Evaluation of the mentor Guyton-Minkowski potential acuity meter

Edward Bancroft
Pacific University

Robert Wilson
Pacific University

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Evaluation of the mentor Guyton-Minkowski potential acuity meter

Abstract
The Mentor Guyton- Minkowski Potential Acuity Meter (PAM) is an instrument for measuring the retinal visual acuity behind ocular opacities. This paper evaluates the ease of operation and the accuracy of the findings of the PAM. Between November 12, 1983 and February 21, 1984, twenty-two patients were examined using the PAM prior to cataract removal. Ten patients were followed post- surgically and post-operative best visual acuity was compared to acuities predicted by the PAM. The PAM was more accurate with mild to moderate opacities, but may be used on dense opacities. The PAM was found to be easy to set up and operate, quick to perform, and easy to understand and relate the results.

Degree Type
Thesis

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EVALUATION OF THE MENTOR

GUYTON-MINKOWSKI POTENTIAL ACUITY METER

by

Edward Bancroft

and

Robert Wilson

IN PARTIAL FULFILLMENT FOR THE DEGREE DOCTOR OF OPTOMETRY

PACIFIC UNIVERSITY COLLEGE OF OPTOMETRY

May 1984
Advisor:

J.R. Roggenkamp, O.D.
ACKNOWLEDGEMENTS

We would like to thank Dr. Curtis Mumford and Dr. Timothy Denmen for their patience and assistance. Also, we express gratitude to Dr. J.R. Roggenkamp, for his help and understanding.
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The Mentor Guyton-Minkowski Potential Acuity Meter (PAM) is an instrument for measuring the retinal visual acuity behind ocular opacities. This paper evaluates the ease of operation and the accuracy of the findings of the PAM. Between November 12, 1983 and February 21, 1984, twenty-two patients were examined using the PAM prior to cataract removal. Ten patients were followed post-surgically and post-operative best visual acuity was compared to acuities predicted by the PAM. The PAM was more accurate with mild to moderate opacities, but may be used on dense opacities. The PAM was found to be easy to set up and operate, quick to perform, and easy to understand and relate the results.
I. **Introduction**

In examining a patient with ocular opacities, such as cataracts, it is important to determine whether the patient would benefit from surgery to remove the opacity. The retinal function, or potential acuity, should be determined in order to advise the patient whether surgery may improve their vision. This study is an evaluation of the Mentor Guyton-Minkowski Potential Acuity Meter (PAM) and the clinical usefulness of this instrument.

There are numerous ways to assess the potential of the retina and macula. Sinclair, Loeb!, and Riva\(^1\) describe four tests often used for the prediction of postoperative macula function:

1. The Blue field entopic phenomenon, in which observation of one's own leukocytes flowing in the parafoveal capillaries, is taken as a positive sign of macular function. Sinclair, et al\(^1\) designed a blue field entopic phenomenon test using a diffuse blue light (430 nm) source held close to the patient's eye to elicit visualization of corpuscles. The criteria for passing or failing the test was set arbitrarily. If fifteen corpuscles or more were seen spread around the macular field, the macula was predicted as "good". The term "good macula" was assigned when corrected to post-surgical best visual acuity of 20/40 or better. A "poor macula" was one with post-operative best visual acuity of 20/50 or worse. With these specific criteria, Sinclair, et al\(^1\) reported a 94 percent correct prediction of "good maculas".

2. The Purkinje vascular entopic phenomenon is the visualization of the retinal vessels. The retinal blood vessels lie between receptor cells and the light coming into the eye. Normal incident light strikes the retina and produces a constant shadow on the rods and cones directly beneath the blood vessels. The receptors become adapted to the shadow
produced by the blood vessels. Once adapted, the human visual system will not process information on a constant stimulus. The rods and cones beneath the blood vessels are always shadowed with normal incident light, and therefore receive no change in stimulation. This leads to a loss of perception of the retinal blood vessels. In a Purkinje vascular entopic phenomenon test abnormal incident light is projected into the eye. This is done by placing a bright light source (such as a pen light) next to the sclera. This allows the light to enter the eye obliquely. The light rays strike the rods and cones which are usually shielded by the blood vessels, exciting the visual system, allowing one to see the shadows produced by the blood vessels. With this test, it is hard to quantify what part of the retina is actually seeing the Purkinje vascular images. Since there are no large blood vessels in the foveal area, this test cannot predict the macular function needed for fine visual discrimination.

