

A Comparative Analysis Of Goldmann Applanation And Tonopen Tonometers In Adults Attending A Private Eye Clinic In Abuja, Nigeria.

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Abstract:

Background: The importance of intraocular measurement in clinical practice cannot be overemphasized. It is useful in the management of glaucoma, ocular hypertension and other eye conditions. This present study aims to compare the efficacy and utility for intraocular pressure (IOP) measurements of two different instruments in the assessment of Intra-ocular pressure i.e. Goldman Applanation Tonometer (GAT), and Tonopen XL (TP) and to analyse the correlation between these instruments.

Materials and Methods: A cross sectional comparative study carried among 259 eyes of 259 Patients aged between 18 and 71(mean age 42.80 ±13.54), 88 males and 171 females attending a private eye Hospital in Abuja, from January to April 2017. The intraocular pressures were taken using two different instruments GAT and TP. All IOP measurements were taken in a sitting position by one examiner. Data was analysed using SPSS version 20 using Paired Sample T Test, Pearson's correlation and Linear Regression.

Results: The mean IOP was 12.22 and 16.87mmhg for GAT and TP respectively. Tonopen was found to exaggerate the mean GAT IOP by 38.05%, $p < 0.001$. This exaggeration was marked at pressures less than 10mmhg (58.93%, $p < 0.001$) and least at pressures greater than 20mmhg (9.37%, $p = 0.311$). The correlation of GAT and Tonopen was moderate ($r = 0.547$, $p < 0.001$). The correlation was highest at pressures less than 10mmhg ($r = 0.501$, $p < 0.001$). Linear Regression Formula (Tonopen's IOP = $7.638 + 0.756$ Goldsmann's IOP, $p < 0.0001$) was derived. Linear regression analysis also confirmed a statistically significant difference between the IOP measurements using these instruments.

Our experience during the study showed that TP was easier and faster to use than GAT. Participants needed more counseling and reassurance while using GAT than the TP. Ten participants were eliminated from the study because they could not cooperate for GAT measurements. Challenges noted with the TP include occasionally there has to be multiple contact with the cornea before it reads which build anxiety in some patients. Participants also complained of their eyes feeling different after using the anesthetic drops for GAT and TP.

Conclusion: TP was found to overestimate the GAT IOP values. IOP measurements vary significantly between the instruments and level of IOP measured has a role to play. The correlation between the instruments was found to be modest to moderate. Our recommendation would be that the Tonopen should be reserved for use in outreach camp situations or home visits, while bearing in mind that the IOP obtained tends to be exaggerated.

Key Word: Goldsman Applanation Tonometer; Tonopen tonometer; Intraocular pressure.

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I. Introduction

The importance of intraocular measurement in clinical practice cannot be overemphasized. It is useful in the management of glaucoma, ocular hypertension and other eye conditions. There are various devices for measuring IOP with their advantages and challenges. The Goldmann Applanation Tonometry (GAT) is the gold standard for measuring intraocular pressures and the most widely accepted method¹. It also has been said to be the most accurate modern tonometer². Goldmann Applanation Tonometry measures the force required to flatten a constant area of the cornea. Challenges with the Goldmann applanation tonometry include a difficult learning curve especially for non ophthalmologists. It also requires constant electricity supply as it is connected to a power source, requires contact with the cornea and positioning in the slit lamp and hence poses a challenge especially with children, patients with spinal issues, mental challenges, anxious and uncooperative patients. It also has to be disinfected after every use and requires anaesthetic drops to the cornea. The table-top format cannot be used in outreaches or screening of a large number of people within a short time.^{3,4,5} Owing to these challenges, other tonometry devices have been developed over the years.

Tonopen is a hand held, compact, portable applanation device which measures intraocular pressure by flattening a much smaller area of the cornea. Although it requires contact with the cornea and the use of anaesthetic drops, it has a much easier learning curve, can be used during outreaches and with Patients in supine position e.g. in theatre and for Patients with irregular cornea.^{6,7,8.}

There have been limited studies comparing tonometers in Nigeria. An earlier study carried out in our practice in 2009 compared the Keeler Pulsair Easy-Eye non-contact tonometer (NCT) with the 'gold standard' Goldmann applanation tonometer (GAT) and reported no statistically significant difference in the two instruments .The mean IOP were NCT (17.36 mmHg) and GAT (17.42 mmHg; p = 0.769). There was also a very high correlation between the two instruments as the GAT/NCT correlation coefficient, r, was 0.883.⁹ Onochie reported a statistically significant difference between GAT and Tonopen .The mean IOP in mmHg using Goldmann tonometer (GAT) was 17.1 ± 6.9, the corrected mean GAT pressure was 18.9±7.5 and the mean IOP with Tonopen was 21.1 ±6.8 with a mean difference of +3.9 ±2.6 mmHg (95% C.I 0.3 – 4.5mmHg) between the instruments.¹⁰

This present study aims to compare two instruments we have had cause to use in our hospital, (GAT and Tonopen), to examine the issues with the use of these instruments in our experience, compare IOP measurements, and assess the correlation between them.

