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# A comparative study between the PAM and the laser interferometer in cataracts

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**Abstract.** We conducted a prospective study on 35 consecutive eyes undergoing cataract extraction to compare the Guyton-Minkowski Potential Acuity Meter (PAM) and the Laser Interferometer (LI) in determining potential visual acuity. The eyes were divided into: group A, which had good visualization of optic disc details, and group B, whose media allowed only disc outline or less to be seen. We found that in group A eyes, both instruments were reliable (with accuracies of 94% for the PAM and 88% for the LI). However, in group B eyes (advanced cataracts), both instruments were unreliable (accuracies of 33% for the PAM and 53% for the LI). Interestingly, in a subgroup of high myopes (axial length >29 mm) with moderate cataracts and poor visual acuties, both instruments were very reliable and helpful in determining how much of the vision loss was due to the cataracts. We therefore strongly recommend potential acuity testing in high myopes with moderate cataracts and poor visual acuity.

## Introduction

We are currently interested in formulating methodology to document and monitor cataracts (Datiles et al. 1987). One of the subjective methods is the use of new devices to determine how much of the vision loss is due to cataracts and how much to posterior segment disorders. This is not only important for long-term follow-up of elderly cataract patients who may be placed on anticataract agents and who may also develop age related macular disease, but also for cases when a standard ophthalmological examination may still leave doubts about the status of the posterior segment.

We therefore conducted a prospective comparison of two widely used and currently available devices, the Guyton-Minkowski Potential Acuity Meter (PAM) and the Rodenstock Laser Interferometer (LI).[1]

## Materials and methods

The PAM (Mentor) projects a standard Snellen chart through a 0.15 mm diameter aperture (Minkowski et al. 1983). This chart is directed through small "windows" in the opacity onto the retina. The patient reads the chart from 20/400 to 20/20. The PAM has a field of vision of 6° and uses a low-cost incandescent lamp (Faulkner 1983a).

The Rodenstock Laser Interferometer uses beams of coherent light from a low power helium-neon laser from two point sources (Faulkner 1983a, b). Interference fringes are formed wherever the two beams overlap. By varying the width of the interference fringe pattern, visual acuity can be determined with the Snellen equivalent from 20/660 to 20/20, independent of the optics of the eye. The LI has a field of vision of 5.5°.

We prospectively evaluated 27 consecutive patients prior to cataract surgery at the Clinical Branch of the National Eye Institute. These accounted for 35 eyes undergoing surgery. The patients had same-day preoperative refraction, ocular examination, and determination of potential vision using the PAM and the LI. No masking of observers was done, and either instrument was randomly used first. Informed consent was obtained from all patients participating in the study.

The patients were divided into two groups. Group A had media that allowed adequate visualization of the optic disc details by indirect ophthalmoscopy. The 17 cases in group A had visual acuity ranging from 20/60 to counting fibers at 1 foot. Three of these cases (nos. 13, 26, 29), all high myopes, were referred because of suspected retinal lesions, raising doubts concerning the successful visual outcome of cataract surgery. Based on the prediction of good postoperative visual acuity by the PAM and LI, surgery was performed. These cases will be discussed in greater detail.

In group B (15 cases), the fundus details could not be adequately visualized by indirect ophthalmoscopy. Visual acuity in this group was counting fingers or less.

In three other cases, each with preexisting retinal lesions (one with media allowing visualization of optic disc details, and two whose media did not allow visualization of the disc), potential vision was better than the patient's best corrected vision. For these patients, cataract surgery was recommended with guarded prognosis. This group will be discussed separately.

Extracapsular cataract extraction with or without intraocular lens implantation was performed on 34 eyes by one surgeon (MBD) and intracapsular cataract extraction was performed on 1 eye by another surgeon (C. Kupfer). The patients were followed between 10 and 70 weeks post-

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[1] The authors have no commercial, proprietary, or financial interest in the Laser Interferometer or the Potential Acuity Meter