3. Color perception is also used as a predictive measure for retinal potential. Color perception through a diffusing opacity is a sign of a functional cone system. There are no standard colors or criteria for predicting a normal functioning retina. This is a test of cone integrity and not a specific test correlated to the potential of the macula.

4. The two-light test is another method used to assess the potential of the retina. Two bright point light sources are held at a distance from the eye being evaluated. The two lights are moved closer together until the subject can no longer distinguish two separate lights. The testing procedure specifications (test distance, light requirement, etc.) are not standardized. In addition, the minimal separation of the lights for predicting useful visual acuity behind the opacity is not standardized. Lack of norms and expecteds makes it difficult to assess
the potential of the macula with this test.

Other instruments and methods have been used to predict macular function through ocular opacities. Visual Evoked Response (VER), Critical Fusion Frequency (CFF), and Electroretinogram (ERG) have been used.\textsuperscript{1}

These tests are good indicators of gross retinal function, but not of macular integrity behind diffusing ocular opacities. The test results depend on specific test procedures used and the degree of the opacity. The findings from these tests do not lead directly to a quantitative potential of post-operative visual acuity.

**Laser Interferometry**

Laser Interferometry is frequently used today as a standard measure of macular integrity. Two small images of a coherent light source (a laser) are focused in the pupil of the eye forming an interference pattern on the retina. The pattern is sinusoidally modulated and appears to the subject as a grating. The spatial frequency depends on the distance between the images. The resolved density of the stripes is a measure of the degree of function of the retina.\textsuperscript{3,7,8} Since the optics of the eye are not used to form the interference pattern, this is an effective method of measuring acuity in an eye with opacities.\textsuperscript{2,3}

There are several advantages to the use of lasers. One reason for the effectiveness of the interference-fringe method is the apparatus enables one to variably increase the light flux that enters the eye. This can compensate for light lost through absorption and scatter. The size of the projected light is also an advantage. The laser emits only a small bundle of light rays that enters the eye. So if a small area of the lens is free from opacities, the light can enter easily. Another
advantage is the retinal pattern produced in this system is not affected by the state of accommodation of the eye, as long as the system is properly adjusted and the two source images are focused at the first principal point of the eye.\textsuperscript{2,4,5}

The disadvantages of the laser (interference pattern) system are: it is large, expensive, and difficult to construct and operate. Fine precision must be exercised using this test, thereby making the examinations very time-consuming. Another disadvantage is the focal images must be accurately placed on the pupil, or else the patient will see a uniform field and not a grating. This leads to low estimation of retinal function. Also sine-wave test patterns can be difficult for patients to recognize.\textsuperscript{2,5,6}

**Potential Acuity Meter**

Recently a new product has come into the market to estimate the functional potential of an eye. The Mentor Guyton-Minkowski Potential Acuity Meter (PAM) is an instrument for measuring the retinal visual acuity behind a cataract or other ocular opacity. It does this by taking advantage of the fact that most cataracts are not homogeneous, but have tiny clear areas described as windows.\textsuperscript{11} The PAM projects a Snellen visual acuity chart into the eye via a narrow beam of light which converges to a minute aerial operture of only 0.1 mm in diameter. When this beam is placed in a "window" of a cataract, the full acuity chart is imaged on the retina, bypassing the scattering effect caused by the rest of the cataract. This allows direct measurement of the retinal acuity.\textsuperscript{9}

In order to evaluate the Potential Acuity Meter, several areas were examined: ease of operation, accuracy of the findings, and the effects of different types of cataracts on the results obtained.
There are many different types of cataracts, but they can be divided into four main groups:

1. Anterior cortical (AC)
2. Nuclear sclerosis (NS)
3. Posterior subcapsular cataracts (PSC)
4. Combinations (most cataracts are combinations)

Lenticular opacities which are discrete and located within one plane of the lens, such as central posterior subcapsular cataracts, and homogeneous nuclear sclerosis are easily penetrated by the PAM. Dense cataracts make it difficult for even the smallest beam of light to pass through without considerable amounts of scattering and diffraction. Therefore, the credibility of the PAM decreases with preoperative best visual acuity (BVA) of 20/300 or worse (caused by dense opacities). Part of this study was designed to correlate the type of cataract present with the accuracy of the PAM findings.

