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Indentation, Applanation and Non Contact Tonometry: A Comparative Study

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Abstract:
A comparative study conducted on a discrete population of 130 patients all of whom attended the outpatient department of our Hospital, on a voluntary basis; with an objective to compare and contrast the objective measurement of IOP using the Schiotz indentation tonometer, Applanation tonometer and the non contact air puff tonometer in patients with various refractive errors. In our study, we conclude that; in patients with high myopia (> 6 Diopters) a Perkins Applanation tonometer reads higher than Schiotz and Air puff tonometer. In patients with Hypermetropia, Schiotz tonometer reads higher than Applanation and Air puff tonometer.

Keywords*: Perkins Applanation Tonometer, Schiotz Indentation Tonometer, Air Puff Tonometer*

1. Introduction

Glaucoma is one of the major causes of blindness throughout the world. It causes 15% of preventable blindness in the late adult life (50 - 70 yrs.)[1, 2]. This disease of considerable magnitude can be best dealt by early diagnosis & treatment. But it is very unfortunate that ignorance on the part of patients or insufficient attention of ophthalmologists in many cases especially in borderline cases permit the disease to advance, resulting into blindness.

Despite the great increase in our understanding of disease during past 30-40 yrs; we often have difficulty in establishing an early diagnosis due to many factors, such as "ocular rigidity". The use of tonometry in the diagnosis of glaucoma depends upon the fact of elevated I.O.P. which is one of the characteristic of this disease process except in normal tension glaucoma [3]. There are various methods to measure the I.O.P., for example, digital tonometry, tonometry, Schiotz tonometry, Applanation tonometry, electronic tonometers, etc [4].

The two most practicable methods are Schiotz and Applanation tonometry. The principal objection to indentation type of tonometers (Schiotz tonometer) is that such tonometers do not offer a direct measure of I.O.P. Moreover, measurement of I.O.P. by Schiotz tonometry is significantly affected by scleral rigidity. The importance of scleral rigidity must be kept in mind when Schiotz tonometer is being used.

Friedenwald (1937) and others have devised many methods for estimating the coefficient rigidity, but none is satisfactory, which leads one to conclude that there is considerable variability. In actual practice, it is very difficult to determine the initial I.O.P. value and ocular rigidity using two Schiotz weights (Differential tonometry) since each measurement is subject to appreciable error.

The major development which brought new levels of accuracy to tonometric measurement was the Goldmann applanation tonometer developed in the 1950s. This allowed the flattened area of the cornea to be observed through a slit lamp and through the transparent cone on the eye and using the fixed prismatic vernier measurement system in the cone, a very accurate measurement method was established, which also allowed the patient to remain in a sitting position. The Goldmann tonometer is still the yardstick by which all other tonometers are judged. [6]

Non-contact tonometer used the principle of a jet of air flattening the cornea, detecting the changes in reflective light from the corneal surface, as it was forced from a curved to a flat state. The time taken for a jet of air to flatten the cornea was directly proportional to the IOP. The Keeler Pulsair hand held, non-contact tonometer, which measured the actual pressure required to create an "applanation event" rather than a correlate of time, does not require topical anesthetic and fluorescein.

In most of the cases the I.O.P. value is simply taken from a single measurement and interpreted by means of calibration table, which is valid only for eyes with an average coefficient of ocular rigidity. Controversy still exists regarding the relationship of Schiotz and Applanation tonometry. This study has been undertaken to compare the results of I.O.P. by Schiotz tonometer, Applanation tonometer and Pulsair non contact tonometer and the effect of various factors on the I.O.P. so that an early and the reliable diagnosis of the glaucoma can be done and the possible chance of developing blindness in the future because of glaucoma can be minimized.

2. Aims and Objectives

To compare and contrast the objective measurement of IOP using the Schiotz indentation tonometer, Applanation tonometer and the non contact air puff tonometer in patients with various refractive errors.

