

Correlation of the Intra Ocular Pressure Measured by Non Contact Tonometer with the Perkins Applanation Tonometer and Study of Non Contact Tonometer as a Screening Tool

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Abstract: *Background:* Intra ocular pressure (IOP) measurement is essential in ophthalmological assessment as raised IOP is an important risk factor for development as well as progression of glaucoma. *Aims:* To correlate the IOP by the Non Contact Tonometer (NCT) with the Perkins Applanation Tonometer (PAT) and to study NCT as a screening tool. *Materials and Methods:* It is a comparative study on Patients attending Out Patient Department of Ophthalmology, from 1st December 2014 to 30th September 2016. We included 260 participants. Data collected using proforma, informed consent, history, ophthalmological examination. Patients were subjected to Non Contact Tonometry and Perkins Applanation Tonometry. 3 readings were taken for each method and mean calculated. *Statistical analysis used:* Paired-T test & Correlation-co-efficient. Sensitivity and Specificity were calculated for the NCT. *Results:* The NCT showed excellent agreement with the PAT. The correlation coefficient(r) of IOP measured by NCT and PAT is 0.879 and 0.894 for right eye and left eye respectively with p value <0.05, showed strong positive correlation between the IOP measured by NCT and PAT. The NCT also scored high as an effective screening tool. The NCT showed high sensitivity 95.5 and 94.3 for right eye and left eye respectively, high specificity 94.5 and 99.1 for right and left eye respectively, coming across an excellent agreement with PAT, using an IOP of more than/equal to 21 mm Hg with the PAT as the standard criterion. *Conclusion:* The current study shows that the NCT compares well with the PAT. The NCT can be used as a reliable screening tool.

Keywords: Non Contact Tonometer, Perkins Applanation Tonometer, Intraocular Pressure, Screening Tool.

Key Messages: In Indian context where the large number patients are being screened for glaucoma by measuring Intra ocular pressure, Non contact tonometer is useful for screening as it does not need anesthesia, sterilization of tonometer in-between patients and it is not operator dependent, as it records automatically, so it can be done by Non ophthalmologists (Para medical or Non medical personnel).

Introduction

Now the Glaucoma is second leading cause of blindness globally, after cataracts, according to World Health Organization [1]. Approximately 11.2 million Indians above 40 years suffer from glaucoma [2] with over 90% of the cases being diagnosed only after significant vision loss has occurred. Glaucoma, previously defined as a state of raised intra ocular pressure, is today better understood to be an irreversible and progressive optic neuropathy resulting from a variety of risk factors. The most prominent among these is raised intra ocular pressure (IOP) and is the only risk factor amenable to treatment, provided it is detected early. Thus, blindness resulting from glaucoma is largely preventable, if adequate measures to control levels of intra ocular pressure

are taken early enough in the pathogenesis of the disease. This makes the early detection of Glaucoma suspects and cases very crucial.

However, poor awareness among the general public and low detection rates pose a problem. Therefore, intra ocular pressure measurement is essential in ophthalmological assessment along with the examination of the Optic nerve head and an assessment of the Visual fields by ophthalmologists. Measurement of Intra ocular pressure at the primary health care level can go a long way in detecting cases as well as screening suspects from the general population [3]. PAT (hand held version of gold standard Goldmann's tonometer because it is based on the same principles as the

Goldmann applanation tonometer) is portable, simple [4]. As it needs topical anaesthesia, fluorescence staining and specialist to do procedure, it is cumbersome instrument for screening purposes. Corneal factors like corneal curvature, central corneal thickness and astigmatism, affect its accuracy [4-5].

Moreover, in measuring IOP by NCT there is no need of anesthesia, staining and no corneal factors affect its reading. It is not operator dependent, as it records automatically, so it can be done by Non ophthalmologists (Para/Non medical personnel), so it can be a screening tool. In view of this, this study is an effort to correlate IOP measured by NCT with PAT and study reliability of the Non-Contact Tonometer as screening tool, considering its advantages over PAT in Indian context where large numbers of patients have to be screened and risk of transmission of infection is high.

Material and Methods

The study was designed as prospective, comparative study. This study was conducted on Patients attending Out Patient Department of Ophthalmology in a Tertiary Care Center. It was conducted from 1st December 2014 to 30th September 2016. This study was approved from Institutional Ethics Committee.

