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"COMPARATIVE STUDY OF IOP MEASURED BY GOLDMANN APALLANATION TONOMETER TO NONCONTACT TONOMETER AND SCHIOTZ TONOMETER IN GLAUCOMATOUS SUSPECTS-

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ABSTRACT-

INTRODUCTION-
Accurate measurement of IOP remains critical in the diagnosis and management of glaucoma, especially in resource-limited settings. Goldmann Applanation Tonometry (GAT) is the gold standard, but NCT and Schiotz Tonometry are widely used alternatives due to ease, cost-effectiveness, and portability.

AIM-
To compare the reliability of NCT and Schiotz tonometry against GAT in glaucomatous suspects.

MATERIALS AND METHODS-
This prospective and comparative study included 100 glaucomatous suspects aged >30 years. IOP was measured using NCT, GAT, and Schiotz in a fixed sequence by a single investigator. Statistical analysis included ANOVA, Pearson correlation, and Bland-Altman plots.

RESULTS-
Mean IOPs were: NCT 22.13 ± 7.44 mmHg, GAT 22.09 ± 7.36 mmHg, and Schiotz 23.25 ± 8.58 mmHg ($p=0.2430$). GAT strongly correlated with NCT ($r=0.967$) and Schiotz ($r=0.980$).On comparing tonometers in different IOP range, IOP across the 10–30 mmHg range showed no statistically significant differences between NCT, GAT, and Schiotz tonometers, However, at higher IOP levels (>30 mmHg), significant differences emerged, with both NCT and especially Schiotz Tonometry showing a tendency to overestimate IOP compared to GAT. On Bland Altman plot NCT shows closer agreement with GAT as compared to Schiotz, with minimal mean differences and narrower limits of agreement.

CONCLUSION-
NCT is generally reliable and consistent for measuring IOP in most clinical scenarios, caution is

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necessary when interpreting higher IOP values, as discrepancies with GAT may occur. This emphasizes the importance of GAT as the gold standard, especially for elevated pressures.

KEY WORDS-INTRAOCULAR PRESSURE, NONCONTACT TONOMETER,SCHIOTZ TONOMETER,GOLDMANN APPLANATION,RELIABILITY.

MAIN TEXT-

INTRODUCTION-

Glaucoma is the second leading cause of blindness[1.]

Elevated intraocular pressure (IOP) has been found to be closely related to the development of glaucoma and the progression of glaucomatous damage, which is associated with nerve fibre layer loss and irreversible visual loss.[2–4] Nowadays even though the diagnosis of glaucoma is done on the basis of structural and functional changes found in retinal nerve fibre layer, Intraocular pressure is the only factor which can be used to titrate the management.[5]

Thus, an accurate assessment of IOP is of paramount importance in glaucoma cases.[6] In 1954, the Goldmann Applanation Tonometer (GAT) was introduced, and till today it is considered as the gold standard test for the calculation of IOP[7]

However, since their introduction, non-contact tonometers (NCTs) have become well established in clinical practice. NCT is a rapid, simple and objective method of intraocular pressure (IOP) measurement that can be performed by ancillary staff without the use of corneal anaesthesia[8.]

The Schiotz Tonometer, developed in the early 20th century, measures IOP based on the principle of indentation. In India, public health institutions, particularly those serving underprivileged communities, rely heavily on rural camps for population-wide screening of vision disorders. In these settings, cost-effectiveness of tonometers play a crucial role in device selection. Often, due to limited manpower, optometrists perform rapid IOP measurements, raising questions about the accuracy of cheaper, user-friendly tonometers.

This study aims to conduct a comprehensive comparison of NCT and Schiotz tonometry against GAT in glaucomatous suspects. By evaluating the agreement, correlation and potential sources of discrepancy between these tonometry techniques.

AIM-

To evaluate and compare the accuracy, reliability, and clinical utility of the Non-Contact Tonometer (NCT) and the Schiotz Tonometer in measuring intraocular pressure (IOP) against the Goldmann Applanation Tonometer (GAT)in Glaucomatous suspects.

MATERIAL AND METHODS- The study involved 100 adults over 30 years of age, suspected of having glaucoma, who visited the Ophthalmology Outpatient Department at J.A. Group of Hospitals between July 2022 and December 2023 for a period of 6 months

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SAMPLE SIZE: 100 Patients.
STUDY DESIGN: Prospective and comparative study.
INCLUSION CRITERIA - The study included 100 adults who were suspected of having glaucoma and attended the Ophthalmology Outpatient Department at J.A. Group of Hospitals. Patients aged over 30 years who presented with any of the following conditions were included:

- Chronic Headache
- Shallow anterior chamber
- High Myopia
- Known case of glaucoma

EXCLUSION CRITERIA - patients were excluded if they had any one of the following features-

- Any acute pathology such as, Acute Uveitis, Ulcers, corneal oedema.
- Patient with significant corneal astigmatism (≥3D) are excluded.
- Any pathology that can affect biomechanics of cornea like keratoconus, corneal infection, microphthalmos, previous refractive surgery.

