Comparison of the CT80 Non-Contact Tonometer and Goldmann Applanation Tonometer

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Abstract

Aim of Study: To compare the intraocular pressure (IOP) measurements obtained with the computerized tonometer 80 non-contact tonometer (CT80 NCT) and those with the Goldmann applanation tonometer (GAT) in patients with normal and high IOP.

Patients and Methods: This observational clinical study comprised 187 eyes of 105 patients (54 men and 51 women), who had their IOP readings measured with both the CT80 NCT and the GAT. The study patients were recruited from the Department of Ophthalmology at Aseer Central Hospital in Abha, Saudi Arabia. The agreement between the two techniques was determined by regression analysis and the Bland-Altman method.

Results: The mean IOP of the study population was 13.28±4.32mmHg as measured by the CT80 NCT and 14.6±4.15mmHg as measured by the GAT. There was a strong positive correlation between tonometry measured by both techniques (r=+0.836, p<0.001). Bland-Altman analysis revealed the absence of any fixed bias and a comparable performance between the two instruments.

Conclusion: The CT80 NCT provides IOP measurements that are comparable to those obtained by the GAT in patients with normal and high IOP.

Key Words: Applanation tonometer – Intraocular pressure – Non-contact tonometer.

Introduction

INTRAOCULAR pressure (IOP) is measured based on the force used to achieve applanation (flattening of a convex surface) of the cornea with a puff of air. This force increases linearly with time. When an optoelectronic system detects applanation, the air pump is halted electromechanically. The time taken for light rays to reach the optoelectronic monitoring device is then converted into an IOP reading (measured in mmHg) [1].

The Goldmann applanation tonometer (GAT) is considered the gold standard in tonometry [2]. Although the GAT was considered the most widely used tonometry method, another type of tonometer, known as the non-contact tonometer (NCT), has been developed and available for clinical use over the past 3 decades. One of these instruments is the computerized tonometer 80 (CT80). The advantages of using NCTs include the following:

- No anesthetic agents or stains are required.
- The lack of direct contact also lowers the possibility of cross-infection.
- Highly trained personnel are not required to perform the procedure.
- Repeated measurements do not reduce IOP caused by the ocular massage effect, which occurs with Goldmann tonometry [3,4].

One possible disadvantage of using NCT is the possibility of infection caused by micro-aerosol formation [5]. Several previous studies have compared IOP measurements made with the NCT and the GAT in normotensive patients [6].

The purpose of the present study was to compare IOP measurements made with the CT80 NCT and the GAT in patients with normal and high IOP.

Patients and Methods

An observational clinical study of consecutive patients who had their IOP measured with both the NCT and the GAT was conducted. A Total of 187 eyes of 105 patients were studied. The study population (mean age, 52.1 ± 17.1 years; median age, 55 years) consisted of 54 men (51.4%) and 51 women (48.6%), as shown in Table (1). Patients were recruited from the Department of Ophthalmology at Aseer Central Hospital in Abha, Saudi Arabia. Patients with keratoconus, corneal scarring,
corneal edema, or previous ocular surgery were excluded from the study. Approval from the Institutional Review Board Committee was obtained. All patients included in this study signed a written consent form to have their IOP measured with both the CT80 and GAT techniques.

All IOP readings (average of three CT80 NCT readings followed by one GAT reading for each eye) were obtained from patients in the sitting position by the same operator. To avoid any possibility of IOP reduction by anterior chamber compression with the GAT, the IOP readings were measured first with the CT80 NCT (Topcon, Japan) and then with the GAT (Haag Streit, Switzerland). After instillation of topical proparacaine and fluorescein drops, IOP readings were obtained with a calibrated Haag-Streit GAT. Because IOP measurements tend to decrease upon multiple testing with the GAT, only one IOP reading was taken with the GAT.

IOP was considered to be high with IOP measurements of more than 22mmHg. In all patients, central corneal thickness was between 500 and 550 µm using Galilei dual-Scheimpflug analyzer (Ziemer, Switzerland). Correlation and linear regression analysis was used to evaluate the association between tonometry measured by CT80 and tonometry measured by GAT.

