Comparison of adapted Vryghem macular function test and Lotmar-light interferometer in predicting visual acuity after cataract surgery

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ABSTRACT.

Purpose: **To assess the accuracy of a newly described macular function test (Vryghem macular function test) adapted to our examination equipment and to compare it to the Lotmar-light interferometer for the preoperative evaluation of cataract patients at the University Eye Clinic, Geneva, Switzerland.**

Methods: **This prospective study included 71 consecutive patients (72 eyes) who were undergoing uneventful cataract surgery. Testing with the Lotmar-light interferometer and an adapted form of Vryghem macular function test (AVMFT) using a Birkhauser reading chart, a hyperaddition of +8 D and halogen illumination were performed to assess macular function and to predict postoperative visual acuity (VA). The duration of each test and the density and location of lens opacities were also noted. Best-corrected postoperative VA was compared to the predicted values of each test.**

Results: **The positive predictive value was 94.2% for AVMFT compared to 92.2% for the Lotmar-light interferometer. The negative predictive value was 50% for AVMFT compared to 42.9% for the Lotmar-light interferometer. The sensitivity was 83.1% for AVMFT and 79.7% for the Lotmar-light interferometer. The specificity was 76.9% for AVMFT and 69.2% for the Lotmar-light interferometer. The correlation coefficient for AVMFT and preoperative Lotmar results (both in LogMAR) with postoperative best-corrected VA (poBCVA; LogMAR) were similar (0.74 and 0.77 respectively).**

Conclusion: **The results of this study suggest that AVMFT is as reliable as the Lotmar-light interferometer in predicting postoperative VA after uneventful cataract surgery. The correlation coefficients with postoperative VA were 0.74 and 0.77, respectively. Both tests showed a high positive (94.2% and 92.2%, respectively) but a low negative (50.0% and 42.9%, respectively) predictive value.**

Key words: cataract – cataract surgery – phacoemulsification – potential vision – diagnostic tests – surgical outcomes – testing

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Introduction

Several potential visual tests have been developed to predict potential visual acuity (VA) after cataract surgery. The common goal of all these tests is to determine whether preoperative visual impairment is because of cataract opacity alone or other underlying ocular pathologies affect the visual potential. Identifying those patients in whom cataract extraction will not yield a satisfactory postoperative VA helps to properly inform and prepare those patients with realistic expectations. If no pathology is seen in the ocular fundus, a supplementary test can help to reassure both patient and surgeon that actual visual loss is because of cataract alone. If macular retinal pathology is seen preoperatively, a potential visual test can help to determine which part of the visual loss is because of lens opacity alone. Note that if coexistent ocular pathology compromises the expected visual outcome, the patient's satisfaction with surgery will not depend only on the postoperative VA (Monestam & Wachtmeister 1999; Mozaffarieh et al. 2005). Cataract surgery may improve other aspects of visual function such as contrast sensitivity, colour perception, reduction of glare and visual field (Mangione et al. 1992; Steinberg et al. 1994; Lundstrom et al. 1997, 2006; Sundelin et al. 2005). Sometimes

a very dense cataract does not permit satisfactory fundoscopic examination; in these cases, a reliable potential VA test may be helpful in the preoperative decision-making process.

The ideal potential visual test should be precise, reproducible, easy to use and require only minimal examination equipment. It should have good accuracy and also a high predictive value (Odom et al. 1987). A number of methods using different examination equipment have been described: electroretinography (Bertrand et al. 1984; Sherman et al. 1988; Wu et al. 1991), visual evoked potentials (Bertrand et al. 1984; Odom et al. 1987; Sherman et al. 1988; Mori et al. 2001), colour saturation discrimination (Kogure et al. 1999), blue-field entoptic tests (Sinclair et al. 1979; Miris & Missotten 1982; Grignolo et al. 1988), B-scan ultrasonography (Sherman et al. 1988), critical flicker frequency (del Romo et al. 2005), laser or white-light interferometry (Lotmar 1980; Spurny et al. 1986; Lasa et al. 1995; Le Sage et al. 2002; Reid et al. 2005) and potential acuity meter (PAM) (Spurny et al. 1986; Lasa et al. 1995; Devereux et al. 2000; Gus et al. 2000; Le Sage et al. 2002; Reid et al. 2005; Uy & Munoz 2005). Other tests using routine eye examination equipment have also been proposed: potential acuity pinhole test (Melki et al. 1999; Uy & Munoz 2005), illuminated near card assessment (Hofeldt & Weiss 1998) and reading speed test (Pesudovs et al. 2002; Stifter et al. 2005); these have been compared to the more sophisticated methods (Uy & Munoz 2005).