The patients examined were preoperative cataract patients. They were followed post-surgically and their best post-operative visual acuity compared to the preoperative PAM findings.

II. Description of the Potential Acuity Meter (PAM)

The PAM mounts by a single pin that inserts into the central column of a Haag-Streit or Mentor type slit-lamp biomicroscope. The patient looks down approximately 14 degrees from the horizontal, directly into the light source of the PAM. The patient is actually looking at a projected image of a Snellen visual acuity chart. The examiner views the patient's eye through the slit-lamp binoculars over the top of the PAM and aims the light beam into the patient's eye within the pupil. The
light beam narrows to its smallest diameter exactly at the viewing plane of the slit lamp binoculars. This allows great accuracy in directing the light source precisely on the "windows" of cataracts.

There are three basic components of the PAM which allow the instrument to perform as it does. They are: a pinpoint light source, a transilluminated calibrated visual acuity chart, and a condensing lens that forms an image of the pinpoint light source at the focal plane of the slit lamp.

A conventional pinhole, 1.2 mm in diameter, placed before a 4 mm pupil, decreases the retinal illuminance by 91 percent. On the other hand, the entire light source of the PAM is focused to a pinpoint aimed through the pupil. This difference in illumination, rather than the exact size of the small projected aerial aperature, appears to be the main reason for the effectiveness of the PAM. 10

On the side of the PAM unit is a knob which changes the vergence of the projected acuity chart. It is calibrated in diopters of spherical refraction correction. This optometer control is usually preset to the patient's spherical equivalent refractive correction. It can easily be adjusted during the testing to help find the clearest setting for each different patient.

The PAM projects a visual acuity chart with lines of letters calibrated, as shown in Table 1.
<table>
<thead>
<tr>
<th>Letters</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>T . .. .. .. .. ..</td>
<td>20/400</td>
</tr>
<tr>
<td>F . .. .. .. .. ..</td>
<td>20/300</td>
</tr>
<tr>
<td>E . .. .. .. .. ..</td>
<td>20/200</td>
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<tr>
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<tr>
<td>D A O F .. .. .. ..</td>
<td>20/60</td>
</tr>
<tr>
<td>E G N D H .. .. .. ..</td>
<td>20/50</td>
</tr>
<tr>
<td>F Z B D E .. .. .. ..</td>
<td>20/40</td>
</tr>
<tr>
<td>O F L C T .. .. .. ..</td>
<td>20/30</td>
</tr>
<tr>
<td>A P E O T F .. .. .. ..</td>
<td>20/25</td>
</tr>
<tr>
<td>T C V E C L .. .. .. ..</td>
<td>20/20</td>
</tr>
</tbody>
</table>
III. Testing Methods

Between November 12, 1983 and February 21, 1984, twenty-two patients were examined using a Potential Acuity Meter (PAM). Thirty-seven eyes exhibited characteristics suitable for measurement with the PAM.

The patient's best visual acuity (BVA) was determined prior to the PAM examination by their ophthalmologist by means of normal clinical refraction.

All the patients were tested with the same PAM unit under similar testing conditions. The examiners were usually informed of the current BVA at the time of the testing. The PAM was used in a dimly lighted room. The patient's pupils were usually not dilated. The test can be performed satisfactorily with normal size pupils; however, maximal dilation is preferred to expose all available "windows" in the cataract to the examiner. There were no other acuity charts visible in the examination room.

The projected light beam from the PAM can be seen by the examiner as it penetrates the patient's eye. The beam of light was directed to the various "windows" in the eye's opacities. At times when few or no definite "windows" were observed, the beam was systematically moved about the pupil to detect the clearest points for the subjects. The patients were given instructions to call out the smallest letters they could read. The patients were asked to speak through clenched teeth to avoid unnecessary bouncing motion of the head. With some patients the chin rest was lowered to allow the patient to speak without losing alignment.
The optometer (sphere power control) was set at the approximate spherical equivalent of the eye's refractive correction. Occasionally, the patients themselves were able to adjust the sphere power control during the testing to refine the focus of the letters.

The post-operative best visual acuity was determined by the patient's ophthalmologist in the same manner as the preoperative BVA. This post-operative BVA was obtained after the necessary recovery period, generally six to eight weeks in length, after the vision had stabilized.