Data was collected using a proforma, with the informed consent of the patient. A detailed history was obtained from each patient (participant) followed by routine ophthalmological examination including visual acuity testing, anterior segment and also fundus examination. Patients were subjected to two methods of tonometry - Non Contact Tonometry and Perkins Applanation Tonometry (Perkins under topical anaesthesia with 0.5% Proparacaine eye drops). Non Contact Tonometer readings were recorded first, then Perkins tonometer. Three readings were taken for each method and mean calculated.

Sample size: According to a study [4], the Mean and SD of Intraocular pressure measured by Non contact tonometer are 14.53 +/- 3.36 and of Perkins tonometer are 13.06 +/- 2.69 with average standard deviation of 3.95 and difference between two mean is 1.47 and considering 99% confidence level and with the power 90% the

minimum calculated sample size was 257 using the following statistical formula.

$$n = \frac{(Z \alpha + Z \beta)^2 \times 2 \times SD^2}{d^2}$$

n = Sample size

Z α = 99% Confidence level.

Z β = Power 90%.

SD = Common Standard Deviation.

d = difference between two means.

With a minimum sample size of 257, we had included 260 participants in our study.

Statistical Analysis: Data was analyzed using Diagrammatic presentation, Mean \pm SD Sensitivity, Specificity, Paired T test and Correlation coefficient.

Both males and females, with Age >40 years were included in study. Age < 40 years. Diagnosed cases of Glaucoma, patients with scarred or hazy Corneas, history of previous Corneal surgery including Refractive surgery, Microphthalmos, Blepharospasm, Manifest Nystagmus, Keratoconus, and with any current Conjunctival or Corneal infections were excluded from study. All participants in the study underwent Slit lamp examination, Visual acuity testing, Fundus examination, and IOP measurement by Non contact tonometer and Perkins applanation tonometer. The study was approved from Institutional Ethics Committee.

Results

This comparative study was conducted on a total 260 participants attending our institute. All participants were subjected to the two methods of tonometry- Non contact tonometry and Perkins applanation tonometry. The analysis of the data obtained showed that, from a total of 260 participants, 155 (59.6%) were males, while 105 (40.4%) constituted females with the mean age of 55.3 years, the youngest participant being 41 years of age and the oldest was 85 years old.

In this study the total participants were divided into 4 groups based on age for analysis purpose, as participants aged 41-50 years, 51-60 years, 61-70 years and more than 70 years.

Age (In Years)	Male		Female		Total	
	Number of Participants	Percent	Number of Participants	Percent	Number of Participants	Percent
41-50	64	41.3	40	38.1	104	40
51-60	53	34.2	41	39.0	94	36.1
61-70	24	15.5	22	21.0	46	17.7
>70	14	9.0	2	1.9	16	6.2
Total	155	100.0	105	100.0	260	100