**Table 1.** Summary of clinical data for group A eyes (mild to moderate cataracts)

| Eye no. | Sex | Age | Diagnosis | Preoperative visual acuity | PAM | LI | Postoperative visual acuity |
|---|---|---|---|---|---|---|---|
| 4 | M | 77 | Mature presenile Cat | 20/100 | 20/40 | 20/60 | 20/20 |
| 5 | M | 48 | PSC | CF 1′ | 20/25 | 20/40 | 20/20 |
| 10 | M | 73 | Hyperopia/nuclear Cat | 20/ 80 | 20/25 | 20/25 | 20/25 |
| 11 | F | 53 | Myopia/steroid Cat | 20/ 60 | 20/30 | 20/40 | 20/20 |
| 12 | M | 71 | Brunescent Cat | 20/200 | 20/40 | 20/20 | 20/20 |
| 13 | M | 78 | High myopia/cat | 20/200 | 20/40 | 20/20 | 20/20 |
| 17 | M | 48 | PSC | 20/100 | 20/25 | 20/25 | 20/15 |
| 18 | M | 70 | Mature Cat | 20/200 | 20/30 | 20/20 | 20/20 |
| 21 | F | 52 | Mature presenile Cat | 20/ 80 | 20/20 | 20/40 | 20/20 |
| 22 | M | 57 | Diabetes/Cat | 20/200 | 20/25 | 20/50 | 20/20 |
| 24 | M | 76 | Mature Cat | 20/200 | 20/60 | 20/25 | 20/20 |
| 26 | M | 78 | High myopia/Cat | CF 18″ | 20/40 | 20/20 | 20/20 |
| 27 | M | 71 | Brunescent Cat | 20/200 | 20/30 | 20/20 | 20/20 |
| 29 | M | 65 | High myopia/diabetes | 20/200 | 20/40 | 20/30 | 20/20 |
| 31 | M | 79 | Senile Cat | 20/ 80 | 20/40 | 20/20 | 20/15 |
| 34 | F | 64 | Mature Cat | 20/200 | 20/30 | 20/25 | 20/20 |
| 35 | F | 61 | Mature Cat | 20/100 | 20/30 | 20/20 | 20/20 |

Cat, cataract; PSC, posterior subcapsular cataract; CF, counting fingers

**Table 2.** Results for group A eyes

| | | LI predicted vision | | Total |
|---|---|---|---|---|
| | | 20/40 or better | Worse than 20/40 | |
| PAM Predicted vision | 20/40 or better | 14 | 2 | 16 |
| | Worse than 20/40 | 1 | 0 | 1 |
| | | 15 | 2 | 17 |

Percent accuracy (95% confidence intervals)
PAM: 94% (71%, 100%)
LI: 88% (64%, 98%)

operatively. Best corrected visual acuity was stable during follow-up and was tabulated on the last visit.

Statistical methods used were McNemar's test (continuity-corrected) for paired dichotomous data and Fisher's exact test for association in fourfold tables (Armitage 1971). All statistical tests were two-tailed.

## Results

Table 1 presents the data for group A eyes. Postoperatively, all 17 eyes in group A achieved 20/25 or better visual acuity. Using the PAM, 16 of the 17 eyes were predicted to have 20/40 or better vision. The 17th eye was predicted to have 20/60 vision and attained 20/20 postoperative acuity. Using the LI, 15 of the 17 eyes were predicted to have 20/40 or better vision. Of the 2 remaining eyes, 1 was predicted to have 20/50 potential and the other 20/60 potential. Both of these had 20/20 vision postoperatively.

Table 2 summarizes the results in group A eyes. Both instruments predicted 20/40 or better in 14 out of 17 eyes. Of those 14 eyes, 11 had 20/25 or better vision postoperatively (see Table 1). In 2 patients, the potential acuity meter did slightly better than the laser interferometer, and in 1 patient the laser did slightly better than the potential acuity meter (Table 2). However, this difference was not statistically significant by McNemar's test.

Table 3 presents the data for group B eyes. In this group, the PAM predicted 20/40 or better potential vision in 5 of 15 eyes, whereas the LI predicted 20/40 or better potential vision in 8 of 15 eyes. Postoperatively, all 15 eyes had 20/30 or better vision. Table 4 summarizes the results in group B eyes with both instruments. The difference between the two instruments was not statistically significant by McNemar's test. Both instruments underestimated the potential acuity in 6 of 15 eyes.

The accuracy and 95% confidence interval in each group are presented in Tables 2 and 4. As all eyes without preexisting retinal lesions had a postoperative vision of 20/40 or better, we have defined accuracy as the percentage of cases that had a predicted vision of 20/40 or better.

The accuracy of the PAM differed between group A (94%, Table 2) and group B (33%, Table 4) with $P=0.001$ (Fisher's exact test). There is also a suggestion that the LI was a better predictor in group A (88%, Table 2) than in group B (53%, Table 4) with $P=0.07$.

