A Comparison of Manual Kinetic and Automated Static Perimetry in Obtaining Ptosis Fields

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Objective: To compare examination time and visual field loss for ptosis fields obtained with manual kinetic (Goldmann) perimetry and automated static (Humphrey) perimetry.

Methods: Both eyes of 12 patients with bilateral aponeurogenic ptosis were prospectively examined using Goldmann and Humphrey (ptosis protocol) perimetry with the eyelids ptotic and taped into a normal position.

Results: Bilateral examination time for Goldmann fields was 10 ± 2 minutes and for Humphrey fields was 50 ± 10 minutes (P < .001, n = 12). Superior fields at the 12:00 meridian were 46° ± 6° taped, and 28° ± 12° untaped for Goldmann perimetry (P < .001), and 38° ± 8° taped, and 24° ± 12° untaped for Humphrey perimetry (P < .001). Goldmann field loss was 18° ± 9° (taped minus untaped). Humphrey field loss was 14° ± 13° (P < .04, n = 24). Mean Goldmann radial fields were 56° ± 6° taped and 39° ± 13° untaped (P < .001). Goldmann superior hemifield areas were 5167 ± 964 degrees² taped and 2830 ± 1466 degrees² untaped (P < .001). Humphrey mean vertical superior hemifield was 37° ± 9° taped and 21° ± 11° untaped (P < .001). Mean sensitivity of Humphrey fields was 15 ± 3 dB taped and 9 ± 5 dB untaped (P < .001). Mean vertical center of gravity was 23° ± 3° taped and 16° ± 5° untaped (P < .001).

Conclusion: Goldmann manual kinetic and Humphrey automated static visual field testing are both effective in documenting ptosis associated visual field loss. Humphrey automated ptosis fields, as performed in this study, require longer examination times than Goldmann manual fields and may be a less sensitive indicator of field loss.


PTOSIS, BROW PTOSIS, and dermatochalasis cause patients to seek ophthalmological consultation for functional and cosmetic reasons. With the advent of health care reform and resource conservation on the part of health care providers and payers, more attention is being given to determining which patients have functional vs purely cosmetic concerns. Classically, ptosis-related visual field loss is quantified using manual kinetic perimetry with the eyelid at baseline and again with the eyelid elevated into a nonptotic position. Automated assessments of ptosis-induced visual field loss have been introduced as an alternate method of documenting ptosis-associated visual deficits. Some insurers have moved toward requiring automated field testing prior to approving a patient for surgery. To our knowledge, no comparison of automated and manual ptosis field testing exists. This is the purpose of our study.

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PATIENTS, MATERIALS, AND METHODS

Twelve patients with bilateral aponeurogenic ptosis were examined using manual kinetic (Goldmann) and automated static (Humphrey) perimetry. All had 20/20 best-corrected Snellen visual acuity, normal ocular motility, no visual field limiting ocular morbidity, and gave informed consent. Patient age (age range, 27-69 years; mean age, 51 years), upper margin reflex distance (1.8 ± 1.1 mm), and diagnoses were recorded.

Manual kinetic perimetry was performed sequentially on both eyes of each patient using the V-4-e target of the Goldmann perimeter (Haag Streit, Bern, Switzerland). Circumferential readings were obtained at 15° intervals with the eyelids in their natural ptotic position and again with the eyelids lifted to a normal position using tape (Figure 1, A). The extent of each visual field at the 12:00 meridian, the mean radial extent, and the area of each superior hemifield were determined for each eye in its natural ptotic position and repeated after the eyelid was lifted to a normal position using tape.

Automated static perimetry was performed sequentially on both eyes of each patient using a Humphrey perimeter (model 640; Allergan-Humphrey Instruments Inc, San Leandro, Calif). A custom protocol, recommended for ptosis testing and provided to us by Allergan-Humphrey Instruments Inc, performed threshold testing at a grid of 36 points confined to the superior hemifield extending 55° to either side of fixation and 45° superior to fixation (Figure 1, B). Threshold testing was accomplished in the standard fashion using a varying 4-mm2 stimulus to determine the visual sensitivity for each gridpoint in the field.12 Vertical extent of field was defined as the point where the average sensitivity of the points to either side of the vertical meridian dropped below 7 dB. Mean vertical extent of field was calculated as the average vertical extent of vision (≥7 dB) for all vertical columns of a given field. Mean sensitivity was calculated as the average of all data points. The vertical center of gravity (CG) for each visual field was calculated using the following formula:

\[ CG = \frac{\sum i S_i}{\sum S_i} \]

where \( S_i \) is the average sensitivity of all points \( i \) degrees above fixation.