Vryghem et al. (2004) proposed a simple and inexpensive macular function test using a Parinaud near reading chart, a +8 D trial lens and a Heine ophthalmoscope, which they called the Vryghem macular function test (VMFT). After their study of 396 uneventful consecutive cataract surgeries, they concluded that the VMFT test was a simple, inexpensive and reliable method of estimating the visual outcome after uneventful cataract surgery. Because of the simplicity and availability of this test, we decided to compare it to the Lotmar-light interferometer, currently the instrument used in our clinic to predict VA after cataract surgery.

Materials and Methods

This prospective study included 71 consecutive patients (72 eyes; 33 right eyes, 39 left eyes) who underwent cataract surgery at the Department of Ophthalmology, University Hospital of Geneva, Switzerland and had preoperative examinations between 1 February 2006 and 31 March 2006. The mean age of subjects was 73.7 years [standard deviation (SD) 9.6 years] and ages ranged from 37 to 91 years. Forty-nine were female and 22 were male. Exclusion criteria were previous eye surgery, complicated surgery, persistent vision-impairing postoperative corneal oedema or secondary cataract.

Testing and surgical techniques

Patients underwent a complete preoperative ocular examination including distance best-corrected VA (BCVA), slit-lamp evaluation, applanation tonometry and dilated fundoscopy. Cataracts were classified into three morphological categories – cortical, nuclear and posterior subcapsular – and their density was assessed subjectively and graded clinically as follows: 0, no cataract; 1, minimal/mild cataract; 2, moderate cataract; 3, severe cataract.

An adapted form of Vryghem macular function test (AVMFT; performed by a single investigator) and Lotmar-light interferometer (performed by a single optometrist) measurements were performed on each study eye preoperatively. An adapted form of the Vryghem macular function test was performed before and after pupil dilatation with tropicamide 0.5% and phenylephrine 2.5%; the better score was noted. Lotmar-light interferometry was always performed after pupil dilatation with tropicamide 0.5% and phenylephrine 2.5%. After some experience with AVMFT was acquired, we started to assess the time required to perform AVMFT as well as Lotmar-light interferometry.

All patients had clear cornea phacoemulsification with foldable intraocular lens implantation under topical or retrobulbar anaesthesia performed by different surgeons. Postoperative follow-up was at 1 and 8 days and about 6 weeks; this was performed at our clinic or by the attending ophthalmologist. BCVA was recorded (the best BCVA of all postoperative controls was considered as poBCVA); if it was worse than 0.8, it was investigated.

Adapted Vryghem macular function test

We used the same technique described by Vryghem et al. (2004) and adapted it to our examination equipment: a Birkhauser reading chart, illuminated by a halogen desk lamp held approximately 30 cm from the reading chart and a +8 D trial lens in addition to the distance correction in a trial frame. The test was performed in a darkened room. The reading chart was first placed 12 cm from the trial lens and then the patient was encouraged to adjust this distance for best reading ability. Once they found 'their' best reading distance, patients were asked to read the smallest line on the chart they could discriminate. We found that the distance at which patients could see the best was always about 12 cm.

Lotmar

The power source of the attached Haag-Streit slit-lamp was set at 7.5 V, and the following interferometer settings were chosen: green 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 until the patient could no longer identify the orientation of the fringe pattern. The test was performed in a darkened room.

