portability and affordability ($300/approx). Several workers have compared the efficacy of tonometers with some showing good correlation between applanation tonometers and indentation tonometers and others finding only a moderate agreement between NCT and applanation tonometer (15).

In this study, we want to correlate between intraocular pressure and central corneal thickness. Intraocular pressure was calculated based on three different tonometer such as schiotz tonometer, non-contact tonometer and Goldmann applanation tonometer. Among three tonometers, Goldmann applanation was considered as a gold standard tonometer to evaluate the accuracy of another tonometer that helps to accurate evaluation of central corneal thickness.

Age Group and Different Tonometers:

Schiotz tonometer and non-contact tonometer were not significantly correlated with gold standard tonometer in less than 40 years patients while the patient's age above 40, Shiotz tonometer and non-contact tonometer highly significantly correlated with our gold standard technique. All the methods had better correlation at >60 years age group. Non-contact tonometer highly correlated compared to Schiotz tonometer in the reference of gold standard technique. Scheler A. et al. (16) and Galgauskas S et al. (17) study also finds similar findings with the present study.

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Gender and Different Tonometer:

Non-contact tonometer and Schiotz tonometer both are equivalently highly correlated in males compared to females. Our results were comparable to similar results found in the study of Bonomi L et al. (1998) (18). Some study like Şenol Dane et al. (19), said males having more prevalence due to higher IOP in the right eye compared to females having similar IOP in both eyes.

In males, non-contact tonometer and Schiotz tonometer both are significantly very good agreement with reference to gold standard. In females, non-contact tonometer and Schiotz tonometer both are significantly moderate agreement with reference to gold standard.

Different Tonometer and Diabetes:

We were observed that diabetic patients of intraocular pressure checking with the help of a different tonometer. Non-contact tonometer and Schiotz tonometer were highly significantly correlated with diabetic patients compared to non-diabetic patients. In diabetic patients, Non-contact tonometer and Schiotz tonometer was significant as well as very good agreement with reference of gold standard tonometer. Ramm L. et al. (20) study findings contradicted the present study results, whereas Scheler A. et al. (16) study findings were similar to the present study results.

Different Tonometer and Hypertension:

We were observed that hypertensive patients of intraocular pressure checking with the help of a different tonometer. Non-contact tonometer and Schiotz tonometer were highly significantly correlated with non-hypertensive patients compared to hypertensive patients. In non-hypertensive, Non-contact tonometer and Schiotz tonometer was significant as well as very good agreement with reference of gold standard tonometer. Yasukawa T. et al. study also found similar study results with the present study results (21).

Central Corneal Thickness and Different Tonometer:

The intra-class correlation was maximum in patients with central corneal thicknesses 520-540 microns. This is probably due to a greater number of patients in this group. We were observed similar results in study of Nagarajan S et al. (22) He was found more accurate results during observation of 510-550 microns. In Central corneal thickness (520-540) group, was having Non-contact tonometer and Schiotz tonometer was significant as well as very good agreement with reference of gold standard tonometer. In Central corneal thickness (>540) group, was having Non-contact tonometer and Schiotz tonometer was significant as well as good agreement with reference of gold standard tonometer.

Conclusion

We were observed that Schiotz tonometer was having the highest correlation compared to non-contact tonometer up to 60 years. After 60 years, non-contact tonometer was highest significant correlation compared to Schiotz tonometer. All the methods had better correlation at >60 years. It may be due to the highest percentage of diabetic patients in our study group.

Intra-class correlation was higher among diabetics than non-diabetics, and the highest correlation observed with Schiotz tonometer which does not major difference with non-contact tonometer.

Non-hypertensive correlated better with gold standard tonometer technique, with intra-class correlation for non-contact tonometer being the highest. This could be due to a higher number of hypertensive patients in the study.

Limitation:

- Limitation associated with GAT such as elasticity of cornea and corneal thickness and can affect the measurement readings
- Non-contact tonometer more influenced by CCT
- Schoitz tonometer readings can be influenced by scleral rigidity

Suggestions:

- Various tonometers are now available in the market, it is therefore becoming essential to determine the reliability of these tonometers with relative cost effectiveness.

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- Schiotz tonometer can be preferred for routine IOP measurement, as a screening instrument at primary and secondary health center and for further referral to a higher center for early diagnosis and management of disease like glaucoma.
- Early treatment can improve the visual prognosis of the patient in diseases like glaucoma where intraocular pressure being one of the most important modifiable factors.

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Ethical statement:

In accordance with Ethical Committee Government Meidcal College in Gujarat,India the study was approved by the Institutional Review Board (IRB), with reference number 1109/2021. Informed and written consent was obtained from all the patients.

Author contribution:

PK and NG aided in the conceptualization, design, and critical revision of the final manuscript, PK aided in design, preparation of manuscripts and critical revision of the final manuscript. YS aided in data analysis and critical revision of the final manuscript. All authors read and approved the final manuscript.

Conflict of Interest

The authors have no conflict of interest in this study.

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Data availability:

The raw data supporting the conclusion of this article are available from the authors upon responsible request.