The order of testing (Humphrey or Goldmann first) was randomly determined for each patient. Examination time for each testing modality was determined from when the patient first sat behind the perimeter machine to when the last field (of 4) was completed. A 2-minute rest between eyes was permitted in all cases. The same experienced technician (S.H.) performed all visual field perimeter measurements.

Data entry, calculations, and statistics were performed using a commercially available software package (Microsoft Excel; Microsoft Inc, Redmond, Wash). Statistical comparisons were made using the t test. All data are reported as mean ± SD.

cal hemifields were 37° ± 9° taped and 21° ± 11° untaped (\( P < .001 \)) (Table 1). Mean Goldmann radial field loss was 17° ± 10° and mean Humphrey vertical field loss was 16° ± 13° (\( P = .51 \)) (Table 2). Using this technique of interpretation to assess field loss, similar percentages of Goldmann and Humphrey fields demonstrated at least 10°, 12°, 15°, and 20° of mean field loss (Figure 2).

Goldmann superior hemifield areas were 5167° ± 964° taped and 2830° ± 1466° untaped (\( P < .001 \)). Mean sensitivity of Humphrey fields was 15 ± 3 dB taped and 9 ± 5 dB untaped (\( P < .001 \)) (Table 1). When both of these data sets were normalized to their respective taped means (Table 1), loss of Goldmann area was 0.45° ± 0.19° and loss of Humphrey sensitivity was 0.38 ± 0.30 dB (\( P = .09 \)) (Table 2). Percentage of Goldmann area loss was 47% ± 22% and percentage of Humphrey sensitivity loss was 38% ± 28% (\( P = .01 \)) (Table 2 and Figure 3).

The superotemporal and superonasal quadrant areas were calculated for each Goldmann field. Superotemporal area was 3114° ± 815° taped and 1557 ± 1019 degrees2 untaped (\( P < .001 \)). Superonasal area was 2053° ± 299° taped and 1273° ± 513° untaped (\( P < .001 \)). Superotemporal area loss was 1557° ± 613° and superonasal area loss was 780° ± 460° (\( P < .001 \)) (Table 1).

Mean Humphrey superotemporal sensitivity was 17 ± 4 dB taped and 10 ± 6 dB untaped (\( P < .001 \)). Mean Humphrey supersonasal sensitivity was 12 ± 3 dB taped and 8 ± 4 dB untaped (\( P < .001 \)). Superotemporal Humphrey sensitivity loss was 7 ± 5 dB and supersonasal sensitivity loss was 4 ± 4 dB (\( P = .003 \)). Mean vertical center of gravity for Humphrey fields was 23° ± 3° taped and 16° ± 5° for untaped (\( P < .000001 \)) (Table 1).

**COMMENT**

Patients with visual loss from upper eyelid and/or facial structures descending from their normal anatomic positions are termed to have functional defects implying a medical need for reconstructive procedures. Documentation of the functional nature of these disorders has become increasingly important, difficult, and confusing over the past decade. Patients and physicians may have treatment options limited by insurance reviewers applying arbitrary guidelines to define functional ptosis. Insurance guidelines for functional indications for ptosis surgery include: Obstruction of any part of the pupil, obstruction of the entire pupil, obstruction of the visual axis, visual field defect,3 superior visual field loss of greater than 12°, and different thresholds of percentage visual loss as defined by the American Medical Association.4 Some insurers require visual field testing while others will not reimburce it if performed.3