To compare the two macular function tests we calculated for each test the positive and the negative predictive value, the sensitivity and the specificity, and then compared the results. In this context, positive predictive value was defined as the proportion of postoperatively good BCVA (≥0.8) of all patients who were predicted to have a good postoperative VA (≥0.8) and negative predictive value as the proportion of postoperatively bad BCVA (<0.8) of all patients who were predicted to have a bad postoperative VA (<0.8). Sensitivity was defined as the proportion of eyes that were predicted to have a good poBCVA (≥0.8) of all patients who had a poBCVA of ≥0.8 and specificity as the proportion of eyes that were predicted to have a bad poBCVA (<0.8) of all patients who had a poBCVA of <0.8.

The Pearson correlation coefficient between the expected macular function and the poBCVA (both in LogMAR) was calculated for each test and for each of the three morphological categories of cataract, and the results were compared.

Results

The mean preoperative BCVA was 0.44 (SD 0.21). Cataract classification and grading is presented in Table 1. In addition to cataract, 15 patients showed concomitant ocular pathologies (see the following and Table 2).

Using AVMFT preoperatively, 52 eyes (72.2%) were able to read the line on the Birkhauser reading chart corresponding to VA = 1.0 or better. 94.2% of these eyes had a poBCVA of 0.8 or better (positive predictive value). Forty-two eyes (58.3%) could read the line corresponding to VA = 1.25 or better preoperatively and 36 (50%) the line corresponding to VA = 1.5 preoperatively. All eyes in the latter two groups had a poBCVA of 0.8 or better (positive predictive value: 100%). In comparison, the Lotmar-light interferometer predicted in 51 eyes (70.8%) a poBCVA of 0.8 or better, which was finally true in 92.2% of them.

In three cases, AVMFT predicted a good poBCVA (VA = 1.0 could be read) but postoperatively a BCVA of <0.8 was achieved. The reason was diabetic macular oedema in one eye and early macular degeneration in another; there was no apparent reason in the third eye. The Lotmar-light interferometer had predicted good poBCVA in these three cases, and also in a fourth case that had post-uveitic endothelial precipitates.

Of the 20 eyes (27.8%) that were not able to read the Birkhauser reading line of VA = 1.0 with AVMFT preoperatively, 50% had a poBCVA of <0.8 (negative predictive value). This negative predictive value was worse in the groups who were not able to read the line corresponding to VA = 1.25 and VA = 1.5 (43.3% and 36.1%, respectively). In comparison, the Lotmar-light interferometer predicted in 21 eyes (29.2%) a poBCVA of worse than 0.8. This was finally true in 42.9% of them.

The sensitivity (what percentage of the 59 eyes with a poBCVA of ≥0.8 did we detect before surgery?) was between 61.0% and 83.1% for AVMT (83.1% for those who could read the line corresponding to VA = 1.0 or better, 71.2% for those who could read VA ≥1.25 and 61.0% for those who could read VA = 1.5) and 79.7% for the Lotmar-light interferometer (Table 3).

The specificity (what percentage of the 13 eyes with a poBCVA of <0.8 did we detect before surgery?) was between 76.9% (for those who could not read the line corresponding to VA = 1.0) and 100% (for those who could not read VA = 1.25 and VA = 1.5) and 69.2% for the Lotmar-light interferometer (Table 3).

The correlation coefficient for preoperative AVMFT (LogMAR) and poBCVA (LogMAR) was similar to the correlation coefficient for preoperative Lotmar results (LogMAR) and poBCVA (LogMAR; Table 4). For Lotmar-light interferometry, this correlation coefficient was higher if severe cataracts or severe nuclear cataracts were excluded. For AVMFT, it was higher if severe cataracts or subcapsular cataracts were excluded (Table 4).

An adapted form of Vryghem macular function test was performed before and after pupil dilatation, and the better score was noted in all but four cases in which the score was noted only either before or after pupil dilatation; thus, the following percentages

Table 1. Classification of cataracts.