IV. Case Reports

From a field study of twenty-two patients seen in the Portland, Oregon area, follow-up data was available on ten of the patients. These ten patients had the basic characteristics required to be included in this study. They all had been diagnosed by an ophthalmologist as having various forms of cataracts and were scheduled to have the lens removed from the eye in the near future. The Potential Acuity Meter (PAM) was tested on these patients as close to the day of scheduled surgery as possible. The final post-operative best visual acuity (BVA) and other pertinent data was relayed to the examiners by the ophthalmologists.

Case 1: A 70-year-old female diagnosed with nuclear sclerosis of the left lens. The best preoperative visual acuity was 20/60 for the left eye. The PAM was used and the patient was able to read 20/40 letters. Following the cataract surgery and required recovery period, the best visual acuity was 20/50.

Case 2: A 56-year-old female patient diagnosed with nuclear sclerosis and posterior subcapsular cataract in the left eye. The pre-operative BVA at the time of examination was 20/40. The PAM allowed the patient to correctly read the 20/20 line. Following the cataract surgery
and required recovery period, the final BVA was 20/20.

**Case 3:** A 64-year-old female diabetic patient with diagnosed posterior subcapsular cataract in the left eye. The onset of the cataract had been very recent and its progression rapid. The best visual acuity of the cataractous eye was 20/60. The PAM was used preoperatively and through several peripheral "windows" the patient was able to read the 20/25 letters. Following the cataract surgery and necessary recovery period, the BVA was 20/40.

**Case 4:** A 91-year-old female manifested anterior cortical spoking and dense nuclear sclerosis in the right eye. The preoperative BVA in that eye was 20/200. The PAM was tested on the patient and a potential acuity of 20/80 was found. The patient had previously undergone cataract surgery on the left eye. The left eye had an aphakic BVA of 20/40 as well as a PAM reading of 20/40. Cataract surgery was performed on the right eye, and following recuperation, the BVA was 20/40.

**Case 5:** A 74-year-old male patient was diagnosed with macular degeneration, nuclear sclerosis, and posterior subcapsular cataract of the right eye. The BVA of the right eye at that time was 20/80. The patient was able to call out the 20/25 letters with the PAM. After surgery and recovery, the BVA was 20/40.

**Case 6:** A 75-year-old male patient had previously undergone cataract surgery on the left eye. The patient had bilateral macular degeneration and nuclear sclerosis with posterior subcapsular cataract of the right lens. The best visual acuity in the eye with the ocular implant was 20/30, and in the nonaphakic eye the BVA was 20/60. When examined with the PAM, the outcome was a 20/40 acuity potential of the right eye. Following surgery in the right eye and the two month recovery period, the BVA was reported as 20/60.
Case 7: A 76-year-old female diagnosed with bilateral nuclear sclerosis and scattered punctate opacities was seen preoperatively. The BVA of the right eye was 20/50 and the BVA of the left was 20/40. Using the PAM, potential acuities of 20/25 were found for both eyes. Following cataract surgery on the right eye and the recovery period, the BVA was found to be 20/20.

Case 8: An 83-year-old male demonstrated bilateral nuclear sclerosis, cortical spoking, and central lenticular vacuoles. The preoperative BVA on the right eye was 20/40, and the left had a BVA of 20/40. The PAM was used on both eyes and the patient could read the letters of the 20/30 and 20/25 lines, right and left eye respectively. The right eye was soon operated on and after the recuperative period, the BVA of the right eye was 20/40.

Case 9: An 80-year-old male was diagnosed with arthritis, hypertension, and bilateral nuclear sclerosis of the lenses. The preoperative BVA of the right eye was 20/80. The BVA of the left eye was 20/50. The patient was able to identify the letters of the 20/25 line of the PAM with each eye. Surgery was performed on the right eye. After the recovery period the aphakic BVA was 20/20.

Case 10: An 80-year-old female patient with nuclear sclerosis and 20/70 BVA on the left side was examined prior to cataract removal. The PAM finding was 20/30. Following surgery and recovery, the BVA was 20/20.
V. Discussion

The Potential Acuity Meter (PAM) was easy to operate. Set-up time for the PAM and patient was approximately equal to set-up time for any biomicroscopic procedure. The instructions for the patient were few and simple: the patient was asked to hold their head still and read letters from a chart. Most patients were familiar with the Snellen chart and could respond quickly to this test.

