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A COMPARISON OF KEELER NONCONTACT TONOMETRY WITH REICHERT NONCONTACT TONOMETRY

by

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A thesis submitted to the faculty of the
College of Optometry
Pacific University
Forest Grove, Oregon
for the degree of
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Advisor: Paul Kohl, O.D.
Abstract

Eighty subjects between 21 and 48 years of age were measured for IOP on both the Keeler Pulsair and Reichert NCT tonometers. Statistical analysis revealed a high correlation ($r=\sim0.82$) and no significant difference in the measured IOP between these two instruments. Both devices proved to be clinically useful in the measurement of intraocular pressure, especially as a screening tool.

Key Words:

Intraocular pressure (IOP), Keeler Pulsair tonometer, Reichert NCT tonometer, noncontact tonometry.
Introduction

Tonometry is the measurement of the intraocular pressure (IOP) and is important in the early detection of glaucoma. IOP results from the forces exerted on the tunics of the eye by the aqueous humor. Clinically, IOP can be measured noninvasively with remarkable accuracy, reliability, and reproducibility with various tonometers. One of the most routinely used instruments in optometric practice is the American Optical (AO)/Reichert Noncontact Tonometer. This device uses a pulse of air to applanate the cornea, thus measuring the resistant tension inside the eye. A newer, hand-held device which also uses an air pulse is the Keeler Pulsair Noncontact Tonometer. This study will attempt to determine whether a significant difference exists between the measurement of IOP by these two noncontact tonometers. The comparison of these two existing noncontact tonometers is necessary as both are used clinically and any significant differences in their measurements should be known. Also, any procedural advantages/limitations between the two instruments should be investigated. This
information should help eye care professionals evaluate the merits of each of these devices.

**Methods**

Eighty subjects between the ages of 21 and 48 were tested at the Pacific University College of Optometry Family Vision Center. Subjects were selected at random from optometry faculty, staff, students, and spouses. No subjects were excluded from this study.

A brief history was taken and the experiment was explained to each subject prior to testing. All testing was performed by two optometry students in their third academic year. Subjects were seated while being tested. Testing began with the Reichert NCT II for one half of the subjects and with the Keeler (J-series) for the other half. Four readings per eye were taken with each device. Measurements were alternated between right and left eye for both instruments. Examiners alternated between instruments for each subject. Half of all tests started with the right eye and half with the left eye. All measurements were taken in the standard operating mode of each device (i.e. no override was necessary). After testing,
each subject filled out a brief survey concerning instrument preference. (See Appendix A).

Both a within-instrument and between-instrument analysis was utilized. A paired t-test was performed on the mean IOP readings and the mean range of IOP readings using each subject as their own control. Also, an analysis of variance (ANOVA) was performed for each instrument to see if the four trials and their mean were significantly different for each eye, both within and between instruments. Finally, a comparison of mean IOP between right and left eye for each subject was evaluated using a t-test.

Results

IOP data was analyzed by instrument, by eye, and by trial (4 per eye). Mean IOP for each instrument, by eye, was 12.22mmHg Reichert NCT OD, 12.04mmHg Reichert NCT OS, 12.33mmHg Keeler OD, and 12.41mmHg Keeler OS (See Table 1). Standard deviations for all trials were between 2.62mmHg and 3.76mmHg. The overall range of IOP values for the Keeler was 4mmHg to 31mmHg, and for Reichert NCT 4mmHg to 24mmHg. The maximum range for any eye was
8mmHg for Reichert NCT, and 17mmHg for Keeler. For standard deviation of ranges see Table 1. Paired t-tests using a 95% level of significance revealed no significant differences in the means between Reichert right and left eyes, Reichert right and Keeler right eyes, or Keeler right and Keeler left eyes. There was a significant difference however between Reichert left and Keeler left eye means (t=.0384, p<.05). The mean of the range (high to low reading) for each instrument, by eye, was 3.01mmHg Reichert OD, 2.80mmHg Reichert OS, 4.21mmHg Keeler OD, and 4.19mmHg Keeler OS.