The results of three cases with known macular disorders are shown in Table 5. Case 1 was known to have gyrate atrophy of the choroid and retina, with a preoperative visual acuity of 20/200, visual fields of 5° and extensive retinal degeneration. This patient was predicted to have 20/60 vision with the PAM and 20/40 with the LI. The actual postoperative vision was 20/50. It has been reported by Faulkner (1983b) that in cases of macular disorders, the LI overestimates potential acuity. Knowing this limitation of the laser interferometer, the patient was given a guarded prognosis and was extremely pleased with 20/50 postoperative vision. Previous to these tests cataract surgery was not offered to the patient, because her decreased acuity was thought to be related primarily to her retinal disorder. Consequently, despite extensive retinal disease, these two instruments were useful in recommending surgery.

In cases 2 and 3, both patients were known to have amblyopia because of congenital cataract with nystagmus

**Table 3.** Summary of clinical data for group B eyes (moderately advanced to advanced cataracts)

| Eye no. | Sex | Age | Diagnosis | Preoperative visual acuity | PAM | LI | Postoperative visual acuity |
|---|---|---|---|---|---|---|---|
| 1 | F | 21 | Congenital Cat | CF 5 ft. | 20/200 | 20/100 | 20/20 |
| 3 | F | 53 | Myopia/steroid Cat | CF 5 ft. | 20/ 30 | 20/ 30 | 20/20 |
| 6 | F | 64 | Hyperopia/PSC | CF 8 ft. | 20/ 30 | 20/ 60 | 20/20 |
| 7 | F | 52 | Mature presenile Cat | CF 6 in. | 20/ 50 | 20/ 30 | 20/20 |
| 8 | M | 64 | Mature Cat | CF 5 ft. | 20/ 50 | 20/ 30 | 20/20 |
| 9 | M | 49 | Congenital Cat | HM | LP | LP | 20/20 |
| 14 | F | 21 | Congenital Cat | CF 6 in. | 20/300 | 20/100 | 20/20 |
| 15 | M | 57 | Hypermature Cat | HM 6 in. | LP | 20/660 | 20/20 |
| 16 | F | 63 | Brun Cat/glaucoma | CF 1 ft. | 20/ 40 | 20/ 20 | 20/20 |
| 20 | F | 44 | Presenile Cat | CF 5 ft. | 20/ 40 | 20/ 30 | 20/20 |
| 23 | M | 77 | Brunescent Cat | CF 1 ft. | LP | LP | 20/30 |
| 25 | F | 55 | Myopia/presenile Cat | CF 5 ft. | 20/ 60 | 20/ 30 | 20/20 |
| 28 | F | 74 | Brunescent Cat | CF 1 ft. | 20/ 30 | 20/ 20 | 20/20 |
| 32 | M | 77 | Brunescent Cat | CF 2 ft. | 20/200 | 20/160 | 20/30 |
| 33 | M | 78 | Mature Cat | CF 2 ft. | 20/ 50 | 20/ 40 | 20/30 |

Brun, brunescent; CF, count figures; HM, hand movement

**Table 4.** Results for group B eyes

| | | | | |
|---|---|---|---|---|
| PAM predicted vision | 20/40 or better | 4 | 1 | 5 |
| | Worse than 20/40 | 4 | 6 | 10 |
| | | 8 | 7 | 15 |

Percent accuracy (95% confidence intervals)
PAM: 33% (12%, 62%)
LI: 53% (27%, 79%)

in one, and uncorrected anisometropia and congenital cataract in the other. In both cases the PAM did not overestimate potential vision, whereas the LI did overestimate in one case. Faulkner (1983a, b), as mentioned above, and Gstalder and Green (1971) have found that in amblyopic patients, there is an overestimation of visual function potential by laser interferometry. However, as in case 1, because of careful consideration and discussions with the patient, cataract extraction was performed. Postoperative vision improved, as predicted by the PAM. The patients were satisfied.

Three eyes with high axial myopia with nuclear cataracts and presumed severe myopic retinal degeneration were found to have good retinal acuity and underwent extracapsular cataract extraction (Table 6). Postoperative results were excellent. These will be discussed below.