Graph-1: Mean Distribution of participants according to gender and age

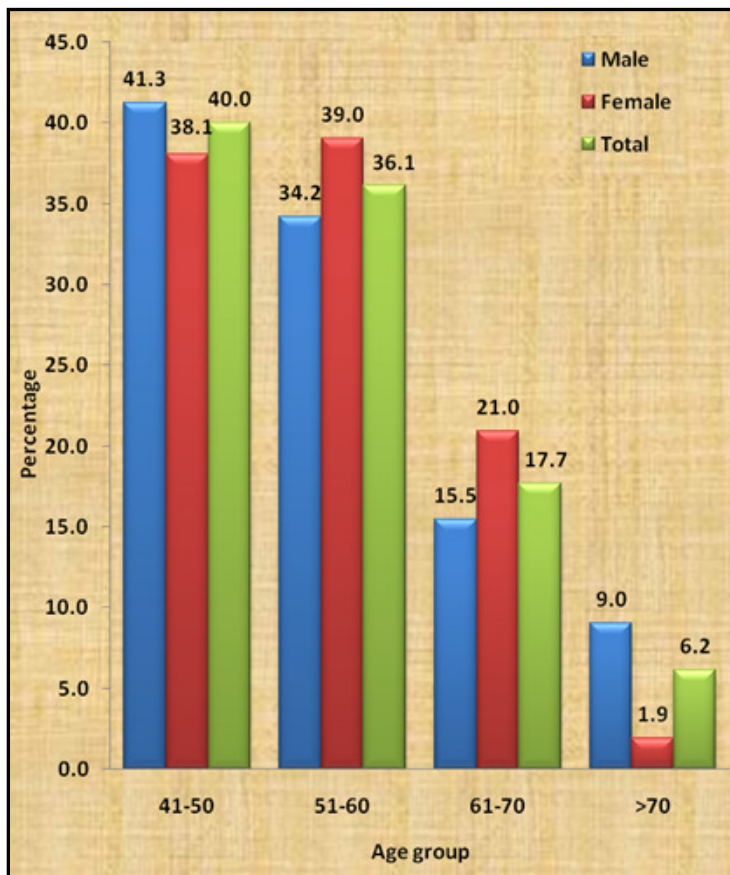


Table No. 1 and Graph No. 1 shows that of the 260 participants maximum number of participants i.e. 104 (40.0%) were in 41-50 years age group. 94 (36.1%) participants were in 51-60 years group, 46 (17.7%) participants were in 61-70 years age group and remaining 16 (6.2%) participants were in the more than 70 years age group. Maximum number of participants were males and maximum participants were in the age group of 41-50 years.

Table No.2 shows that the mean IOP for right eye with NCT and PAT were 16.0 mm Hg and 15.9 mm Hg respectively with p value of 0.239, for left eye with NCT and PAT were 16.0 mm Hg and 15.8 mm Hg respectively with p value of 0.118, showed that there was no significant difference between the Intraocular pressure measured by the both instruments and suggest fair agreement between NCT and PAT.

Intraocular Pressure	Method	Mean	SD	p value
Right eye	NCT	16.0	3.8	0.239
	PAT	15.9	3.3	
Left eye	NCT	16.0	4.1	0.118
	PAT	15.8	3.6	

Table No. 3 and Graph No. 2 shows that mean Intraocular pressure in right eye for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with Non contact tonometer and Perkins applanation tonometer were 15.9 mm Hg, 16.2mm Hg, 16.7 mm Hg ,13.7 mm Hg and 15.8 mm Hg,16.0 mm Hg,16.4 mm Hg,14.0 mm Hg respectively for both tonometers with standard deviation of 3.5,4.0,4.4,2.9 and 3.0,3.1,4.3,2.1 with p values of 0.705,0.299,

0.396,0.676 respectively, showed there was no significant difference between two tonometers and also a good agreement between two tonometers. And also Table No. 3 and Graph No. 2 shows that mean Intraocular pressure in left eye for both males and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with Non Contact Tonometer and Perkins Applanation Tonometer were 15.5 mm Hg,

16.4mm Hg, 16.6 mm Hg,15.3 mm Hg and 15.5 mm Hg,16.0 mm Hg,16.3 mm Hg,15.3 mm Hg respectively for both tonometers with standard deviation of 3.4,4.1,5.3,4.4 and 3.0,3.3,5.1,4.2 with p values of 0.914,0.102,0.423,0.99 respectively, showed there was no significant difference between two tonometers and also a good agreement between two tonometers.

Table-3: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among Total Participants by Age

Age (In Years)	Right eye					Left eye				
	NCT		PAT		p value	NCT		PAT		p value
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
41-50	15.9	3.5	15.8	3.0	0.705	15.5	3.4	15.5	3.0	0.914
51-60	16.2	4.0	16.0	3.1	0.299	16.4	4.1	16.0	3.3	0.102
61-70	16.7	4.4	16.4	4.3	0.396	16.6	5.3	16.3	5.1	0.423
>70	13.7	2.9	14.0	2.1	0.676	15.3	4.4	15.3	4.2	0.99

Graph-2: Mean Intraocular Pressure between NCT and PAT (in mm Hg) among total participants by age

