

Comparison of the potential acuity meter and the visometer in cataract patients

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CLINICAL STUDY

Abstract

Purpose To compare the Guyton–Minkowski Potential Acuity Meter (PAM) and the Haag–Streit Lotmar Visometer (Visometer) in their ability to predict postoperative best corrected visual acuity (BCVA) in cataract surgery.

Setting University of British Columbia/ Vancouver General Hospital Eye Care Center, Vancouver, British Columbia, Canada.

Methods In total, 292 eyes (223 patients) of subjects with cataracts and no known macular or optic nerve pathology were recruited over 6 months. Preoperative predictions of postoperative BCVA were compared with actual postoperative BCVA. The usefulness of these instruments as a ‘diagnostic test’ for predicting true surgical success (defined as postoperative BCVA of 20/40 or better) from predicted surgical success (PAM or Visometer predicted acuity 20/40 or better) was analysed.

Results Neither the PAM nor the Visometer predictions were statistically significant predictors of postoperative BCVA. The sensitivities of PAM and Visometer for predicting surgical success were 84.7% and 96.1%, respectively. The specificity of the PAM and Visometer for predicting surgical success was 27.3% and 9.1%, respectively. Overall, 92.7% of patients had ‘successful surgery’. Given a predicted success from the PAM or Visometer the post-test probability of success was 93.5% and 93.1%, respectively. Given a predicted failure from the PAM or Visometer there was a post-test probability of surgical success of 87.5% and 84.6%, respectively.

Conclusion We found no clinical benefit to support using the PAM or Visometer in the preoperative assessment of cataract patients with no known retinal or optic nerve pathology.

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Introduction

An accurate assessment of macular function in the presence of cataract is typically performed to determine if surgery will be of benefit. Preoperative macular assessments include both structural and functional testing. Structural evaluation primarily is performed by slit-lamp biomicroscopy or binocular indirect ophthalmoscopy. Two technologies commonly used for preoperative functional macular assessments include the Snellen chart projector (Potential Acuity Meter (PAM)) and the white-light interferometer (Visometer).

The Guyton–Minkowski PAM works by projecting a miniature Snellen chart through a small window, approximately 0.1 mm in diameter, in the lens opacity. The image traverses the lens without diffraction from the edges of the aperture or loss of illumination, allowing determination of retinal acuity.¹

The first quantitative assessment of macular function made by projecting interference fringes onto the retina was described by LeGrand in 1935.² Lotmar documented Moiré fringe testing in 1972 leading to the development of the Visometer, a tool which is able to measure retinal acuity using white light, interferometry in the presence of lenticular, corneal, or vitreous opacities.^{3,4}

Although validation studies have been performed for the PAM,^{5–7} no large-scale study has evaluated these two commonly used instruments in a patient population undergoing cataract surgery. The purpose of this study is to analyse the capabilities of both PAM and Visometer in predicting postoperative

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best-corrected visual acuity (BCVA) and interpret their clinical usefulness in a consecutive series of patients with no known underlying ocular pathology undergoing cataract surgery.

Methods

From the offices of nine cataract surgeons, a consecutive series of cataract patients who underwent preoperative functional testing at the University of British Columbia/Vancouver General Hospital Eye Care Centre during a 6-month period in 1999 were evaluated. Ethics approval was received from the University of British Columbia's Clinical Research Ethics Board. Patients with known vision loss from pre-existing macular or optic nerve disease were excluded.

Procedure dates, gender, date of birth, and preoperative visual acuity data, as well as preoperative PAM and Visometer measurements, were collected for each patient. All subjects underwent phacoemulsification with intraocular lens implantation. The nine ophthalmic surgeons performed cataract surgery by a small incision phacoemulsification technique and measured the pre- and postoperative BCVA. The timing of the final BCVA assessment was left to the discretion of the attending physician.