The relation between ptosis and superior field loss has been well documented in theory5 and in practice.6-14 The peripheral isopter of kinetic perimetry has been customarily used to document visual field loss from ptosis.5,12 Since the advent of automated, computerized static perimetry, several articles9,10,15 have described the use of this testing modality in patients who have ptosis. The objective nature of automated perimetry has motivated...
Table 1. Ptosis-Related Visual Field Loss Demonstrated

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Taped Eye</th>
<th>Untaped Eye</th>
<th>Loss</th>
<th>P†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goldmann perimetry, degrees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00 Meridian field</td>
<td>46 ± 6</td>
<td>28 ± 12</td>
<td>18 ± 9</td>
<td>7E-10</td>
</tr>
<tr>
<td>Mean radial field</td>
<td>56 ± 6</td>
<td>39 ± 13</td>
<td>17 ± 10</td>
<td>3E-08</td>
</tr>
<tr>
<td>Field area, degrees‡</td>
<td>5167 ± 964</td>
<td>2830 ± 1466</td>
<td>2337 ± 977</td>
<td>4E-11</td>
</tr>
<tr>
<td>Superonasal area‡</td>
<td>2053 ± 299</td>
<td>1273 ± 513</td>
<td>780 ± 460</td>
<td>2E-08</td>
</tr>
<tr>
<td>Superotemporal area‡</td>
<td>3114 ± 815</td>
<td>1557 ± 1019</td>
<td>1557 ± 613</td>
<td>1E-11</td>
</tr>
<tr>
<td>Normalized field area§</td>
<td>1.00 ± 0.19</td>
<td>0.55 ± 0.28</td>
<td>0.45 ± 0.19</td>
<td>4E-11</td>
</tr>
<tr>
<td>Humphrey perimetry, degrees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12:00 Meridian field</td>
<td>38 ± 8</td>
<td>24 ± 12</td>
<td>14 ± 13</td>
<td>2E-05</td>
</tr>
<tr>
<td>Mean vertical field</td>
<td>37 ± 9</td>
<td>21 ± 11</td>
<td>16 ± 13</td>
<td>3E-06</td>
</tr>
<tr>
<td>Center of gravity</td>
<td>23 ± 3</td>
<td>16 ± 5</td>
<td>7 ± 5</td>
<td>5E-07</td>
</tr>
<tr>
<td>Humphrey sensitivity, dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>15 ± 3</td>
<td>9 ± 5</td>
<td>6 ± 4</td>
<td>2E-06</td>
</tr>
<tr>
<td>Superonasal‡</td>
<td>12 ± 3</td>
<td>8 ± 4</td>
<td>4 ± 4</td>
<td>9E-05</td>
</tr>
<tr>
<td>Superotemporal‡</td>
<td>17 ± 4</td>
<td>10 ± 6</td>
<td>7 ± 5</td>
<td>2E-06</td>
</tr>
<tr>
<td>Normalized sensitivity§</td>
<td>1.00 ± 0.20</td>
<td>0.62 ± 0.32</td>
<td>0.38 ± 0.30</td>
<td>2E-06</td>
</tr>
</tbody>
</table>

*All data reported as mean ± SD unless otherwise indicated.
†Paired, 2-tailed t test.
‡P = 3E-08 for Goldmann temporal vs nasal and P = .003 for Humphrey temporal vs nasal comparisons.
§Normalized values were obtained by dividing all measurements by mean taped eye value.