II. Material And Methods

This is a cross-sectional comparative study carried out at Rachel Eye Center, Garki, Abuja from January to April 2017. Two hundred and fifty-nine eyes of 259 Patients were included in the study, aged between 18 and 71. Participants with corneal pathologies, contact lens wear, secondary glaucoma, inflammation, past ocular surgeries, significant corneal astigmatism and gross ocular pathologies were excluded. The study was in keeping with Helsinki’s ethical guidelines. A written informed consent was obtained from all the participants. All participants had a detailed history and ophthalmic examination i.e. Snellen visual acuity, slit lamp examination, fundus examination and refraction. Consecutive patients who met the inclusion criteria and were willing to participate were included in the study. IOP was measured using, Tonopen (Reichert Technologies, Depew, NewYork, USA) and Goldman Applanation Tonometer (Shin Nippon, Tokyo Japan) in that order at 10 minutes interval to the right eye. The average of three successive readings was taken for all instruments. Anaesthetic drops Proparacaine Hydrochloride 5mg with 0.0002ml of 50% Benzalkonium Chloride solution (Primax) was placed in the fornix prior to measuring with TP and GAT and fluorescein strip prior to GAT measurements. Measurements were taken between 9 and 11am, in a sitting position and by one examiner and using same instruments. . Data was analyzed using SPSS version 20 using Paired Sample T Test , Pearson’s correlation and Linear Regression.

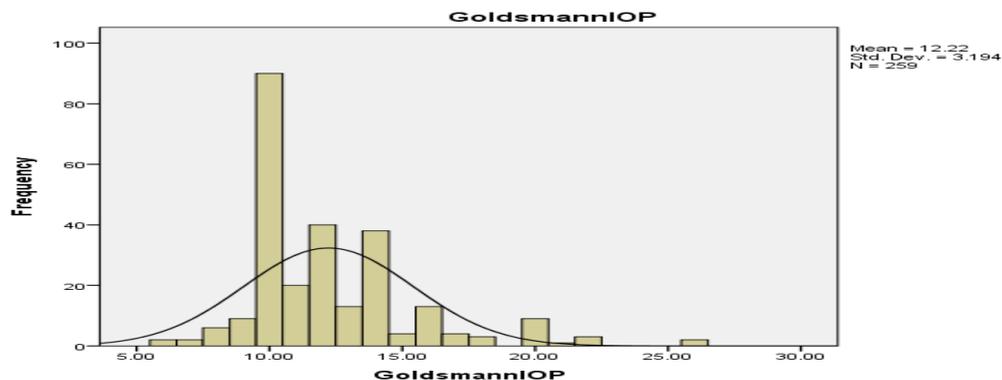
III. Result

TABLE 1: COMPARING IOP STATISTICS AMONG GOLDMANN AND TONOPEN.

	Mean ± SD	Median	Mode	Minimum	Maximum
Goldmann	12.22 ± 3.19	12	10	6	26
Tonopen	16.87 ± 4.42	17	17	4	38

Goldmann tonometer had the lowest mean intraocular pressure while Tonopen had the highest mean intraocular pressure.

GRAPH 1: HISTOGRAM SHOWING THE FREQUENCY OF IOP MEASUREMENTS BY GOLDMANN APPLANATION TONOMETER IN THE STUDY POPULATION.