3. Material and Methods

This study was conducted on a discrete population of 130 patients all of whom attended the outpatient department of our Hospital, on a voluntary basis. These patients were selected with reference to the following guide lines:

- No specific attempts was made to separate the population on basis of gender.
- The patients selected covered all age groups from 7 to76 years.
- Patients below the age of 7 yrs. were not included in the study as the anticipated difficulties of performing applanation tonometry and Schiotz tonometry in this sub group were evident.

Patients who had been rendered aphakic recently as well as those with established cases of POAG on whom filtering Surgery had been performed recently have been excluded from study as the hazards of performing Schiotz indentation tonometry were kept in mind.

Those who were known to be suffering from any systemic diseases were excluded from studies. The selected population was then subjected to a rigorous ocular evaluation which included a detailed examination of the anterior segment using both diffuse illumination and slit lamp biomicroscopy. The ocular fundus was evaluated to assess the health of optic nerve head and to rule out any other concomitant ocular pathology. A meticulous objective determination of the IOP of two eyes of patients was then performed in the following manner:

The instruments used to determine IOP were Schiotz tonometer, Goldman applanation tonometer and Keeler Pulsair non contact tonometer. Three readings were taken with each instrument and average value is determined with an interval of five minutes between each instrument and one minute between each reading. IOP measured first by Keeler Pulsair non contact tonometer then applanation tonometer and lastly with Schiotz tonometer with 5.5 gmwt. The IOP noted were recorded with a view to analyze the same.

4. Observations

Total of 130 cases were selected from outpatient department of our Hospital

5. Distrtbution of Cases

Table (1) Gender and refractive status of the studied population. The table (1) shows the total population of 130 patients divided into the following sub groups.

GROUPS	MALES	FEMALES	TOTAL
MYOPIA	43	16	59(45.4%)
HYPERMETROPIA	29	13	42(32.3%)
PAOG	20	09	29(22.3%)
TOTAL	92	38	130(100%)

Table 1

Table (2) Relations of IOP measurement by various Tonometric methods in sub group of myopic patients include myopia of less than 6 Diopters. All values are in mm of Hg.

Tonometric Methods	Mean I.O.P. (+/-S.D)		
	Right Eye	Left Eye	Average
Air Puff	11.06 +/- 1.24	11.0 +/- 1.26	11.03 +/- 1.21
Applanation	12.34 +/- 2.58	12.57 +/- 2.44	12.46+/- 2.53
Schiotz	12.40 +/- 1.72	12.62 +/- 1.70	12.51 +/- 0.055

Comparison of Tonometer	'P' value	significance
Air Puff v/s Applanation	P < 0.05	SIGNIFICANT
Air Puff v/s Schiotz	P < 0.05	SIGNIFICANT
Applanation v/s Schiotz	P >0.05	NOT SIGNIFICANT

Table 2

From this table it is evident that difference between average IOP in Schiotz and Applanation tonometer is 0.055 i.e. insignificant in clinical practice. Average IOP by Schiotz and air puff tonometer shows a difference of 1.465 where in Air puff shows numerically lower measurement of IOP than does Schiotz tonometer and this difference is SIGNIFICANT. Average IOP by Applanation and air puff tonometer shows a difference of 1 .41 where in Air Puff tonometer shows numerically lower measurement of IOP as is the case with Schiotz tonometer and this difference too is SIGNIFICANT.

Table (3): Relations of IOP measurement by various Tonometric methods in sub group of myopic patients include myopia of more than 6 Diopters.

Tonometric Methods	Mean I.O.P. (+/-S.D)		
	Right Eye	Left Eye	Average
Air Puff	11.33 +/- 1.05	11.16 +/- 1.13	11.25 +/- 1.15
Applanation	14.50 +/- 2.23	15.00 +/- 2.21	14.75 +/- 2.20
Schiotz	13.50 +/- 2.50	13.93 +/- 2.39	13.72 +/- 2.41

Comparison of Tonometer	'P' value	significance
Air Puff v/s Applanation	P < 0.05	SIGNIFICANT
Air Puff v/s Schiotz	P < 0.05	SIGNIFICANT
Applanation v/s Schiotz	P >0.05	NOT SIGNIFICANT