Table 2. A Comparison of Goldmann and Humphrey Visual Field Loss in Patients

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Loss†</th>
<th>P‡</th>
<th>% Loss†</th>
<th>P‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 Meridian field, degrees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goldmann</td>
<td>19 ± 9</td>
<td>.04</td>
<td>42 ± 22</td>
<td>.20</td>
</tr>
<tr>
<td>Humphrey</td>
<td>14 ± 13</td>
<td>.36</td>
<td>36 ± 32</td>
<td>.13</td>
</tr>
<tr>
<td>Mean field, degrees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goldmann (radial)</td>
<td>17 ± 10</td>
<td>.51</td>
<td>32 ± 20</td>
<td>.11</td>
</tr>
<tr>
<td>Humphrey (vertical)</td>
<td>16 ± 13</td>
<td>.40</td>
<td>40 ± 32</td>
<td>.11</td>
</tr>
<tr>
<td>Normalized Goldmann field areas, degrees§</td>
<td>0.45 ± 0.19</td>
<td>.47</td>
<td>22 ± 22</td>
<td>.77</td>
</tr>
<tr>
<td>Normalized sensitivity, dB§</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humphrey</td>
<td>0.38 ± 0.30</td>
<td>.09</td>
<td>38 ± 28</td>
<td>.01</td>
</tr>
<tr>
<td>Nasal</td>
<td>0.34 ± 0.35</td>
<td>.07</td>
<td>30 ± 34</td>
<td>.005</td>
</tr>
<tr>
<td>Temporal</td>
<td>0.40 ± 0.31</td>
<td>.30</td>
<td>42 ± 29</td>
<td>.13</td>
</tr>
</tbody>
</table>

*All data reported as mean ± SD. Ellipsis indicates does not apply.
†Taped eye minus untaped values.
‡Paired, 2-tailed t test.
§Normalized values were obtained by dividing all measurements by mean taped value.
certain insurers to mandate this testing modality prior to approving ptosis surgery. This negation of patient complaints and physician judgment is occurring despite no consensus on the sensitivity of automated ptosis field perimetry. We know of no comparisons between manual kinetic and automated static ptosis field testing to date.

Examination times were 5 times longer for Humphrey testing than for Goldmann testing. Goldmann fields were all performed by one of us (S.H.) who has more than 25 years of experience in performing this test. Less experienced technicians would likely have longer examination times. We believe that the advantage of a single unmasked Goldmann examiner in limiting reduction of data noise outweighed the theoretical concerns of unconscious data manipulation by an unmasked examiner.

We configured our Humphrey perimeter to perform threshold testing. While threshold-related or screening algorithms might be expected to result in shorter examination times, our Humphrey examination times were comparable to those previously reported in the literature. One article used a screening threshold strategy that presented test stimuli 6 dB above threshold to a grid of 114 locations in the superior hemifield. A second article used full threshold testing in 8 radial meridians from fixation (0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°) comprising 44 test locations. A third study performed screening testing (points seen or missed) on a rectangular grid of 40 points in the superior hemifield.

The Humphrey testing protocol used in this study was selected as a result of personal communication with a representative of Allergan-Humphrey Instruments Inc (1996). The 3 previous studies reporting the use of automated perimetry for ptosis testing each used unique testing configurations all of which were different from the manufacturer’s recommendations. As no standardized method for using static perimetry exists for ptosis field testing, we chose to configure the machine as recommended by the manufacturer.

Humphrey sensitivity testing was performed using a 4-mm² target (equivalent in size to the Goldmann III-4-e target). The 16-mm² V-4-e target was selected for Goldmann ptosis testing because it has customarily been employed at this institution for several decades. The discrepancy between the V-4-e Goldmann target and the 4-mm² Humphrey spot size did not alter the outcome measures in this study. Neither the examination time to perform Goldmann ptosis testing nor the field loss detected are affected by the spot size used. Goldmann testing on 4 ptotic eyes using both the III-4-e and V-4-e isopters revealed slight contraction of the III-4-e vs V-4-e isopters, but identical amounts of visual field loss from ptosis (Table 3).

Goldmann kinetic and Humphrey static perimetry results are not amenable to quantitative comparisons because of the different formats of data produced by each device. The Goldmann perimeter produces a circular isopter on a polar coordinate grid and the Humphrey perimeter produces a discreet grid of logarithmic sensitivities with x-y coordinates (Figure 1). A comparison between Humphrey and Goldmann testing in patients with glaucoma revealed that Humphrey central 30° testing was

![Figure 3. Field loss from ptosis demonstrated by different techniques of ptosis perimetry interpretation. Error bars denote SEM.](https://archopht.jamanetwork.com/)