	Number of eyes
Cortical cataract	
Density grade 1	33
Density grade 2	11
Density grade 3	0
Nuclear cataract	
Density grade 1	16
Density grade 2	41
Density grade 3	10
Subcapsular cataract	
Density grade 1	20
Density grade 2	14
Density grade 3	5

Table 2. Comparison of adapted Vryghem macular function test (AVMFT) and the Lotmar-light interferometer in predicting postoperative best-corrected visual acuity (poBCVA) in underlying ocular pathology.

poBCVA	AVMFT (not dilated)	AVMFT (dilated)	Lotmar	Pathology	Pathology seen preoperatively?
0.1	0.2	0.2	0.05	ARMD	Yes
0.1	0.1	0.2	0.2	ARMD	Yes
0.4	0.9	0.9	0.6	ARMD	Yes
0.3	0.4	0.2	0.5	ARMD	Yes
0.6	0.8	0.8	0.5	ARMD	Yes
0.8	1.0	1.25	0.8	ARMD	Yes
0.9	0.7	0.7	0.7	ARMD	No
0.7	1.0	1.0	1.0	ARMD	Yes
0.5	0.9	0.7	0.7	Postuveitic endothelial precipitates	Yes
0.7	0.4	0.5	0.9	Postuveitic endothelial precipitates	Yes
0.8	1.5	1.5	0.8	Postuveitic endothelial precipitates	Yes
0.8	1.25	1.25	1.0	Epiretinal membrane	No
0.2	0.05	0.05	0.2	Epiretinal membrane	Yes
0.7	1.0	1.0	1.1	Diabetic retinopathy	Yes
0.8	0.5	0.6	0.6	Asteroid hyalosis	Yes

ARMD, age-related macular degeneration.

Table 3. Comparison of accuracy of the Lotmar-light interferometer, adapted Vryghem macular function test (AVMFT) and Vryghem macular function test (VMFT) in predicting postoperative best-corrected visual acuity (poBCVA).

	Lotmar (%)	AVMFT (%)			VMFT* (%)
	≥ / <0.8	≥ / <1.0	≥ / <1.25	≥ / <1.5	
Positive predictive value	92.2	94.2	100.0	100.0	94.2
Negative predictive value	42.9	50	43.3	36.1	32.4
Sensitivity	79.7	83.1	71.2	61.0	93.1
Specificity	69.2	76.9	100.0	100.0	36.4

*Vryghem et al. 2004.

Table 4. Comparison of the correlation coefficient between the tested macular function tests and postoperative visual acuity (VA) depending on type and grading of cataract.

Type of cataract (grading) excluded	Correlation coefficient AVMFT/poBCVA (LogMAR)	Correlation coefficient Lotmar/poBCVA (LogMAR)
No exclusions (n = 72)	0.74	0.77
Subcapsular cataract (3) excluded (n = 67)	0.80	0.78
Subcapsular cataract (2 + 3) excluded (n = 53)	0.81	0.69
Subcapsular cataract (1 + 2 + 3) excluded (n = 33)	0.80	0.72
Nuclear cataract (3) excluded (n = 62)	0.76	0.85
Nuclear cataract (2 + 3) excluded (n = 21)	0.48	0.55
Nuclear cataract (1 + 2 + 3) excluded (n = 5)	0.11	0.47
Cortical cataract (2 + 3) excluded (n = 61)	0.73	0.75
Cortical cataract (1 + 2 + 3) excluded (n = 28)	0.22	0.20
Severe cataract excluded (all types) (n = 57)	0.83	0.86

poBCVA, postoperative best-corrected visual acuity; AVMFT, adapted Vryghem macular function test; VMFT, Vryghem macular function test.