Table 3

From this table it is evident that difference between average IOP in Schiotz and Applanation tonometer is 1.035 where in applanation tonometer shows numerically higher measurement of IOP than does Schiotz tonometer and this is not significant. Average IOP by Schiotz and air puff tonometer shows a difference of 2.47 where in Air puff shows numerically lower measurement of IOP than does Schiotz tonometer and this difference is SIGNIITICANT. Average IOP by Applanation and air puff tonometer shows a difference of 3.505. Again, Air Puff tonometer shows numerically lower measurement of IOP than does Applanation and this difference is SIGNIFICANT.

Table (4): Relation of IOP measurement by various Tonometric methods in Hypermetropic patients. All values in mms. Of Hg.

Tonometric Methods	Mean I.O.P. (+/-S.D)		
	Right Eye	Left Eye	Average
Air Puff	13.35 +/- 2.33	13.57 +/- 2.30	13.46 +/- 2.31
Applanation	13.57 +/- 3.07	14.00 +/- 2.93	13.79+/- 2.98
Schiotz	14.79 +/- 2.56	15.23 +/- 2.48	15.01 +/- 2.51

Table 4

From this table it is evident that difference between average IOP in Schiotz and Applanation tonometer is 1.225 where in Schiotz tonometer shows numerically higher measurement of IOP than does applanation tonometer and this is SIGNIFICANT. Average IOP by Schiotz and air puff tonometer shows a difference of 1.55 where in Air puff shows numerically lower measurement of IOP than does Schiotz tonometer and this difference is SIGNIFICANT. Average IOP by Applanation and air puff tonometer shows a difference of 0.325. Again, Air Puff tonometer shows numerically lower measurement of IOP than does Applanation and this difference is not significant

Comparison of Tonometer	'P' value	significance
Air Puff v/s Applanation	P > 0.05	NOT SIGNIFICANT
Air Puff v/s Schiotz	P < 0.05	SIGNIFICANT
Applanation v/s Schiotz	P < 0.05	SIGNIFICANT

Table 5

6. Results and Discussion

When a discrete population of apparently normal eyes was examined by Air puff, Applanation and Schiotz tonometry; the agreement between the values of the airthematic averages obtained in individual eye, significant difference in estimates of IOP of same eye obtained by three methods was shown to be in concordance with a desirable frequency in clinically important range of IOP.

DISTRIBUTION OF CASES: In the present study of 130 patients, for the sake of convenience cases were divided into three groups, Hypermetropia (42), myopia (59) and patients with POAG (29). They are again divided on the basis of gender. 92 patients were male and 38 cases were females. The subgroups of myopic patients were further divided into high myopia (more than 6 Diopters) and low myopia (less than 6 Diopters). Cases were also divided age wise into three groups ranging from 7 to 7 6 years, group 1: 7 -20 years, group 2:21 - 45 years and group 3 : 46 - 76 years. Glaucoma cases were also divided according to refractive state of two eyes. In 29 cases with POAG, 18 were with myopia and 11 were with Hypermetropia.

7. Relation of Myopia to Various Parameters and Tonometric Methods

In the present study; the mean Applanation I.O.P. was nearly the same as the mean Schiotz 5.5 gm.wt. Difference being 0.05 which is not significant (P > 0.05) in the low myopic patients while in the high myopic patients the mean Applanation I.O.P. was higher than the mean Schiotz 5.5 gm.wt. Value difference being 1.03 which is also not significant (P > 0.05).