PROCEDURE- After obtaining informed consent, a detailed history was taken, including any ocular conditions, refractive surgery, trauma, use of contact lenses, and medications that could affect intraocular pressure (IOP). A thorough ophthalmic examination of both the anterior and posterior segments was performed. IOP was measured by single investigator first with NCT, then 30 minutes later using GAT, followed by Schiötz tonometry. Measurements were taken during routine morning OPD hours, between 9 a.m. to 12 noon.
First, in the NCT procedure, the patient fixates on a target and examiner aligns the cornea with a stationary ring. When triggered, a puff of air flattens the cornea, and the intraocular pressure (IOP) is displayed digitally. Three readings are taken at random points during the cardiac cycle and averaged for accuracy.

Next, for the Goldmann applanation method, we begin by instilling Proparacaine Hydrochloride 0.5% drops and fluorescein. Then by using cobalt blue light, positioning it at a 45-degree angle. The light is directed onto the prism head, and the cornea is centrally applanated. The dial is adjusted until the two semicircles meet at the inner margin to measure IOP.

For the Schiötz tonometry, local anesthetic is instilled, and the patient is asked to wait for 30 seconds. The patient is instructed to focus on a fixed object and remain still. The examiner gently holds the eyelids open without applying pressure and places the tonometer plunger on the central cornea. The scale reading is recorded, and if the reading is ≤2, a heavier weight is applied, and the readings are converted to IOP using the scale card.

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STATISTICAL ANALYSIS- The data were expressed as mean values including the standard deviation (SD) and the 95% confidence interval (CI). Mean IOP measurements between NCT, GAT and SCHIOTZ were compared by One-way ANOVA. Pearson correlation was used to evaluate the correlation between instruments. Bland-Altman analysis was applied to assess the agreement between the IO*P* values measured by three methods. A *P* value of less than 0.05 was considered to be statistically significant.

RESULTS-The sample includes 52 males and 48 females.
The gender distribution is nearly balanced, with a slight male predominance.
This close male-to-female ratio suggests that the findings of this study are applicable to both genders almost equally.

The study's participants had a mean age of 49.31 ± 10.34 years, with ages ranging from 32 to 68 years. The largest group was 41-50 years (40%), followed by 51-60 years (26%). The smallest groups were ≤40 years (18%) and >60 years (16%). Males had a mean age of 56.66 ± 9.35 years, while females had a mean age of 48.66 ± 10.22 years.

CORRELATION BETWEEN TONOMETERS- GAT shows very strong significant correlations with NCT: r = 0.967 and Schiotz Tonometry: r = 0.980

These high correlation values (all significant at $p < 0.01$) suggest that the measurements obtained using GAT are highly consistent with those obtained using both NCT and Schiotz tonometry.

TABLE 1-**MEAN AND STANDARD DEVIATION OF IOP BY TONOMETERS**

	NCT	GAT	Schiotz	p-value
Mean	22.13 ± 7.44	22.09± 7.36	23.25 ± 8.58	0.2430

The **mean intraocular pressure (IOP)** values for all three methods (NCT, GAT, and Schiötz) are similar, with NCT at 22.13 mmHg, GAT at 22.09 mmHg, and Schiötz at 23.25 mmHg. The **standard deviation (SD)** values indicate some variation in the measurements across individuals in each method, with the highest variation seen in Schiötz tonometry (± 8.58 mmHg). The **p-value of 0.2430** suggests that there is **no statistically significant difference** in the IOP measurements between the three tonometry methods, as the p-value is above the common threshold of 0.05 for significance