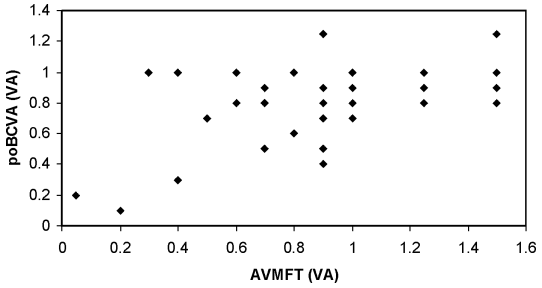

Fig. 1. Correlation between the adapted Vryghem macular function test (AVMFT) and postoperative best-corrected visual acuity (poBCVA). VA, visual acuity.

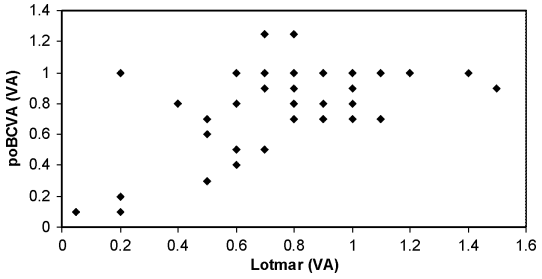

Fig. 2. Correlation between Lotmar and postoperative best-corrected visual acuity (poBCVA). VA, visual acuity.

consider only 68 eyes. In 25% of the eyes the score was better without dilatation, in 19.1% with dilatation and in 55.9% the scores were equal with and without dilatation. Comparison of the correlation coefficients for preoperative AVMFT (LogMAR) and poBCVA (LogMAR) in these subgroups showed that the best correlation was found if the dilated and the non-dilated score were identical. In the other two subgroups, the better AVMVT score showed better correlation with poBCVA (see Table 5). Concerning the distribution of the different types and grades of cataracts in these groups, we noted that the highest proportion of very dense cataracts (grade 3, all three morphological categories confounded) or dense subcapsular cataracts (grade 2 or 3) was found in the group that reached better scores with dilatation.

Time needed to perform Lotmar-light interferometry (mean 1.9 min) was about twice the time needed for AVMFT (mean 0.9 min). In addition to cataract, 13 patients had a pathological ophthalmological status preoperatively that could, in theory, influence the poBCVA: seven patients showed age-related macular degeneration (ARMD); three patients had endothelial precipitates from prior uveitis; one patient had an epiretinal membrane; one patient showed asteroid hyalosis; and one patient had diabetic macular oedema.

In two additional patients, additional diagnoses that could affect the visual prognosis were made postoperatively. In one case, a dense cataract did not permit fundus visualization preoperatively and ARMD was diagnosed postoperatively; in another case, an epiretinal membrane was seen only postoperatively. AVMFT overestimated poBCVA in 11 of these 15 cases; the Lotmar-light interferometer did so in eight cases (see Table 2).

Discussion

Predicting postoperative VA from cataract surgery helps the surgeon to decide on recommending this surgery to a patient and helps the patient to understand the prognosis for improvement in VA. Le Grand (1935) first described a quantitative assessment of macular function by projecting interference fringes onto the retina.

Two coherent light beams of the same wavelength, very slightly out of phase, are simultaneously projected onto the retina. The interference of the two beams produces alternating

Table 5. Dependence of accuracy of adapted Vryghem macular function test (AVMFT) in predicting postoperative best-corrected visual acuity (poBCVA) of pupil dilatation.

	Correlation coefficient AVMFT/poBCVA (LogMAR)	
	AVMFT non-dilated pupil	AVMFT dilated pupil
AVMFT dilated = non-dilated (n = 38)	0.86	0.86
AVMFT dilated < non-dilated (n = 17)	0.64	0.37
AVMFT dilated > non-dilated (n = 13)	0.52	0.61
AVMFT overall (n = 68)	0.68	0.67