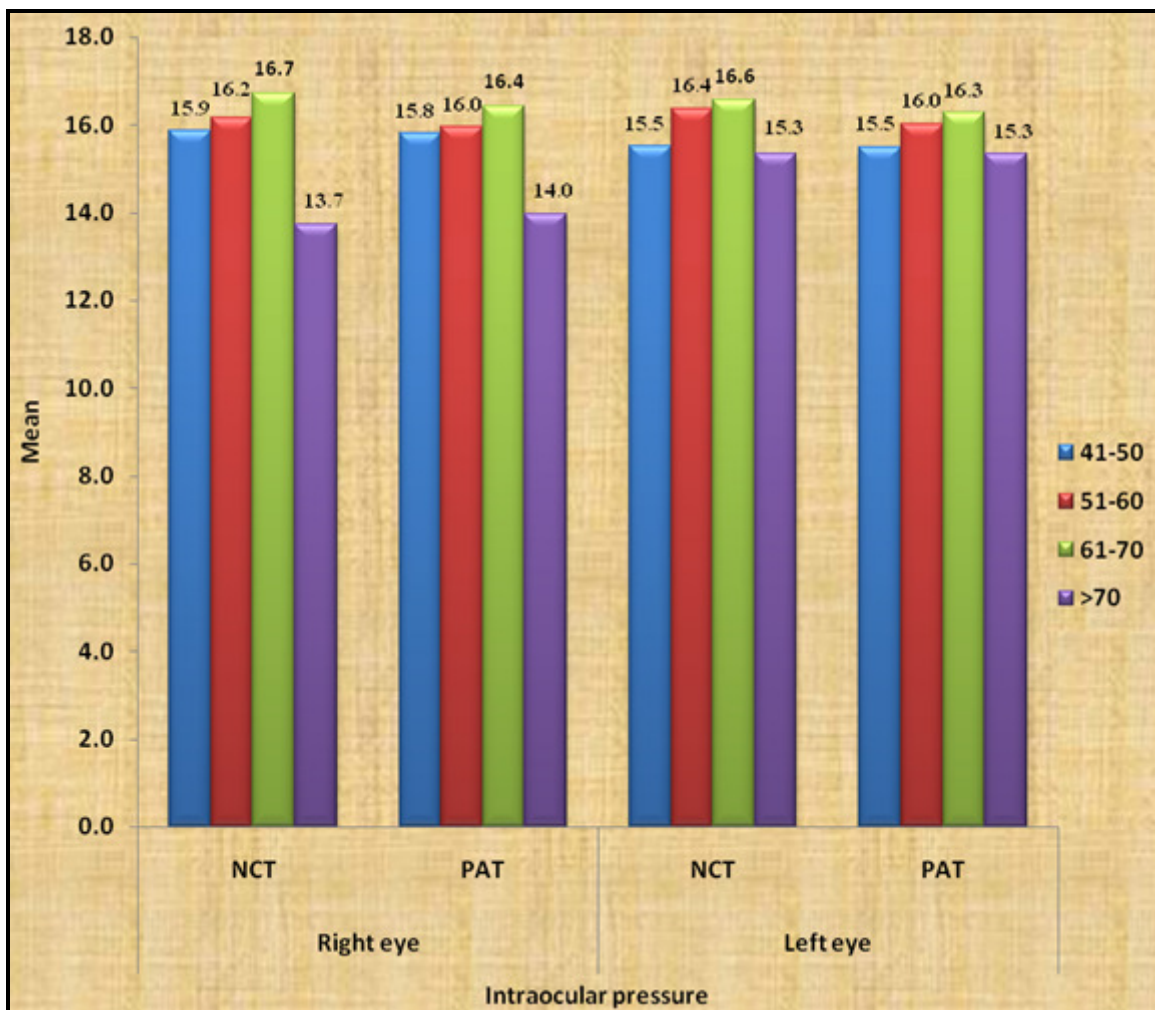


Table-4: Correlation Coefficient of Intraocular Pressure between NCT and PAT							
Intraocular Pressure	Method	Male		Female		Total	
		r value	p value	r value	p value	r value	p value
Right eye	NCT	0.919	<0.05	0.83	<0.05	0.879	<0.05
	PAT						
Left eye	NCT	0.928	<0.05	0.862	<0.05	0.894	<0.05
	PAT						

Table No.4 shows, the correlation coefficient of Intraocular pressure measured by Non contact tonometer and Perkins applanation tonometer were 0.919 and 0.928 for right and left eye respectively with p value of <0.05 in males, showed strong positive correlation between the Intraocular pressure measured by NCT and PAT among males.

