Estimation of pupil size using a digital camera

Avelino L. Zapanta Jr., MD
Jerome S. Sarmiento, MD
Carlos Alberto, MD
Monserat A. Zapanta, MD

1Fatima Medical Center
Valenzuela City, Philippines

2St. Luke’s Medical Center
Quezon City, Philippines

ABSTRACT

Purpose
To compare pupil-size determination using a digital camera with the Rosenbaum-pupil-comparison and the millimeter-ruler methods.

Methods
The pupil size of 30 eyes of 15 medical students with a mean age of 27 years was measured by two examiners using a digital camera, Rosenbaum pupil comparison, and direct millimeter rule. Both examiners determined the mean pupil sizes for bright, dim, and dark settings.

Results
The mean pupil size as measured by both examiners at bright and dim light conditions was 5.6 mm (range 4.5 to 7.5) and 6.3 mm (range 4.5 to 8.0) respectively. The mean measurement for both examiners for dark is 7.0 (range 6.5 to 7.5). Only the digital camera was able to measure in dark setting with mean of 7.0 mm (range 6.5 to 7.5) for both examiners. Inter-examiner difference was lowest for the digital photography in all simulated settings.

Conclusion
The use of digital camera in determining pupil size was comparable to Rosenbaum chart and direct millimeter rule with lower inter-examiner differences.

Keywords: Digital camera, Pupil size, Rosenbaum pupil comparison
PUPIL size is important in performing laser-assisted in situ keratomileusis (LASIK). It has been shown that patients with large pupils express dissatisfaction with their surgery.\(^1\) While most parameters measured before LASIK allow repeatable measurements with consistent results, pupil size has been the most difficult and inconsistent.\(^3\)

Many devices have been developed for measuring pupil size, but these can be very expensive. One of these devices is an infrared video camera that can calculate the average pupil size of 10 pupil images captured in 2 seconds. It can measure the pupil in 3 adjustable light settings (bright, dim, very dark). The instrument is accurate up to ± 0.10 mm.\(^6\) Although accuracy and reliability are factors in choosing a device, one limiting factor that a clinician or center considers is cost. Currently, the Colvard infrared pupillometer is considered the gold standard for pupil measurement.\(^4\)

This paper introduces a method of pupil-size measurement using a digital camera. A study by Twa has shown that estimation of pupil size by digital photography, though not fast in getting a result, was repeatable and more accurate than estimates using other clinical methods.\(^5\)

Unlike the Twa study, where a standard measurement (infrared video recorder) was assigned as reference and 4 other methods of measurements were used (ruler, semicircular templates, Colvard pupillometry, digital camera), this study had no standard reference and used only 3 methods. The three methods were treated equally.

**METHODOLOGY**

Fifteen volunteer medical students 23 to 36 years old (mean 27) with a pair of healthy eyes with normal pupil functions were enrolled in the study. Informed consent was taken. Excluded were those with history of eye trauma, intraocular surgery, and use of medicines (amphetamines, opiates) that could alter pupil function.

Each of the subjects underwent slit-lamp examination of the external and posterior part of the eye after which two examiners measured their pupil size. The digital photo measurements using a Sony DSC-P10 digital camera (Sony Electronics, Oradell, NJ, USA) were compared with the measurement taken with the use of Rosenbaum pupil-comparison gauge and direct millimeter rule.

The digital camera with 22 mm lens and 6.1x magnification was mounted on a tripod and placed 53 centimeters in front of the subject’s eye. The subject was positioned with the chin resting on the slit-lamp table (the slit-lamp was removed for this purpose). The camera was set up to take photos of the right eye of all the subjects first, and then repositioned for the left eye. The digital camera was set to automatic flash. The camera’s shutter speed was fast enough to capture the image before the pupil could react to the flash. A light meter measured the change in the lighting condition inside the room (4 m x 4 m). One thousand lux was used for bright, 10 lux for dim, and < 1 lux for dark. Measurements in bright setting were done first, followed by dim, then dark. The subjects were allowed 5 minutes to adapt to each lighting condition.