Preoperative testing was performed by two ophthalmic technicians following identical protocols. The PAM assessment was performed before the Visometer. Both instruments were used in a darkened room, following pupil dilation with Phenylephrine Hydrochloride 5% and Tropicamide 0.8%. For the Lotmar Visometer, the power source of the attached Haag-Streit BM™ slit-lamp was set at 5.0 V, and the following interferometer settings were chosen: white filter, stop set at 0.5 mm diameter, acuity scale on 0.05, and visual field at 3.5°. The acuity scale was advanced by increments of 0.1 from 0.1 to 1.0 or until the patient could no longer identify the orientation of the fringe pattern. (0.1 and 1.0 on the Visometer decimal system correspond to 20/200 and 20/20, respectively). For PAM testing, the Haag-Streit power input was set at 5.0 V and subjects were aligned until the projection beam was visible to them. Subjects were tested progressing from largest to smallest acuity lines. A single incorrect response per line was accepted.

Data were entered and analysed using Statistical Package for Social Sciences (SPSS) 10.0.⁸ Best corrected Snellen visual acuity was reported and used for the primary analyses comparing pre- and postoperative visions. Mean postoperative acuities were analysed using the mean values to the Log of the Minimum Angle of Resolution (LogMAR).⁹

Primary analyses included comparisons of (1) preoperative visual acuity estimated using the Visometer and postoperative Snellen BCVA and (2) preoperative visual acuity using the PAM and postoperative Snellen BCVA. Mean values of visual acuities obtained preoperatively by the PAM and the Visometer were compared with the postoperative BCVA using Pearson correlation coefficients.¹⁰

The accuracy with which the PAM and the Visometer can predict surgical success and failure was compared such that both the PAM and Visometer could be thought of as 'diagnostic tests' being compared to the postoperative BCVA as the 'gold standard'. For this comparison, a successful surgery was defined as a BCVA of 20/40 or better (either predicted or actual), whereas a surgical failure was defined as a BCVA of less than 20/40 (either predicted or actual). Sensitivity of the diagnostic test (either PAM or Visometer) was calculated as the proportion of eyes that were predicted to have 'successful surgery' amongst the total number of eyes that were postoperatively found to have undergone 'successful surgery'. Sensitivity, specificity, predictive values, and likelihood ratios were calculated for both PAM and Visometer as diagnostic tests in predicting postoperative surgical success. For sensitivity, specificity, and predictive values, 95% confidence intervals are reported.¹⁰ In addition, a multivariate logistic regression analysis was used to predict 'postoperative surgical success' using the PAM and Visometer predictions while controlling for age, gender, and the number of eyes each subject had in the study simultaneously.

Results

In total, 557 PAM and Visometer tests were performed during the 6-month study period. Tests from nonparticipating physicians ($n = 107$) and those with known macular or optic nerve pathology were excluded ($n = 143$). This left 307 tests for evaluation that represented single eyes of 223 subjects (139 subjects had one study eye included and 84 subjects had two study eyes included). Of the 307 eyes considered as data points for the analysis, four Visometer prediction values were missing and 11 PAM prediction values were missing. Consequently, PAM predictions were compared to postoperative BCVA using 296 eyes, Visometer predictions were compared to postoperative BCVA using 303 eyes, and PAM and Visometer predictions were compared using 292 eyes.

Of the 223 eligible subjects, 136 (61%) were female and 87 (39%) were male. The mean age of the subjects was 75.5 years (SD = 10.0 years) and ranged from 32 to 93 years. The mean follow-up time prior to recording the final postoperative BCVA was 11 weeks (range 4–52).

The mean true postoperative BCVA was 0.16 LogMAR units (SD = 0.16). The PAM and Visometer estimates of postoperative BCVA were 0.23 (SD = 0.35) and 0.12 (SD = 0.29) LogMAR, respectively. Preoperative PAM predictions tended to overestimate true postoperative BCVA (mean overestimation = 0.07), whereas Visometer tended to underestimate postoperative BCVA (mean underestimation = 0.04). Table 1 shows the distribution of postoperative acuities compared to PAM and Visometer predictions—measured as the difference in lines of vision between predicted and measured acuities.

There was a rough correlation between postoperative BCVA and PAM predictions (Pearson Correlation, $\rho = 0.206$, $P < 0.01$) and between postoperative BCVA and Visometer predictions (Pearson Correlation, $\rho = 0.222$, $P < 0.01$).