**Statistical analysis:**

Paired and unpaired t-test was applied to compare readings by both tonometers. The Bland-Altman plots were used to evaluate the agreement between IOP measurements obtained by GAT and CT80. The differences between measurements for each parameter were plotted against their mean. These plots allow to investigate the existence of any systematic difference between the measurements (i.e., a fixed bias). The mean difference is the estimated bias, and the standard deviation of the differences measures the random fluctuations around this mean. If the mean value of the difference differs significantly from 0 on the basis of a 1-sample t-test, this indicates the presence of fixed bias. Bland-Altman plots also were used to investigate any possible relationship of the discrepancies between the measurements and the mean value (i.e., a proportional bias). The existence of proportional bias indicates that the methods do not agree equally through the range of measurements, that is, the limits of agreement will depend on the actual measurement. To evaluate this relationship formally, the difference between the methods was regressed on the average of the 2 methods [7]. p-values less than 0.05 were considered statistically significant.

**Results**

The NCT measurements ranged from 5 to 37mmHg (mean, 13.28±4.32mmHg; median, 13mmHg), whereas the GAT measurements ranged from 6 to 34mmHg (mean, 14.6±4.15mmHg; median, 14mmHg), with no significant difference between readings, as shown in Table (2).

The study revealed a strong positive correlation between tonometry measured by both techniques ($r=+0.836, p<0.001$). A Linear regression analysis of CT80 NCT versus GAT measurements (Fig. 1) revealed a slope of 0.81 with $r^2$ of 0.7. The analysis shows that 70% of the variability in GAT tonometry can be explained by CT-80 tonometry.

Table (1): Personal characteristics of study sample.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age:</td>
<td>Mean±SD 52.1±17.1 years</td>
</tr>
<tr>
<td>Gender:</td>
<td>Males 54 (51.4%); Females 51 (48.6%)</td>
</tr>
</tbody>
</table>

Table (2): Intro-ocular pressure measurements (mmHg).

<table>
<thead>
<tr>
<th>Tonometer type</th>
<th>Range</th>
<th>Median</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computerized tonometer</td>
<td>5-37</td>
<td>13</td>
<td>13.28±4.32</td>
</tr>
<tr>
<td>80 non-contact</td>
<td>6-34</td>
<td>14</td>
<td>14.60±4.15</td>
</tr>
<tr>
<td>Goldmann applanation</td>
<td></td>
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![Fig. (1): Linear regression analysis of CT-80 NCT and GAT measurements of IOP.](image)

Bland-Altman analysis showed an estimated bias value of 0.3 and a standard error of 0.19. The mean difference is the estimated bias, and the standard deviation of the differences measures the random fluctuations around this mean. 1-sample t-test statistics ($t=0.75, p=0.142$) showed that the mean value of the difference did not differ significantly from 0, indicating the absence of any fixed bias.
bias and a comparable performance between the two instruments.

**Discussion**

Tonometry is invaluable in the screening and follow-up of glaucoma patients. Conventionally, the GAT is considered the gold standard in tonometry, and the NCT is used as an alternative. In an effort to determine the agreement between the two techniques, this study compares IOP measurements performed with the GAT and the NCT in patients with normal and high IOP.

Some studies have shown clinical agreement between the two devices [8,9], whereas other studies have reported an extreme range of IOP readings [10,11]. Other studies have reported a tendency to overestimate low pressures and underestimate high pressures in earlier NCT models compared with the Goldmann tonometry [12,13]. The results from this study show a statistically insignificant but consistently lower average reading taken with the CT80 non-contact tonometer compared with the Goldmann tonometer in normal and high IOP groups.

In the present study, the correlation of measurements in the linear regression analysis and Bland-Altman method revealed close agreement between measurements obtained with the CT80 NCT and those with the GAT.

Although all tonometers, including the GAT and the NCT, are affected by corneal thickness, rigidity, curvature, and hydration [14-16], in this study the CT80 NCT identified all eyes with IOP >21mmHg. However, further evaluation with a larger sample size is needed to determine the accuracy of the device in cases with high IOP.

In conclusion, this study shows that the CT80 NCT provides an accurate measurement of IOP in patients with normal and high IOP when compared with the GAT. Further studies are needed to confirm these findings.

**References**