## Discussion

Our findings show that both the PAM and laser interferometer were good predictors of visual acuity through media hazy due to mild-to-moderate cataracts (group A eyes) (Table 2) were there was good retinal function. This was aided by the fact that all these patients had good postoperative results and, hence, the main variables in the analysis pertained to the reliability of the instruments. There is also evidence that each instrument was more accurate in group A eyes than in group B eyes. This compares well with find-

**Table 5.** Summary of clinical data for three eyes with preexisting retinal disorders and a postoperative vision of less than 20/40

| Case | Diagnosis | Ophthalmoscopic visualization of optic disc | Preoperative vision | PAM | Laser | Postoperative vision |
|---|---|---|---|---|---|---|
| 1 | Gyrate atrophy of the choroid and retina; cataract | Disc details | 20/200 | 20/ 60 | 20/ 40 | 20/ 50 |
| 2 | Aniridia; nystagmus; amblyopia; congenital cataract | Disc outline | 20/200 | 20/100 | 20/330 | 20/ 70 |
| 3 | Anisometropia; uncorrected amblyopia; congenital cataract | No disc details | CF | 20/200 | 20/ 60 | 20/200 |

**Table 6.** Summary of clinical data for three eyes with high arial myopia

| Case no | Type of cataract | Preoperative refraction | A-scan | Postoperative refraction |
|---|---|---|---|---|
| 13 | Nuclear | $-23.50+3.50\times180$ | 29.95 mm | +2.00 |
| 26 | Nuclear | $-24.25+0.75\times$ 05 | 29.95 mm | $+1.25+1.25\times87$ |
| 29 | Nuclear and posterior subcapsular | $-18.25+1.75\times180$ | 30.63 mm | $+1.00+1.50\times96$ |

ings of others who only used either a laser interferometer (Faulkner 1983b; Goldmann et al. 1980; Halliday and Ross 1983) or the potential acuity meter (Minkowski et al. 1983; Christenbury and McPherson 1985).

In group B, despite the low accuracy of the methods, the information obtained was still useful because in most cases actual postoperative visual acuity was better than the vision predicted. This served to encourage the surgeon to recommend cataract surgery, because the patient's vision would not improve and would probably get worse without surgery. The postoperative vision would improve, at least to the level predicted by the instruments or better and, in most of our cases, was excellent.

Spurny et al. (1986) prospectively compared a white light interferometer (Lotmar Visometer) with the PAM and found that the Visometer gave more accurate predictions than the PAM. However, they did not group the eyes as to severity of the cataract. In addition, their patient population included those who were undergoing Nd: Yag capsulotomy, as well as many patients with chronic open-angle glaucoma and senile macular degeneration (SMD) with resultant poor postoperative visual acuity.

Guyton (1986) has warned that inclusion of eyes with various ocular conditions could artificially increase the apparent accuracy of the instruments. In particular, such conditions may cause the predicted vision to be better than actual postoperative vision, resulting in what Guyton refers to as "false positives". We have reported results separately for those eyes with and without preexisting retinal disorders. In the three eyes with preexisting retinal disorders, two were false-positives using the LI (Table 5). In addition, as mentioned above, Faulkner (1983b) lists seven conditions that could produce "false-positive" results: cystoid macular edema, macular holes or cysts, geographic atrophy of the macula, serous detachment of the macula, amblyopia, early postoperative detachment and field cut through fixation. Our experience confirms these observations.

An interesting finding in this study is the one on high myopes. Three eyes in group A had high axial myopia (Table 6) and were previously considered poor candidates for cataract surgery because of the presence of severe myopic degeneration and poor visual acuity. After finding good potential vision by both instruments, these patients underwent cataract extraction, which resulted in excellent visual acuity. The cataracts were mainly nuclear and were only moderately dense so that the examiner could still adequately visualize fundus details with the indirect ophthalmoloscope, suggesting that the poor vision was due to severe myopic retinal degeneration. However, direct ophthalmoscopy did not allow good visualization of the retina, suggesting that there was marked distortion of light as it passed through the lens.

It may be that, due to the long axial length of these eyes, minimal changes in the nuclear area or posterior subcapsular region of the lens may cause distortion significant enough to prevent adequate focusing of images on the macula. Thus, patients cannot be aided by refraction despite the relative clarity of the lens. The retinal function may still be good despite the poor appearance of the retina, and only potential acuity testing can determine this. In these three cases, the postoperative visual acuities were excellent with very little spectacle correction, just as both PAM and LI had predicted.

Thus, in group A eyes (moderate cataracts), both PAM and LI were reliable in determining how much of the vision loss was due to the cataracts (with accuracies of 94% and 88%, respectively). Neither was significantly better than the other. However, in group B eyes (advanced cataracts), both instruments were unreliable (accuracies of 33% for the PAM and 53% for the LI). Interestingly, in a subgroup of patients with high myopia and moderate cataracts, both instruments were very reliable and helpful in determining how much of the vision loss was due to the cataract. We therefore strongly recommend that these tests be performed on all high myopes with mild-to-moderate cataracts and poor visual acuity to aid in determining the extent of vision loss due to the cataracts.

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