This was in accordance with the studies of Isabelle McGarry and Eveanstion (1960) who found that Applanation tonometry showed higher I.O.P.s in eyes having a low scleral rigidity. Similarly, Smith et al (1967), Sorsby et al (1957), Schmidt et al

and Abdulla and Hamid (1970) and Temlinson & Phillips (1970) reported higher IOP readings with Applanation as compared to Schiotz tonometer in myopic patients[14,15,16].
Smith et al (1964) and Jackson et al (1965) showed the difference between Applanation and Schiotz readings to fall within the range of 1.3 mms. of Hg. Similarly, Schwarta (1966) also reported ; discrepancy of 1.21 mms. of Hg between Applanation and Schiotz measurements[14,16,18,19].
Jain and Chaudhary (1974) reported statistically significant difference between Schiotz and Applanation tonometry in high and moderate myopia. And Cordova (1970) states that in high myopic patients the Applanation tonometer would be the tonometer of choice. The slight difference in the results of our studies could be due to the discrete population, which we are studying; having different parameters as compared to the population studied by the other investigators [19].
We found that the mean IOP by Air puff tonometer in the subgroup of population "low myopia" were lower than both Schiotz and Applanation tonometer wherein the difference with both is almost the same (1.48 & 1.43 respectively). The mean IOP difference b/w Air puff tonometer and Applanation is higher (3.505) than Air puff and Schiotz (2.47) in the high myopic patients.
The studies conducted by Derka et al (1980), Yucel AA, Sturmer J. Glorr B (1990), Lagerlof (1990), Brencher, Kohl, Reinke and Yolton (1991) proved that Pulse air read low readings across the entire range of IOP. Studies by Draeger, Jessen and Haselmann (1975) and Buscemi, Capoferri, Garavagllia, Nassivera and Nucci (1991) have shown that the Air puff tonometer is a valuable choice for screening purposes [20,21,22,23,25,26,27,28].
Our, studies correlate with the above studies and the difference although being significant gives us a fair idea of the intraocular pressure of the patient. The lower readings with Schiotz tonometer probably was due to the low scleral rigidity in this subgroup but we are unable to explain the low readings with Air puff tonometer in comparison with Applanation tonometer.

8. Relation of Hypermetropia to Various Parlmeters and Tonometric Methods

In this study, we found that mean Schiotz IOP was higher 1.225 than Applanation IOP. The studies conducted by Sorsby et al (1957), Schimdt et al (1956) and Temlinson Phillips (1970) have reported lower tensions by Applanation tonometer as compared Schiotz tonometer in hypermetropes [34,35]
Studies conducted by Jackson (1965) and Schwarta (1966) have reported differences of 1.3 and 1.21 mms. of Hg respectively between Applanation and Schiotz tonometry. In our studies, we got a difference 1.22 mms. of Hg between the two tonometers. Jain and Chaudhary (1974) reported non-significant difference between Schiotz and Applanation tonometer in hypermetropes[4,7,13,14,15,16,17] but in our studies we have got a significant difference ($p < 0.05$). This could be due to the study of discrete population having slightly different parameters as compared to population in the study.
We also found that mean IOP in Air puff tonometer in this sub group of population were lower than both Schiotz and Applanation IOP. Wherein difference between Air puff IOP and Schiotz is more than 1.55 than with Applanation 0.325.
Studies conducted by Shields (1980), Brencher, Kohl, Reinke and Yolton (1991) and Buscemi, Capoferri, Garagagllia, Nassivera and Nucci (1991) have reported Air puff tonometer to measure low readings across the entire range of IOP and the Air puff tonometer is less reliable than the conventional Applanation and Schiotz tonometer[22,23,24,25,28,29] . This is in accordance to the findings of our study.

9. Conclusion

In this study, we have compared objective measurement of IOP with Schiotz indentation tonometer, Perkins Applanation tonometer and a Keeler Pulsair non contact tonometer of 130 patients who attended outpatient department of our hospital. In our study, we conclude that: In patients with high myopia (> 6 Diopters) a Perkins Applanation tonometer reads higher than Schiotz and Air puff tonometer. In patients with Hypermetropia, Schiotz tonometer reads higher than Applanation and Air puff tonometer
In subgroup population of high myopia we are unable to explain the observed IOP difference between Air puff and Applanation tonometry (3.505). Since this study is done on small population, need for further evaluation on large population probably would enable us to explain the same.

10. References

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