Table No. 4 shows, the correlation coefficient of Intraocular pressure measured by Non contact tonometer and Perkins applanation tonometer were 0.83 and 0.862 for right and left eye respectively with p value of <0.05 in females, showed strong positive correlation between the Intraocular pressure measured by NCT and PAT among females.

And also shows Table No. 4, the correlation coefficient of Intraocular pressure measured by Non contact tonometer and Perkins applanation tonometer were 0.879 and 0.894 for right and left eye respectively with p value of <0.05 in our study participants (both male and female), showed strong positive correlation between the Intraocular pressure measured by NCT and PAT among total (both male and female) participants.

Table No. 5 shows that, the Non contact tonometer on the right eyes, compared well with the Perkins applanation tonometer as evidenced by a r values of 0.92,0.87,0.87,0.66 with a P value <0.05 for correlation, for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years respectively, showed significant correlation between tonometers in total (both male and female) participants.

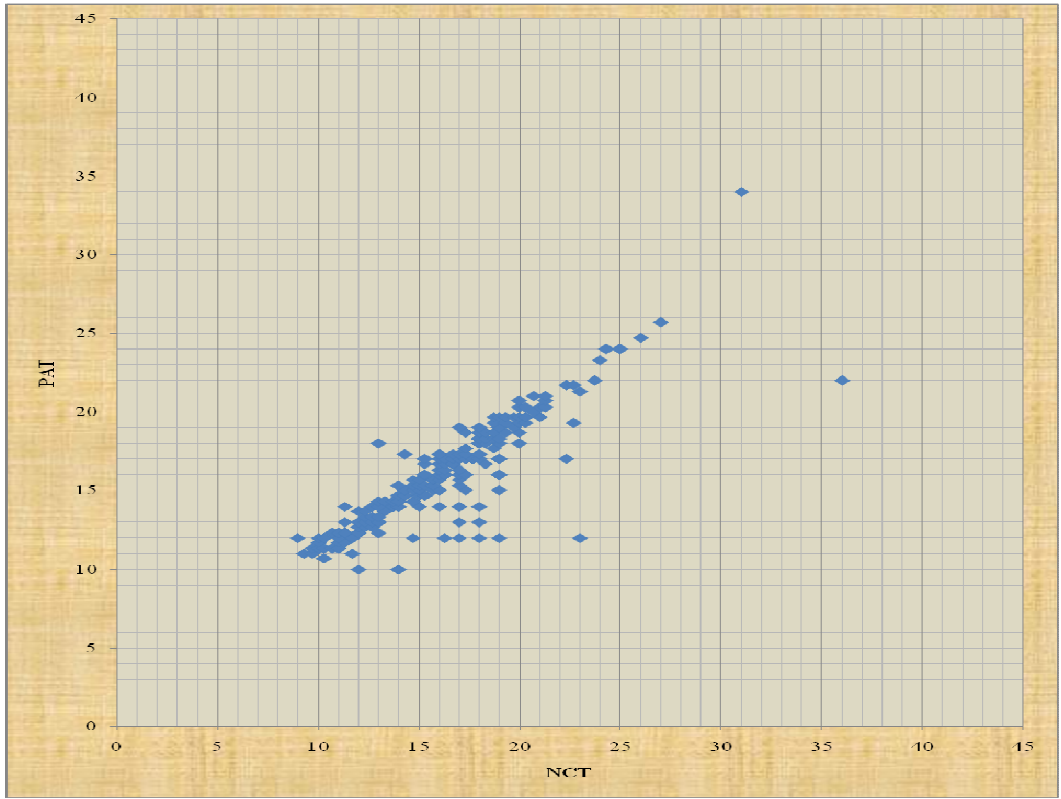
And also shows Table No. 5 that, the Non contact tonometer on the left eyes, compared well with the Perkins applanation tonometer as evidenced by a r values of 0.92,0.88,0.90,0.90 with a P value <0.05 for correlation, for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years respectively, showed significant correlation between tonometers in total (both male and female) participants.