To minimize accommodation, the subjects were asked to fixate at a target coming from a laser pointer at a distance of 4 m. A white ruler was placed just under the lower lid and included in the photo to serve as a gauge.

The photos were enlarged using Adobe Photoshop (Adobe Systems Inc., San Jose, CA, USA). A line was made from edge to edge of the pupil and the measurement was taken by comparing the length of the line to the ruler placed under the lid.

The size of each subject’s pupils was estimated using the Rosenbaum chart. The chart was placed at the temporal side of each subject with the printed comparison gauge at the level of the cornea. The subject’s pupil was compared with the different diameters from the gauge. This procedure was repeated for both eyes on all subjects. Half of a millimeter is added to the reading if the pupil diameter is in between two gauges.

The horizontal diameter of the pupils was also measured using a regular millimeter ruler. The ruler was placed immediately underneath the lower eyelids. This procedure was repeated for both eyes.

**RESULTS**

The mean pupil sizes in bright light were 5.68 mm for examiner I and 5.3 mm for examiner II using the Rosenbaum method, 6.0 mm for examiner I and 6.13 mm for examiner II using the millimeter rule, and 6.0 mm for examiner I and 5.9 mm for examiner II using the digital camera (Table 1).

In dim conditions, examiner I had a mean pupil-size estimation of 6.1 mm using the Rosenbaum, 6.6 mm with the millimeter rule, and 6.53 mm with the digital camera. Examiner II recorded it at 6.13 mm using the Rosenbaum, 6.58 mm with the millimeter rule, and 6.51 mm with the digital camera.

In dark conditions, the mean pupil size using the digital camera was 7.0 mm for examiner I and 7.03 mm for examiner II. Rosenbaum and millimeter rule could not be used.

Using F ratio as test statistic in determining the equality of means in ANOVA (analysis of variance), the mean pupil sizes using the three methods in bright and dim light conditions were equal. There was no difference in the measurements taken with the digital camera, Rosenbaum chart, and millimeter rule.
DISCUSSION

Digital photography method had larger estimates of pupil size in bright lighting, with a 0.46 mm difference from Rosenbaum and 0.12 mm from the millimeter rule methods. The differences were not statistically significant. In dim lighting, the millimeter rule method was 0.09 mm larger than digital photography while the Rosenbaum method had the lowest result.

The interexaminer-measurement difference for digital photography method was lowest in all simulated conditions, 0.1 mm for bright and 0.02 mm for dim. Rosenbaum had the highest interexaminer-measurement difference at 0.38 mm for bright and 0.03 for dim. In dark setting where the examiners could no longer take measurements with either the Rosenbaum chart or millimeter ruler, the digital camera showed a 0.03 mm interexaminer-measurement difference.

The interexaminer bias was lowest for the digital camera due most likely to the stillness of the pupil during measurement. Other advantages include capability of measurements under dark conditions and easy storage of the digital images for future reference.

Table 1. Mean pupil measurements.

<table>
<thead>
<tr>
<th>Lighting Condition</th>
<th>Rosenbaum Examiner I</th>
<th>Rosenbaum Examiner II</th>
<th>Millimeter Rule Examiner I</th>
<th>Millimeter Rule Examiner II</th>
<th>Digital Camera Examiner I</th>
<th>Digital Camera Examiner II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bright</td>
<td>5.68</td>
<td>5.30</td>
<td>6.00</td>
<td>6.13</td>
<td>6.00</td>
<td>5.90</td>
</tr>
<tr>
<td>Dim</td>
<td>6.10</td>
<td>6.13</td>
<td>6.60</td>
<td>6.58</td>
<td>6.53</td>
<td>6.51</td>
</tr>
<tr>
<td>Dark</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>7.00</td>
<td>7.03</td>
</tr>
</tbody>
</table>

References

Acknowledgment
The authors thank Dr. Imelda Garcia for her invaluable role in this study.