The accuracy with which the PAM and the Visometer can predict surgical success and failure was compared and is shown in Table 2. Table 3 shows sensitivity, specificity, predictive values, and likelihood ratios for both the PAM and Visometer as ‘diagnostic tests’ for

Table 1 Deviation of postoperative acuities from PAM and visometer predictions

	Vision	PAM number of subjects	% of total	Visometer number of subjects	% of total
No. of lines Better than Prediction	>4	20	6.76	6	1.98
	3	14	4.73	1	0.33
	2	21	7.09	10	3.30
	1	67	22.64	40	13.20
	0	77	26.01	77	25.41
No. of lines Worse than Prediction	-1	62	20.95	94	31.02
	-2	23	7.77	50	16.50
	-3	8	2.70	18	5.94
	> -4	4	1.35	7	2.31

Table 2 Accuracy of the PAM and visometer in predicting surgical success^a and failure

	Postoperative success	Postoperative failure	Total
<i>PAM predictions</i>			
Predicted success	232	16	248 (83.8%)
Predicted failure	42	6	48 (16.2%)
Total	274 (92.6%)	22 (7.4%)	296
<i>Visometer predictions</i>			
Predicted success	270	20	290 (95.7%)
Predicted failure	11	2	13 (4.3%)
Total	281 (92.6%)	22 (7.3%)	303

^aSurgical success was defined as postoperative BCVA 20/40 or better.

Table 3 Sensitivity and specificity of PAM and visometer in predicting surgical success^a and failure

	PAM	Visometer
Sensitivity	84.7% (79.7–88.6%)	96.1% (92.9–97.9%)
Specificity	27.3% (11.6–50.4%)	9.1% (1.6–30.6%)
Positive predictive value	93.5% (89.5–96.1%)	93.1 (89.4–95.6%)
Negative predictive value	12.5% (5.2%–25.9%)	15.4% (2.7%–46.3%)
Likelihood ratio (success)	1.16	1.05
Likelihood ratio (failure)	560	428

^aSurgical success was defined as postoperative BCVA 20/40 or better.

predicting postoperative BCVA (‘surgical success’ or ‘surgical failure’). Over 92% of surgeries were postoperatively considered ‘successful’.

In addition, a multivariate logistic regression analysis was performed in order to predict postoperative success or failure based on the PAM and Visometer predictions of success or failure after controlling for age, gender, and whether the patient had one or two eyes involved in the study. This analysis showed that none of the above variables could significantly predict postoperative success or failure.

Discussion

Many authors have used case-series data to evaluate the Guyton–Minkowski PAM for predicting postoperative visual acuity after cataract surgery^{1,5–7} or to compare this device to other instruments for predicting postoperative visual acuity after cataract surgery.^{11–16} Two studies have specifically compared the PAM to the Lotmar Visometer.^{17,18} However, these studies employed relatively small sample sizes (<55 each) and a significant proportion of these samples (30–45%) were made up of subjects with known posterior segment pathology. We also believe the interpretations provided by these studies as to the usefulness of the PAM and Visometer were not complete because neither study evaluated these devices in the setting of the preoperative decision-making process for cataract surgery.

The accuracy of both the PAM and the Visometer in predicting postoperative visual acuity in a large consecutive series of cataract patients with no known vision loss from pre-existing eye disease has been previously unknown. The question is important because the comparative strengths and shortcomings of these two instruments, as they relate to cataract pathology, cannot be easily evaluated in the presence of confounding posterior segment pathology. By evaluating a population

with no known macular pathology, the effect of cataract alone on the performance of each instrument, individually and in comparison, can be evaluated.

We found a statistically significant correlation between both PAM and Visometer with postoperative BCVA, yet the correlation coefficient was poor and thus clinically (or practically) insignificant. In general, the Visometer slightly underestimated the postoperative acuity, but was closer to the postoperative acuity than the PAM. These trends are similar to previous research on this subject.^{17,18}

PAM and Visometer both have high sensitivity and low specificity for predicting surgical success/failure. In this context, sensitivity is defined as the proportion of patients who were predicted to have a successful surgery out of all patients who had a postoperatively defined successful surgery, whereas specificity is the proportion of patients who were predicted to have a failed surgery out of all patients who had a postoperatively defined failed surgery. These measures, however, are not necessarily applicable in a preoperative setting because the true outcome of the surgery is not known preoperatively.