Table-5: Correlation Coefficient of Intraocular Pressure between NCT and PAT among total participants			
Eye	Age (In Years)	r value	p value
Right eye	41-50	0.92	<0.05
	51-60	0.87	<0.05
	61-70	0.87	<0.05
	>70	0.66	<0.05
Left eye	41-50	0.92	<0.05
	51-60	0.88	<0.05
	61-70	0.90	<0.05
	>70	0.90	<0.05

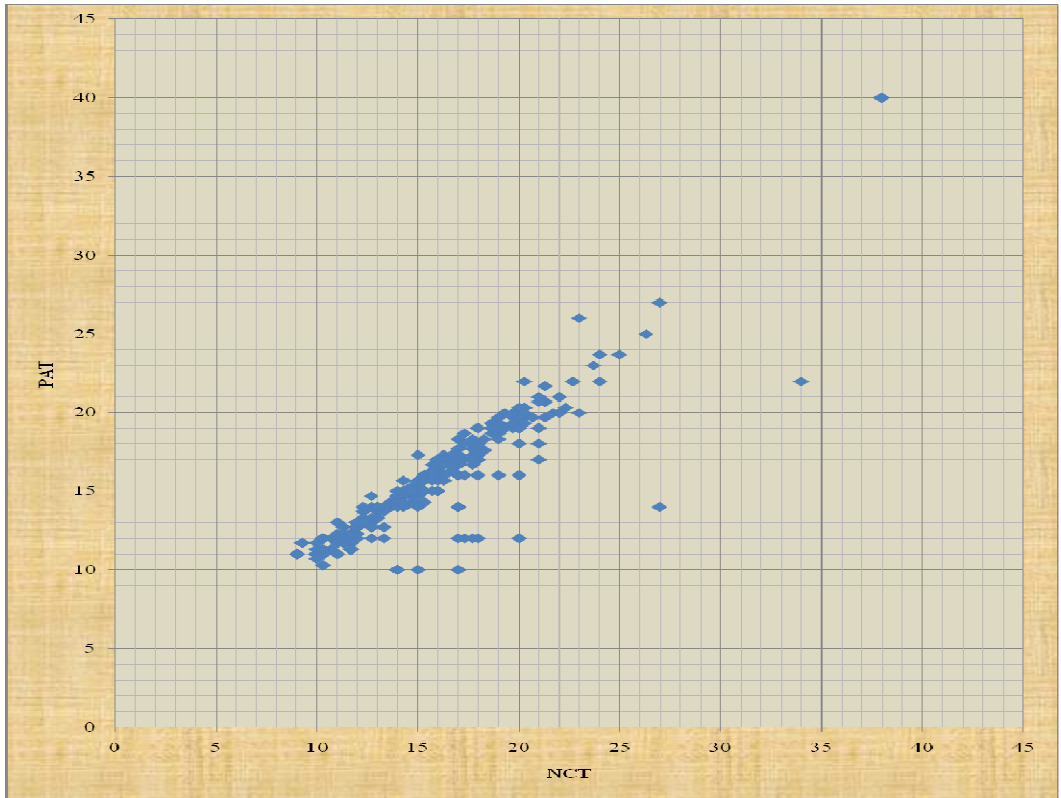
Scattered plot (Graph No. 3) shows strong positive correlation between the Intraocular pressure measured by NCT and PAT for right eye.

Scattered plot (Graph No. 4) shows strong positive correlation between the Intraocular pressure measured by NCT and PAT for left eye.

Graph-3: Scattered plot of Right eye
Intraocular Pressure between PAT and NCT



Graph-4: Scattered plot of Left eye
Intraocular Pressure between PAT and NCT



Sensitivity and specificity of Non contact tonometer with Perkins applanation tonometer. The sensitivity and specificity for the Non contact tonometer were calculated, using an Intraocular pressure of more than or equal to 21 mm Hg with the Perkins applanation tonometer (hand held version of gold standard Goldmann's tonometer) as the standard criterion. The results obtained were tabulated below. Non contact tonometer showed high sensitivity 95.5 and 94.3 for right eye and left eye respectively (right eye more than left eye) i.e. very few false negative results as well as high specificity 94.5 and 99.1 for right eye and left eye respectively (left eye more than right eye) i.e. few false positive results; thus coming across an excellent agreement with Perkins applanation tonometer.