<table>
<thead>
<tr>
<th>Eye</th>
<th>Taped Eye</th>
<th>Untaped Eye</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-4-e 12:00 Meridian Field, Degrees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>47</td>
<td>33</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>28</td>
<td>24</td>
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<td>3</td>
<td>55</td>
<td>17</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>54</td>
<td>11</td>
<td>43</td>
</tr>
<tr>
<td>III-4-e 12:00 Meridian Field, Degrees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>43</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>24</td>
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</tr>
<tr>
<td>3</td>
<td>54</td>
<td>16</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>53</td>
<td>8</td>
<td>45</td>
</tr>
</tbody>
</table>

*P = .72 for V-4-e loss vs III-4-e loss.
Goldmann testing. Beck et al² used previously established criteria to interpret each Goldmann and Humphrey field in a masked fashion as demonstrating or not demonstrating glaucomatous field loss. The absence of any guidelines on what Humphrey findings might be indicative of ptosis associated field loss made such a subjective comparison impossible in our case. We employed 3 different techniques to compare Goldmann and Humphrey perimetry results.

Goldmann testing was more sensitive in detecting visual field loss from ptosis at the 12:00 meridian (Table 2 and Figure 3). The discreet data points which had to fall 10°, 22°, 35°, or 45° superior to the horizontal midline reduced the resolution of the Humphrey machine and thereby decreased its sensitivity.

We compared mean field loss over the entire superior hemifield to make better use of all Humphrey and Goldmann data points. Average radial Goldmann field loss was similar to average vertical Humphrey field loss (Table 2 and Figure 3). The main limitation of Humphrey testing was likely the discreet location of the points 10 to 13 vertical degrees apart from one another. A tighter grid consisting of more test points (a 2° separation is possible) may have improved this limitation but would have made examination times even more lengthy.

The advantage, power, and sensitivity of Humphrey perimetry in general ophthalmology is derived from its finely quantified sensitivity measurements. Based on this, our third method of comparison compared Humphrey loss of mean sensitivity to Goldmann loss of field area. We believe that both of these parameters relate to and in some way quantify the total amount of vision present (Table 2). While quantitatively comparing these 2 very different parameters is of limited practical value, the more statistically significant and greater absolute amount of change in Goldmann data suggest that this testing modality may be more likely to demonstrate ptosis-related changes.

Superotemporal field loss was greater for any given eye than supronasal field loss when measured by either the Goldmann or Humphrey devices (Table 1). Comparisons between the superotemporal Humphrey data with the Goldmann superior hemifield area data revealed a statistically insignificant trend of the Goldmann instrument still being more sensitive to detecting field loss (Table 2).

An alternate method was derived for more fully using the Humphrey sensitivity data. We calculated a vertical center of gravity for each “island of vision” and determined its change from taped to untaped testing as a function of the more superior portion of the island being “truncated to sea level” by ptotic superior field loss. We were unable to derive a conceptually comparable parameter for the Goldmann field data but, nevertheless, found this to be the Humphrey parameter that produced the most statistically significant change between taped and untaped measurements.

Humphrey automated threshold sensitivity testing as used in this study was able to detect visual field loss due to ptosis and, based on these results, is an acceptable test for documenting ptosis-induced visual field deficits. This is essential information for the practitioner’s office which may lack technical support skilled in manual kinetic perimetry or may only have an automated perimeter. Nevertheless, the significantly longer examination time and lack of clear advantage over Goldmann perimetry suggest that, when possible, Goldmann ptosis perimetry should be performed. Goldmann ptosis perimetry may have greater sensitivity for detecting ptosis associated field loss, and is certainly less anxiety provoking to patients. A standardized protocol and statistical algorithm should be developed for the Humphrey machine to provide consistent, meaningful results, with faster examination times. Special attention to the superotemporal field quadrant and the vertical center of gravity of the Humphrey field, as well as employing screening or threshold-related testing algorithms, may enhance the sensitivity and usefulness of this testing modality in the future. The criteria defining “significant” ptosis-associated visual field changes should not be arbitrarily determined by insurance companies and third-party payers, but rather should reflect a patient-oriented approach and be firmly rooted in science.

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REFERENCES

5. Fischer RF. The influences of orbital contours and lid ptosis on the size of the peripheral visual field. Vis Res. 1967;7:671-678.