TABLE NO 2-COMPARISON OF DIFFERENT TONOMETERS IN DIFFERENT IOP RANGE-

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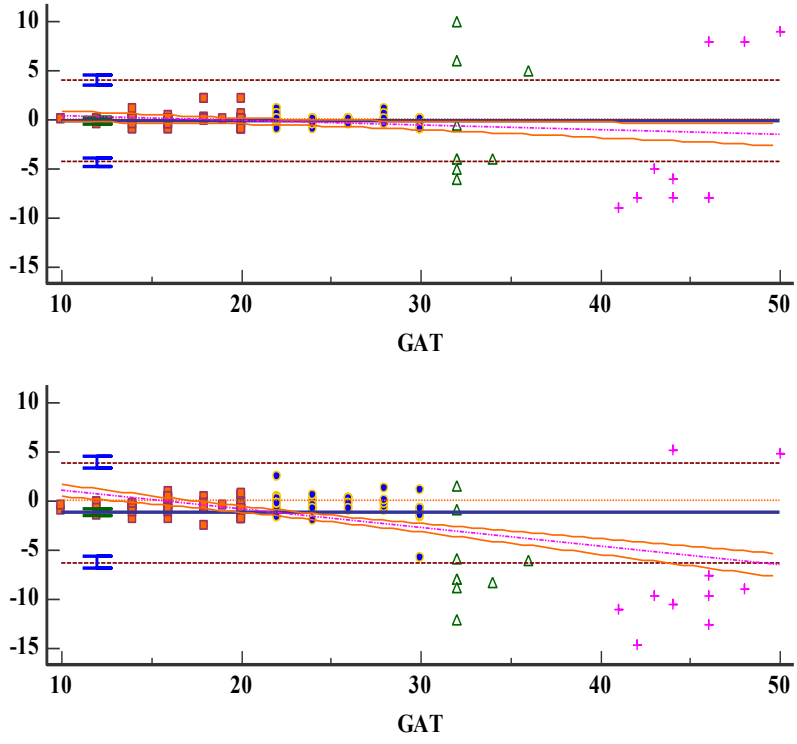
	NCT	GAT	SCHIOTZ	TOTAL	P-VALUE
>10-20	17.17±2.59	17.12±2.55	17.78±2.47	17.36±2.55	0.116
>20-30	24.75±3.01	24.66±2.91	25.40±3.31	24.93±3.00	0.2730
>30-40	32.95±5.69	32.67±1.42	39.04±4.68	34.89±5.13	0.007
>40	44.60±4.55	45.10±2.60	50.09±2.50	46.60±4.10	0.002

The table categorizes the IOP measurements into four groups based on IOP levels:10-20 mmHg, 21-30 mmHg, 31-40 mmHg, and >40 mmHg. In low to moderate IOP ranges (10–30 mmHg), GAT, NCT, and Schiotz tonometers provide comparable readings. IOP across the 10–30 mmHg range showed no statistically significant differences between NCT, GAT, and Schiotz tonometers, indicating that all three methods can be used reliably within this range. However, at higher IOP levels (>30 mmHg), significant differences emerged, especially Schiotz tonometry showing a tendency to overestimate IOP compared to GAT. This overestimation was more pronounced in the very high IOP group (>40 mmHg), where Schiotz readings were considerably higher.

GRAPH 1-BLAND ALTMAN PLOT ANALYSIS



- The x-axis represents the average IOP measured by GAT, while the y-axis represents the difference between GAT and NCT **(Figure 1)**. Data points are plotted across different

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IOP ranges, and different geometrical shapes indicate different IOP groups (10-20, 21-30, 31-40, and >40). Most of the data points fall within the ±1.96 standard deviation (SD) limits, indicating acceptable agreement between GAT and NCT. There is a noticeable increase variability in the differences as the IOP increases, especially beyond 30 mmHg. Some outliers are evident beyond this range. Second plot demonstrates that the differences between GAT and Schiotz measurements become more variable at higher IOPs**.** There are outliers indicating significant differences at higher IOP levels, with more points falling outside the ±1.96 SD limits compared to the GAT vs. NCT plot**(Figure 2)**

DISCUSSION-

Accurate intraocular pressure (IOP) measurement is crucial in diagnosing and managing glaucoma, especially in suspects where early detection is essential to prevent permanent vision loss. Historically, AT has been regarded as the gold standard due to its accuracy and dependability. However, alternatives such as NCT and Schiotz Tonometry have emerged as simpler, non-invasive options.

Evaluation of Measurement Performance of GAT VS NCT-

The current study found a strong agreement between NCT and GAT measurements, confirming that both are dependable methods for assessing IOP. Previous studies have also shown strong correlations, ranging from 0.27 to 0.9 ($p=0.03$ to $p<0.001$)[9,10,11.] In this study, the Pearson correlation coefficient was 0.95 ($p<0.001$), indicating a highly significant level of correlation. These results are consistent with earlier research, which noted variations in NCT performance relative to GAT across different IOP levels.

One study by Tonnu et al., using the Canon NCT model, found that NCT tends to underestimate IOP at lower values and overestimate it at higher values, suggesting model-specific discrepancies in IOP measurement when compared to GAT[12.]

Evaluation of Measurement Performance of GAT VS SCHIOTZ- The mean pressure obtained by the Schiotz tonometer was higher than the mean Goldmann pressure which indicates that the Schiotz tonometer tends to read higher than the Goldmann tonometer. These results are consistent with **Hemant Sharma study[13.]** In addition, Schiotz tonometry is performed in the supine position, which could rise the IOP, contributing to the lower agreement[14].There were several limitations to our study. First, the sample size of subjects included in the low and high IOP group was relatively small for subgroup analysis. Secondly, corneal biomechanics parameters were not evaluated in our study, which may interact with IOP measurement

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CONCLUSION- NCT is generally reliable and consistent for measuring IOP in most clinical scenarios, caution is necessary when interpreting higher IOP values, as discrepancies with GAT may occur. This emphasizes the importance of GAT as the gold standard, especially for elevated pressures, while recognizing the practical benefits of NCT in routine practice. NCT shows closer agreement with GAT as compared to Schiotz, with minimal mean differences and narrower limits of agreement. Schiotz, on the other hand, displays significant bias and wider limits of agreement, indicating less reliability.