References:

1. Shields text book of Glaucoma. Lippincott Williams & Wilkins; 2011.
2. Quigley HA. Number of people with glaucoma worldwide. Am J Ophthalmol 1996;122(3):460. http://dx.doi.org/10.1016/s0002-9394(14)72088-4
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(11):2081–90. http://dx.doi.org/10.1016/j.ophtha.2014.05.013
4. Maurya RP. Glaucoma burden : Indian scenario. Indian J Clin Exp Ophthalmol 2017;3(4):387–8.
5. Kersey T, Clement CI, Bloom P, Cordeiro MF. New trends in glaucoma risk, diagnosis & management. Indian J Med Res 2013;137(4):659–68.
6. Fisher JH, Watson PG, Spaeth G. A new handheld air impulse tonometer. EYE 1988;2 (Pt 3)(3):238–42. http://dx.doi.org/10.1038/eye.1988.48
7. Pearce CD, Kohl P, Yolton RL. Clinical evaluation of the Keeler PULSAIR 2000 tonometer. J Am Optom Assoc 1992;63(2):106–10.
8. Das S, Kumar L K. Comparative study of intraocular pressure measured by non-contact, rebound and Goldmann applanation tonometer and their correlation with corneal thickness and true IOP in a general population. Indian J Clin Exp Ophthalmol 2020;6(1):41–9. http://dx.doi.org/10.18231/j.ijceo.2020.010
9. Medeiros FA, Alencar LM, Sample PA, Zangwill LM, Susanna R Jr, Weinreb RN. The relationship between intraocular pressure reduction and rates of progressive visual field loss in eyes with optic disc hemorrhage. Ophthalmology 2010;117(11):2061–6. http://dx.doi.org/10.1016/j.ophtha.2010.02.015
10. Whitacre MM, Stein R. Sources of error with use of Goldmann-type tonometers. Surv Ophthalmol 1993;38(1):1–30. http://dx.doi.org/10.1016/0039-6257(93)90053-a

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11. Doughty MJ, Zaman ML. Human corneal thickness and its impact on intraocular pressure measures: a review and meta-analysis approach. Surv Ophthalmol 2000;44(5):367–408. http://dx.doi.org/10.1016/s0039-6257(00)00110-7
12. Hagishima M, Kamiya K, Fujimura F, Morita T, Shoji N, Shimizu K. Effect of corneal astigmatism on intraocular pressure measurement using ocular response analyzer and Goldmann applanation tonometer. Arbeitsphysiologie 2010;248(2):257–62. http://dx.doi.org/10.1007/s00417-009-1202-7
13. Whitacre MM, Stein RA, Hassanein K. The effect of corneal thickness on applanation tonometry. Am J Ophthalmol 1993;115(5):592–6. http://dx.doi.org/10.1016/s0002-9394(14)71455-2
14. Walia JS, Chronister CL. Possible iatrogenic transmission of Creutzfeldt-Jakob disease via tonometer tips: a review of the literature. Optometry 2001;72(10):649–52.
15. Chiara GF, Semes LP, Potter JW, Cutter GR, Tucker WR. Portablem tonometers: a clinical comparison of applanation and indentation device. J Am Optom Assoc 1989;60:105–10.
16. Scheler A, Spoerl E, Boehm AG. Effect of diabetes mellitus on corneal biomechanics and measurement of intraocular pressure. Acta Ophthalmol 2012;90(6):e447-51. http://dx.doi.org/10.1111/j.1755-3768.2012.02437.x
17. Galgauskas S, Strupaite R, Strelkauskaite E, Asoklis R. Comparison of intraocular pressure measurements with different contact tonometers in young healthy persons. Int J Ophthalmol 2016;9(1):76–80. http://dx.doi.org/10.18240/ijo.2016.01.13
18. Bonomi L, Marchini G, Marraffa M, Bernardi P, Franco D, Perfetti I, et al. Prevalence of glaucoma and intraocular pressure distribution in a defined population. The Egna-NeumarktStudy. Ophthalmology 1998;105(2):209–15.
19. Şenoldanea K, Ahmettaylanyazicib O. Correlation between hand preference and intraocular pressure from right- and left-eyes in right- and lefthanders. Vision Res 2003;43:405–8.
20. Ramm L, Herber R, Spoerl E, Pillunat LE, Terai N. Intraocular pressure measurements in diabetes mellitus. Eur J Ophthalmol 2020;30(6):1432–9. http://dx.doi.org/10.1177/1120672119890517
21. Yasukawa T, Hanyuda A, Yamagishi K, Yuki K, Uchino M, Ozawa Y, et al. Relationship between blood pressure and intraocular pressure in the JPHC-NEXT eye study. Sci Rep 2022;12(1):17493. http://dx.doi.org/10.1038/s41598-022-22301-1
22. Nagarajan S, Velayutham V, Ezhumalai G. Comparative evaluation of applanation and indentation tonometers in a community ophthalmology setting in Southern India. Saudi J Ophthalmol 2016;30(2):83–7. http://dx.doi.org/10.1016/j.sjopt.2015.11.002

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