Discussion

The current understanding of glaucoma is inclusive of three entities - the optic nerve head, the visual field and Intraocular pressure. While optic nerve head damage and a consequent field loss are pre-requisites for the diagnosis of glaucoma, the raised Intraocular pressure while commonly being associated with glaucoma, is not necessary for designating an eye as glaucomatous. Visual field loss and degenerative optic neuropathy can occur without an elevation in Intraocular pressure as seen in the normotensive glaucoma patients. Conversely, a good number of eyes with pressures above the accepted normal of 21mm Hg have failed to demonstrate glaucomatous optic nerve head changes or visual field defects. However, raised Intraocular pressure has been demonstrated to cause damage to the optic nerve head and its reduction has consequently retarded the progression of such damage [6-8]. Thus tonometry has gained importance and has become the mainstay of glaucoma screening and monitoring.

Perkins tonometer has potential benefits of portability and non requirement of slit lamp but it has disadvantages of touching the cornea, staining with fluoresceine, risk of infection, risk of corneal abrasion and need for a skilled examiner [9]. At the same time NCT does not require touching the cornea and it can be used safely in early post-operative cases, as the risk of infection is minimal and any resident or health care personal (a Non

ophthalmologist) can be trained to measure IOP with NCT. In this study, with the principle aim to correlate the Intraocular pressure by the Non contact tonometer with the Perkins applanation tonometer, total 260 participants aged more than 40 years were included. According to a study by George R et al.,[2] approximately 11.2 million Indians above 40 years suffer from glaucoma, supports our study to include all participants above the age of 40 years. All 260 participants were subjected to two methods of tonometry - Non Contact Tonometry and Perkins Applanation Tonometry (Perkins under topical anaesthesia with 0.5% Proparacaine eye drops). Non Contact Tonometer readings were recorded first, then Perkins tonometer. Three readings were taken for each method and mean calculated. This was done keeping in mind the Non contact tonometer which records randomly with respect to the cardiac cycle and at very short intervals. Since, the scope for fluctuations is higher and it has been recommended that a minimum of three readings be taken and averaged to give the IOP [10-12].

Statistical Analysis: All characteristics were summarized descriptively. For continuous variables, the summary statistics of N, mean, standard deviation (SD) were used. For categorical data, the number and percentage were used in the data summaries. Bivariate correlation analysis using Pearson's correlation coefficient (r) was used to test the strength and direction of relationships between the interval levels of variables. For continuous data, the differences of the mean analysis variables were tested with the paired t-test. If the p-value is > 0.05, then the results, i.e., the difference between the Intraocular pressure measured by Non contact tonometer and Perkins tonometer were considered to be not significant, shows excellent agreement between the tonometers. Sensitivity-specificity analysis was done to check relative efficiency. Data was analyzed using SPSS software.

Out of 260 participants, 155 (59.6%) were males and 105 (40.4%) were females. Maximum number of participants 104 (40.0%) were in 41-50 years age group. 94

(36.2%) participants were in 51-60 years group, 46 (17.7%) participants in 61-70 years age group and remaining 16 (6.2%) participants in the more than 70 years age group. Mean IOP of right eye with NCT and PAT were 16.0 mm Hg and 15.9 mm Hg respectively with p value of 0.239, for left eye with NCT and PAT were 16.0 mm Hg and 15.8 mm Hg respectively with p value of 0.118, showed that there was no significant difference between the Intraocular pressure measured by the both instruments and suggest fair agreement between NCT and PAT among total participants (both males and females). These findings are comparable with a study done by Prabhakar SK et al. [4].

Mean Intraocular pressure in right eye for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with NCT and PAT were 15.9 mm Hg, 16.2 mm Hg, 16.7 mm Hg, 13.7 mm Hg and 15.8 mm Hg, 16.0 mm Hg, 16.4 mm Hg, 14.0 mm Hg respectively for both tonometers with standard deviation of 3.5, 4.0, 4.4, 2.9 and 3.0, 3.1, 4.3, 2.1 respectively with p values of 0.705, 0.299, 0.396, 0.676, showed there was no significant difference between two tonometers and also a good agreement between two tonometers. These findings are comparable with a study done by Prabhakar SK et al [4]. Mean Intraocular pressure in left eye for both males and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years with NCT and PAT were 15.5 mm Hg, 16.4 mm Hg, 16.6 mm Hg, 15.3 mm Hg and 15.5 mm Hg, 16.0 mm Hg, 16.3 mm Hg, 15.3 mm Hg respectively for both tonometers with standard deviation of 3.4, 4.1, 5.3, 4.4 and 3.0, 3.3, 5.1, 4.2 respectively with p values of 0.914, 0.102, 0.423, 0.99 showed there was no significant difference between two tonometers and also a good agreement between two tonometers. These findings are comparable with a study done by Prabhakar SK et al [4].