The positive predictive value (PPV) in this situation is the proportion of postoperatively defined successful surgeries out of all patients who were predicted to have a successful surgery with PAM or Visometer. The negative predictive value (NPV) is the proportion of postoperatively defined failed surgeries, which were predicted to fail preoperatively with PAM or Visometer. The PPV and NPV for both the instruments were high and low, respectively. In general, PPV and NPV are more applicable to the preoperative situation. For instance, if a patient has a preoperative test (PAM or Visometer) that predicts surgical success the PPV gives the clinician an estimate of the probability of surgical success. However, PPV and NPV both necessarily depend on the overall chance of surgical success based on the population of interest.¹⁹

Based on our data, 92.7% of all surgeries performed were successful. If a patient had a positive prediction from PAM or Visometer, the chance of success (ie PPV) was marginally increased from 92.7 to 93.1% for the PAM and from 92.7 to 93.5% for the Visometer. Stated another way, the positive likelihood ratio (PLR), or the odds that a predicted surgical success would be expected in a patient who has a true surgical success (compared to a true surgical failure) is essentially 1.0. Thus, a preoperative prediction of surgical success from either PAM or Visometer is of no clinical value.

Conversely, if the PAM or Visometer preoperatively predicted a negative surgical outcome, the chance of surgical success was still over 84% and surgical intervention would universally be considered appropriate. Furthermore, if a preoperative prediction of

surgical failure led to a decision by an ophthalmologist not to extract a patient's cataract then a patient with a high likelihood of benefit from intervention would not receive surgery.

The reason for this finding is that the PPV of preoperative testing in this setting necessarily rises with the overall proportion of successful cataract surgery (likewise, the NPV necessarily decreases). In our study, the PPV is high and NPV is low mostly because our pre-test likelihood of surgical success is high (92.7% of 'all-comers' had successful surgery). We have already shown how preoperative testing with PAM and Visometer are of negligible benefit in the setting of a high pre-test likelihood of surgical success. However, a diagnostic test is most useful if the preoperative probability is close to 50% (in this situation if there were a 50% pretest likelihood of surgical success). The likelihood ratios for the PAM and Visometer can be used to predict post-test likelihood of surgical success/failure from the pretest likelihood independent of the overall likelihood of surgical success. In our study, both positive and negative likelihood ratios are close to 1.0, making their predictive utility of little clinical value. Therefore, in patients undergoing cataract surgery that has no identified retinal or macular pathology, the PAM and Visometer have little usefulness and are potentially detrimental in the preoperative setting.

There are limitations to our study design. Firstly, we evaluated a population of patients who had been sent for preoperative functional testing at the discretion of their ophthalmologist. Therefore, there is potential for bias if this population differs in how PAM and Visometer could predict postoperative outcome compared to a random population of patients undergoing cataract surgery (who may or may not have been sent for preoperative functional testing at their ophthalmologists discretion). However, by examining a population of patients who have been chosen to undergo preoperative functional testing we were able to look at the effectiveness—or usefulness in a real world setting—of these assessment tools. A second limitation of this study is that we are assessing patients with no known macular pathology but we did not perform a universal retinal exam on each patient as part of the study design. Thirdly, we do not take visual acuity data from standardized postoperative time points and did not specifically account for early posterior capsular opacification or surgery-related complications.

Our study provides quite different conclusions when compared to previously published reports on this subject.^{17,18} First, we found no overall significant difference between the PAM and Visometer in preoperative predictive ability, but this point is of limited value since neither instrument predicted well. Second,

we were unable to find evidence of any clinical benefit to using the PAM or Visometer in the setting of preoperative cataract assessment where the retinal evaluation is grossly normal. We recommend that these preoperative instruments not be used for this purpose due to cost and the potential for withholding potentially vision-saving treatment from patients who may benefit. In conclusion, the use of the Potential Acuity Meter or Visometer in preoperative cataract assessment does not provide a clinically useful prediction of postoperative best-corrected visual acuity.

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