GRAPH 2: HISTOGRAM SHOWING THE FREQUENCY OF IOP MEASUREMENTS BY TONOPEN

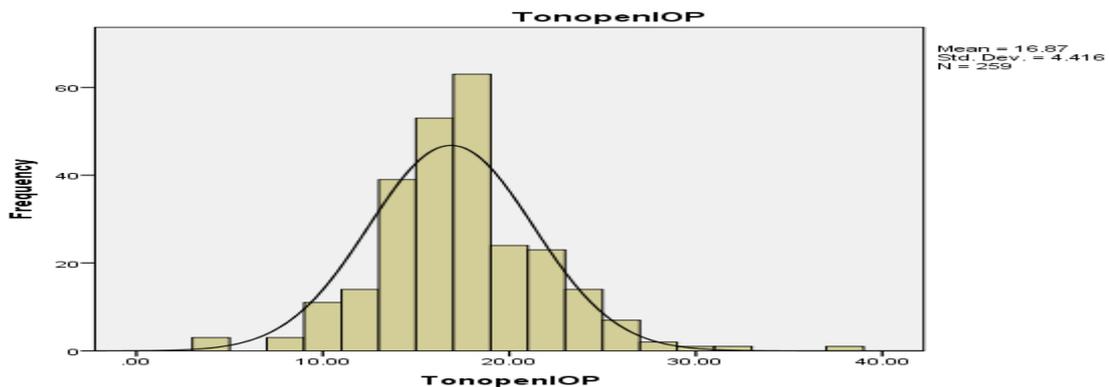


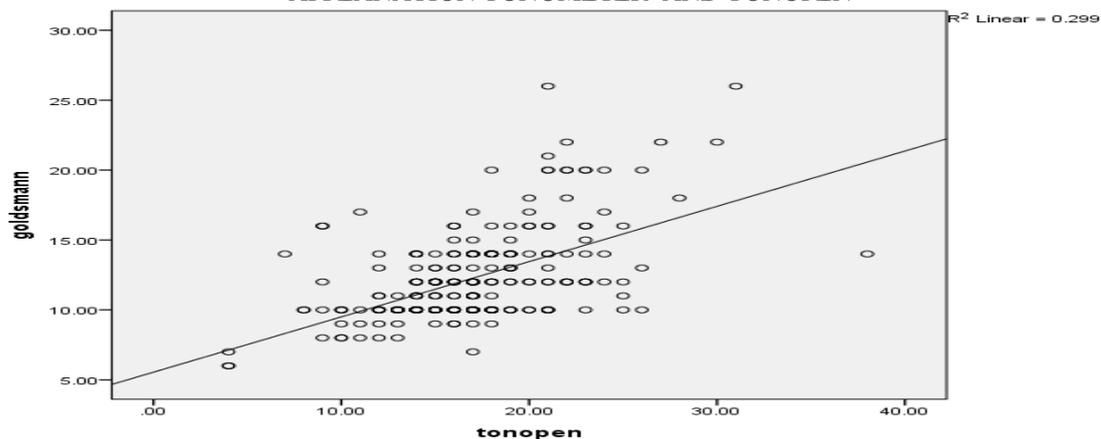
TABLE 2: COMPARING THE DIFFERENCE IN INTRAOCULAR PRESSURE MEASUREMENT AND CORRELATION BETWEEN STANDARD GOLDMANN APPLANATION TONOMETER WITH TONOPEN.

Goldmann pressures	Number of samples	Mean Goldmann Pressures (SD)	Mean Tonopen pressures (SD)	Mean Difference (SD)	Percentage difference when GAT compared to Tonopen(%)	Level of significance	Pearson's correlation of GAT and Tonopen	Level of significance
All values	259	12.22(3.19)	16.87(4.42)	4.65(3.78)	38.05 E	<0.001**	0.547	<0.001**
<=10	109	9.68(0.82)	14.90(3.75)	3.22(3.41)	53.93 E	<0.001**	0.501	<0.001**
11-20	144	13.69(2.37)	18.01(4.06)	4.33(3.95)	31.63 E	<0.001**	0.340	<0.001**
>20	6	23.17(2.23)	25.33(4.59)	2.17(4.71)	9.37 E	0.311	0.189	0.720

Standard deviation is in parenthesis. E: exaggerated percentage as compared to the mean Goldmann pressure, U: underestimated percentage as compared to the mean Goldmann pressure. Pearson's correlation was used. A correlation value of < 0.31 shows a modest correlation, 0.32 to 0.55 shows a moderate correlation and >0.55 shows a strong correlation.. **.The correlations are significant at the 0.05 level-95% degree of confidence.

Tonopen was found to have an exaggerated GAT's IOP across all the ranges of IOP analysed. Overall the exaggeration was 38.05% ,but was most marked(53.93%) amongst Goldmann IOP values less than 10mmhg and there was a decline in the exaggeration as the intraocular pressure value increased. The exaggeration dropped to 9.37% for pressures greater than 20mmhg.