In this study, the Non contact tonometer on the right eyes for both males and females, compared well with the Perkins applanation tonometer as evidenced by a Correlation coefficient (r) values of 0.919, 0.83 with a P value <0.05 for correlation respectively, showed significant correlation between tonometers. In this study, the Non contact tonometer on the left eyes for both males and females, compared well with the Perkins applanation tonometer as evidenced by a

Correlation coefficient (r) values of 0.928, 0.862 with a P value <0.05 for correlation respectively, showed significant correlation between tonometers. In this study, the Non contact tonometer on the right eyes, compared well with the Perkins applanation tonometer as evidenced by a Correlation coefficient (r) values of 0.92, 0.87, 0.87, 0.66 with a P value <0.05 for correlation, for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years respectively, showed significant correlation between tonometers. In this study, the Non contact tonometer on the left eyes, compared well with the Perkins applanation tonometer as evidenced by a Correlation coefficient (r) values of 0.92, 0.88, 0.90, 0.90 with a P value <0.05 for correlation, for both male and females in age groups of 41-50 years, 51-60 years, 61-70 years, more than 70 years respectively, showed significant correlation between tonometers.

In this study, the Non contact tonometer on the both eyes compared well with the Perkins applanation tonometer as evidenced by a Correlation coefficient (r) values of 0.879 and 0.894 with a P value <0.05 for correlation respectively, showed significant correlation between tonometers. These findings are comparable with a study done by Prabhakar SK et al [4]. The Non contact tonometer was the first of the tonometers the participants were exposed to. Moreover, all the participants were being exposed to tonometry for the first time. In spite of being aware of the procedure involved, a certain amount of apprehension and therefore some squeezing of the eyelids in anticipation of the air puff occurred as expected. These factors could be attributed to the minor differences in the correlation coefficient in right and left eye for males, females, and in various age groups. The study by Stephen Vernon addressed this issue and he also attributed these variations in his study to apprehension on first exposure to the Non contact tonometer [13]. An essential criterion for a good screening test is high specificity and high sensitivity. The Non contact tonometer has been shown to be a reliable screening tool by Shields [14] and Moseley et al [15].

In this study, a screening criterion of more than or equal to 21 mm Hg with the Perkins applanation tonometer (hand held version of gold standard Goldmann's tonometer) as the standard was used to study the sensitivity and specificity, the Non contact tonometer showed high sensitivity 95.5 and 94.3 for Right eye and Left eye respectively (Right eye more than Left eye) i.e. very few false negative results as well as high specificity 94.5 and 99.1 for Right eye and Left eye respectively (Left eye more than Right eye) i.e. few false positive results; thus coming across an excellent agreement with Perkins applanation tonometer. Our results are comparable with study done by Moseley M. J et al. [15] who adopted screening criterion of greater than or equal to 21 mm Hg, and reported that NCT has sensitivity of 85% and specificity of 95%. The Non contact tonometer gains further credentials as a screening tool since it is easy to operate and can be operated by non medical and paramedical personnel without any observer bias since it records pressures

automatically. Being a Non contact method, the need for disinfection is obviated, thus giving it additional value in mass screening programmes. Its only drawback is its cost. Thus the Non contact tonometer was found to compare well with the Perkins tonometer (hand held version of gold standard Goldmann's applanation tonometer) and confirmed the finding of previous researchers Hsu et al.,[16] and Ogbuehi and Almubrad [17].

Conclusion

The current study showed that, the Non contact tonometer compares favorably with the Perkins applanation tonometer (hand held version of gold standard Goldmann's applanation tonometer) and has an excellent agreement with it. The Non Contact Tonometer can be used as a reliable screening tool.

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