It does not take a great deal of experience for one to become comfortable with the use of the PAM. Confidence and reliability was gained rapidly and the examiners felt proficient with the use of the PAM on all types of ocular opacities.

The results from testing with the PAM were easily understood by both the patient and the examiner. Direct correlation could be made to the distance Snellen acuity chart. This seemed to encourage the patients. The patients actually experienced what their own eyes were capable of seeing.

The time required to reach a reliable maximal finding varied with each patient. The testing procedure did not take more than ten minutes on any patient. The denser the opacity, the harder it was to find the best area for testing, therefore, those patients took slightly longer than patients with lighter opacities.

The accuracy of the predicted PAM acuities for the most part confirmed the findings of a previous study by Guyton, Minkowski, and Palese.10 The less dense the opacities, the better the predictive power of the PAM. Fifty percent of the cases reported in this study ended up with post-operative BVA within one line (or better) of the PAM predicted acuity. If one looks at an accuracy level of plus or minus two lines of acuity, then 90 percent of the cases in this study fall into this category. A
close look at the cases reveals that better preoperative best visual acuities generally came closest to the predicted PAM acuities. A summary of the case results is shown in Table 2 at the end of the discussion.

One of the ten reported cases (Case 4) did not end up with a post-operative BVA within two lines of the predicted BVA. This patient had the worst preoperative acuity of all reported cases. The result of this particular case agrees with the results of Minkowski, et al,¹⁰ i.e., the denser the opacity, the farther the post-surgical BVA will be from the PAM's predicted BVA.

The sample size in this study was small and it was hard to draw any absolute conclusions, but the general pattern of this study's results are similar to what was previously found by the inventors of the PAM (Guyton and Minkowski).¹⁰ The small sample size also made it impossible to draw any conclusions about the relationship between the type of cataract and that of the PAM. The density of the cataract is the major factor in the accuracy of the PAM.

The examiners knew the BVA of most patients before testing with the PAM. This could have lead to unintentional, or subconscious bias on behalf of the examiners, and kept the examiner from equally encouraging all the patients the same amount, or lead the examiner to give up easier on some patients. On the other hand, prior knowledge of a patient's BVA could be beneficial. The examiner, knowing what to expect, can push the patient to surpass the expected. All information and clues should be used by practitioners to help their patients perform at their best.
# TABLE 2

## CASE RESULTS SUMMARY

<table>
<thead>
<tr>
<th>Case</th>
<th>Involved Eye</th>
<th>Preop. BVA</th>
<th>Type Cataract</th>
<th>PAM Reading</th>
<th>Postop. BVA</th>
<th>Accuracy*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>O.S.</td>
<td>20/60</td>
<td>NS</td>
<td>20/40</td>
<td>20/50</td>
<td>-1</td>
</tr>
<tr>
<td>2</td>
<td>O.S.</td>
<td>20/40</td>
<td>NS/PSC</td>
<td>20/20</td>
<td>20/20</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
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<td>PSC</td>
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<td>-2</td>
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<td>AC/NS</td>
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<tr>
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<td>NS/PSC</td>
<td>20/25</td>
<td>20/40</td>
<td>-2</td>
</tr>
<tr>
<td>6</td>
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<td>20/60</td>
<td>NS/PSC</td>
<td>20/40</td>
<td>20/60</td>
<td>-2</td>
</tr>
<tr>
<td>7</td>
<td>O.D.</td>
<td>20/50</td>
<td>NS</td>
<td>20/25</td>
<td>20/20</td>
<td>+1</td>
</tr>
<tr>
<td>8</td>
<td>O.D.</td>
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<td>AC/NS</td>
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<tr>
<td>9</td>
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<td>20/20</td>
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<tr>
<td>10</td>
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<td>20/70</td>
<td>NS</td>
<td>20/30</td>
<td>20/20</td>
<td>+2</td>
</tr>
</tbody>
</table>

*Accuracy = Difference in lines of acuity between the PAM reading and the post-operative BVA.

- NS = Nuclear sclerosis
- PSC = Posterior subcapsular cataract
- AC = Anterior cortical cataract
REFERENCES