REFERENCES-

1. Quigley H. A. (1996). Number of people with glaucoma worldwide. *The British journal of ophthalmology*, *80*(5), 389–393. https://doi.org/10.1136/bjo.80.5.389
2. 2. Yilmaz, I., Altan, C., Aygit, E. D., Alagoz, C., Baz, O., Ahmet, S., Urvasizoglu, S., Yasa, D., & Demirok, A. (2014). Comparison of three methods of tonometry in normal subjects: Goldmann applanation tonometer, non-contact airpuff tonometer, and Tono-Pen XL. *Clinical ophthalmology (Auckland, N.Z.)*, *8*, 1069–1074. https://doi.org/10.2147/opth.s6391
3. Patel, K. J., Jain, S. P., Kapadia, P. R., Patel, N. V., Patel, S., & Patel, V. (2016). Can higher end tonometers be used interchangeably in routine clinical practice?. *Indian journal of ophthalmology*, *64*(2), 132–135. https://doi.org/10.4103/0301-4738.179723
4. Jóhannesson, G., Hallberg, P., Eklund, A., Behndig, A., & Lindén, C. (2014). Effects of topical anaesthetics and repeated tonometry on intraocular pressure. *Acta ophthalmologica*, *92*(2), 111–115. https://doi.org/10.1111/aos.12058
5. Ahmad, A. (2020). Prevalence and Associated Risk Factors of Glaucoma in Aligarh, India – A population based study. *Delhi Journal of Ophthalmology*, *31*(1). https://doi.org/10.7869/djo.565
6. Lee, M., & Ahn, J. (2016). Effects of Central Corneal Stromal Thickness and Epithelial Thickness on Intraocular Pressure Using Goldmann Applanation and Non-Contact Tonometers. *PloS one*, *11*(3), e0151868. https://doi.org/10.1371/journal.pone.0151868
7. RR Allingham K Damji S Freedman SE Moroi DJ Rhee MB Shields Intraocular pressure and TonometryShields Textbook of Glaucoma. 6th Edn.Wolters Kluwer/Lippincott Williams & WilkinsNew Delhi20112440
8. Shields M. B. (1980). The non-contact tonometer. Its value and limitations. *Survey of ophthalmology*, *24*(4), 211–219. https://doi.org/10.1016/0039-6257(80)90042-9
9. Matsumoto, T., Makino, H., Uozato, H., Saishin, M., & Miyamoto, S. (2000). The Influence of Corneal Thickness and Curvature on the Difference Between Intraocular Pressure Measurements Obtained with a Non-contact Tonometer and Those with a Goldmann Applanation Tonometer. *Japanese journal of ophthalmology*, *44*(6), 691. https://doi.org/10.1016/s0021-5155(00)00250-1
10. Jorge, J., Díaz-Rey, J. A., González-Méijome, J. M., Almeida, J. B., & Parafita, M. A. (2002). Clinical performance of the Reichert AT550: a new non-contact tonometer. *Ophthalmic & physiological optics : the journal of the British College of Ophthalmic Opticians (Optometrists)*, *22*(6), 560–564. https://doi.org/10.1046/j.1475-1313.2002.00077.x
11. Parker, V. A., Herrtage, J., & Sarkies, N. J. (2001). Clinical comparison of the Keeler Pulsair 3000 with Goldmann applanation tonometry. *The British journal of ophthalmology*, *85*(11), 1303–1304.
12. Tonnu, P-A. (2005). The influence of central corneal thickness and age on intraocular pressure measured by pneumotonometry, non-contact tonometry, the Tono-Pen XL, and Goldmann applanation tonometry. *British Journal of Ophthalmology*, *89*(7), 851–854. https://doi.org/10.1136/bjo.2004.056622
13. Sharma, H., Nainiwal, S. K., Sarraf, A., Porwal, R., & Sharma, V. (2022). Comparative study between schiotz tonometer and goldmann applanation tonometer in glaucomatous and normal individuals. *Indian Journal of Clinical and Experimental Ophthalmology*, *8*(1), 85–88. https://doi.org/10.18231/j.ijceo.2022.016
14. Barkana Y. (2014). Postural change in intraocular pressure: a comparison of measurement with a Goldmann tonometer, Tonopen XL, pneumatonometer, and HA-2. *Journal of glaucoma*, *23*(1), e23–e28. https://doi.org/10.1097/IJG.0b013e3182a0762f