A one-way analysis of variance (ANOVA) was performed both within and between instruments using a 95% level of significance. A Scheffe F-test post hoc analysis was utilized to determine whether significant differences existed between any of the four trials on either eye for either instrument. The only significant differences in IOP readings were between the Reichert OS first and fourth trials (Scheffe 3.228, p<.05), and the Reichert OS second and fourth trials (Scheffe 3.002, p<.05). Correlation coefficients between Reichert and
Keeler values were $r=0.813$ and 0.821 for right and left eyes respectively.

**Discussion**

The results of this investigation show that there is a high correlation between these two instruments, higher than that reported in a similar study by Brown and DaRin (1) who found a correlation of 0.576 testing right eyes of 67 patients aged 20 to 88 years. This correlation increased to 0.603 when their data was screened to eliminate extreme readings. One explanation of the differences between these studies may simply be population characteristics. Our population was comprised of a younger and more narrow age range, and was demographically more specific (i.e. an optometric campus population). Other explanations for the difference in correlation are possible differences between instrument models, calibration, age, and shipment and repair histories than the devices Brown and DaRin used.

A few studies have compared the use of Goldmann applanation tonometry to Keeler Pulsair tonometry. Fisher, Watson, and
Spaeth(2) report correlations for the Keeler Pulsair vs. paired Goldmann readings of $r=0.88$ to 0.95 and standard deviations of 1.56 to 2.66mmHg. Their results did not show any increase in the standard deviation at IOP's up to 50mmHg. Sponsel, et.al.(3) in a study using both post mortem and living eyes found strong linear relationships between Goldmann and Keeler IOP readings, with correlation coefficients ranging from 0.79 to 0.97. However, they found that the Pulsair tended to read low at IOP's above the normal range. Moseley, Evans, and Fielder(4) found a correlation of 0.91 between Keeler and Goldmann readings. They also found that at low pressures (<10mmHg) the Pulsair tended to overestimate Goldmann pressures while at high pressures (>19mmHg) the Keeler underestimates Goldmann readings. No significant difference between readings obtained with either method was found between 10 and 19mmHg.

The results of our post-testing survey showed that the Keeler instrument was overwhelmingly favored. 80% of subjects preferred the Keeler, 15% had no preference, and 5% of subjects preferred the
Reichert NCT. Reasons cited for Keeler preference included a softer puff of air, less apprehension, a less startling air puff, greater comfort, and less noise.

Conclusion

Our study shows a high correlation between Keeler and Reichert air puff tonometry in the limited IOP range tested. Given the high correlation between Keeler and Reichert NCT, as well as the high correlation between Keeler and Goldmann from the literature reviewed, combined with the reported patient preference for the Keeler along with its portability, hand-held feature, and usefulness with special populations, may make the Pulsair an instrument of choice when choosing an air puff tonometer.

While statistical analysis revealed no significant difference between either of these two instruments, we would suggest multiple readings with either instrument, but especially the Keeler, to insure greater accuracy of IOP tested. This recommendation stems from occasional large range findings and reports by other investigators of
variable readings when compared to Goldmann, in particular low Keeler findings at high IOP.
Acknowledgments

We would like to thank Dr. Paul Kohl for his assistance with this study.

References

APPENDIX A

PATIENT SURVEY

I preferred: AO NCT KEELER NO PREFERENCE (please circle one)

Why? ____________________________________________

_________________________________________________
REGRESSION ANALYSIS SCATTERGRAM

Figure 1.

\[ y = 0.977x + 0.175, \text{ R-squared: } 0.661 \]

\[ y = 0.841x + 1.608, \text{ R-squared: } 0.674 \]
<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Max. Range</th>
<th>Mean of Range</th>
<th>SD of Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>AO OD</td>
<td>12.219</td>
<td>2.757</td>
<td>8mmHg</td>
<td>3.013</td>
<td>1.782</td>
</tr>
<tr>
<td>AO OS</td>
<td>12.041</td>
<td>2.669</td>
<td>8mmHg</td>
<td>2.800</td>
<td>1.602</td>
</tr>
<tr>
<td>Keeler OD</td>
<td>12.325</td>
<td>2.293</td>
<td>12mmHg</td>
<td>4.213</td>
<td>2.079</td>
</tr>
<tr>
<td>Keeler OS</td>
<td>12.413</td>
<td>2.608</td>
<td>17mmHg</td>
<td>4.188</td>
<td>2.566</td>
</tr>
</tbody>
</table>