GRAPH 3: SCATTER PLOT GRAPH SHOWING CORRELATION BETWEEN GOLDMANN APPLANATION TONOMETER AND TONOPEN



Generally there was a moderate correlation between Goldmann and Tonopen tonometer(0.547,p<0.001) .The correlation was strongest(0.501,p<0.001) at IOP less than 10mmhg but lowest(0.189,p=0.720) at pressures greater than 20mmhg.

R² is a measure of the goodness of fit. In this analysis, it is equal to 0.299, which suggests a poor goodness of fit of the regression line.

TABLE 3 : Linear Regression of Tonopen’s IOP by Goldsmann’s IOP

Model	Unstandardised Coefficient B	Standard Error	P value (level of significance)
constant	7.638	0.912	<0.0001
Goldsmann’s IOP	0.756	0.072	<0.0001

Linear Regression Formula :Tonopen’s IOP =7.638+0.756 Goldsmann’s IOP.

Linear Regression analysis showed a statistically significant difference between Goldsman IOP and Tonopen’s IOP values.

IV. Discussion

The study showed that the mean IOP was lowest in the Goldmann Applanation Tonometer (GAT) and highest in the Tonopen (TP). TP was found to exaggerate the value of GAT by 38.05% p<0.001. Similar findings were reported in the following studies: Onochie reported that Tonopen’s mean IOP was higher than GAT’s mean IOP (21.1:17.1) and TP exaggerated the mean GAT value by 23.39%¹⁰. Raina et al also studied 200 eyes of Indian Children and reported that Tonopen had the higher mean IOP than GAT (15.66:12.44). Tonopen exaggerated GAT by 25.7%. They gave possible explanation to the fact that lesser force is required to applanate a softer eye and Tonopen higher exaggeration is due to the fact that it combines applanation and indentation.¹¹ Galgauskas et al studied 78 eyes and also reported Tonopen mean IOP to be higher than GAT (16.32:15.62). Tonopen exaggerated the GAT by 4.48% although this difference was not statistically significant.¹² Yilmaz et al compared GAT, NCT and Tonopen and reported Tonopen and NCT had higher mean IOP than GAT (16:16.1:15.5)¹³. Tonopen exaggerated GAT by 4.5% although this difference was not statistically significant.¹³ Minckler et al also reported TP to be higher than GAT by 1.7 and similar trend were reported in other studies.¹⁴

However, a number of studies have shown a different trend. Ceska et al noted that GAT was higher than TP (16.55:16.3).¹⁵

There was a statistically significant difference in the degree of exaggeration or underestimation of the GAT mean IOP compared with TP at different IOP levels. In our hands, there was an exaggeration of TP values as compared to GAT at all levels of IOP. We noticed a decline of the exaggeration as the IOP levels increased. The exaggeration was most marked (53.93%) when comparing TP with GAT at IOP less than 10mmhg and this degree of exaggeration dropped to 9.37% for IOP’s greater than 20mmhg. Bradfield et al reported that in the office setting, TP was higher than GAT by 0.4 at IOP greater than 11mmhg but the reverse trend was seen for pressures lower than 11. They also noted under general anesthesia TP was greater than hand held GAT.¹⁶ Minckler et al also reported Tonopen to be greater than GAT by 1.7mmHg for pressure less than 24 and no significant difference for pressures greater than 24.¹⁴

The correlation between Tonopen and Goldmann was found to be moderate (0.547) and was most marked at pressures less than 10mmhg. Baily et al found a strong correlation of 0.592¹⁷ while Saulius et al found a strong correlation of 0.861 between the two instruments.¹²

Our experience during the study showed that TP was easier to use than GAT. The GAT was challenging to use as participants needed more counseling and reassurance than the TP, because for GAT, there were multiple attempts before some patients would eventually cooperate. Ten participants were eliminated from the study because they could not cooperate for GAT measurements. Participants also complained of their eyes feeling different after using the anesthetic drops for GAT and TP. Challenges noted with the TP include occasionally there has to be multiple contact with the cornea before it reads which build anxiety in some patients.

V. Conclusion

There was a statistically significant difference in IOP readings comparing GAT and TP.

TP was found to overestimate the GAT IOPs values at all ranges of IOP accessed.

IOP measurements vary significantly between instruments and level of IOP has a role to play. The correlation between the instruments was found to be modest to moderate and the level of IOP had a role to play with the correlation.

Our recommendation would be that the Tonopen should be reserved for use in outreach camp situations or home visits, while bearing in mind that the IOP obtained tends to be exaggerated. ‘Abnormal’ Tonopen measurements should be cross-checked with Non contact tonometry or GAT in the hospital base before conclusions are reached as to the IOP status of the individuals concerned.

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