dark and light bands on the retina, called Moiré fringes (Lotmar 1972). Thus not the stripes that are seen by the patient are projected through the media (they are formed by interference on the retina) but only the coherent light beams (Goldmann et al. 1980). Originally, lasers were used to form the two light beams until Lotmar (1980) developed the Lotmar-light interferometer, a similar instrument that uses white light of a normal low-voltage incandescent lamp that passes through two rotatable, equal diffraction gratings. Goldmann et al. 1980 helped Lotmar to develop laser interferometry in the early 1970s and first studied the use of the Lotmar-light interferometer in predicting retinal VA in cataractous eyes preoperatively. They found a high correlation between preoperative VA obtained with the Lotmar-light interferometer and the poBCVA for immature cataracts and when red fundus reflex was readily visible through the cataract (Goldmann et al. 1980). However, the first independent clinical evaluation of the Lotmar-light interferometer (Bernth-Petersen & Naeser 1982) concluded that Lotmar-light interferometry was not able to predict precisely the poBCVA in any group of cataracts. Calculating Lotmar-light interferometer accuracy, they found a sensitivity of 50% and a specificity of 84%, but these terms were inversely defined when compared to the present study: sensitivity was defined to mean the proportion of true-positive tests among macular-diseased cataract patients and specificity meant the proportion of true-negative tests among cataract patients with normal maculae. Poor preoperative test results did not give a reliable forecast of poBCVA. A tendency for overestimation of BCVA in cases of macular disease was noted.

In our study, 11 patients had macular disease. In three of them Lotmar-light interferometry underestimated the poBCVA; in six of them it overestimated it; and in two it predicted it correctly (see Table 2).

Three years later, Bryant (1985) analysed in 101 eyes the accuracy of Lotmar-light interferometry in predicting poBCVA. He concluded that predictions were too pessimistic with dense cataracts and too optimistic in the presence of macular pathology.

Spurny et al. (1986) compared Lotmar-light interferometry and PAM testing in 40 eyes and found that the Lotmar-light interferometer gave a better prediction of poBCVA, even in cases of advanced cataract or amblyopic eyes; they concluded that the Lotmar-light interferometer was overall a reliable predictor of postoperative VA.

Recently, Reid et al. (2005) compared the Lotmar-light interferometer and PAM in 303 eyes. For Lotmar-light interferometry, they found relatively high sensitivity (96.1%) and a positive predictive value of 93.1%, but very low specificity (9.1%), a negative predictive value of 15.4% and a Pearson correlation of 0.222. Lotmar-light interferometry tended to underestimate poBCVA. They concluded that both tests were of no clinical value in the setting of preoperative cataract assessment where the retinal evaluation is grossly normal. We also found high positive (92.2%) and lower negative (42.9%) predictive values. Even though the negative predictive value (42.9%) and the specificity (69.2%) were higher in our study, the sensitivity was lower (79.7%). However, the Reid et al. study differed significantly from ours in that they defined successful surgery as BCVA of 0.5 or better but we put the barrier higher at 0.8. Also, they included only patients without any known macular pathology and they did not perform a retinal exam on every patient.

The VMFT was developed in 1993 as a new simple macular function test that was presented to be a reliable test for predicting poBCVA except in eyes with dense cataract or amblyopia. Adapting the VMFT to our examination equipment, we compared it in 72 eyes to the poBCVA after uneventful cataract surgery and we found the same positive predictive value (94.2%), a higher negative predictive value (50% compared to 32.4%) and specificity (76.9% compared to 36.4%) but a lower sensitivity (83.1% compared to 93.1%). We confirm the described trends of a high positive predictive value and sensitivity and a lower negative predictive value and specificity. Because Vryghem et al. did not specify their definition of sensitivity and specificity, and because these terms have been used in different ways by different studies (Bernth-Petersen & Naeser 1982; Odom et al. 1987; Reid et al. 2005), we are not sure that these results are comparable.

Vryghem and colleagues state that VMFT has no negative predictive value in the presence of a dense cataract. We confirm these findings and have the impression that this is especially true in subcapsular cataracts [the correlation coefficient for preoperative AVMFT and poBCVA was higher if severe cataracts (all three morphologic categories together) or subcapsular cataracts were excluded – see Table 4].

Vryghem et al. proposed that in some cases (i.e. eyes with posterior subcapsular plaque or dense nuclear cataract) the test had to be repeated after pupil dilation. Comparing AVMFT before and after pupil dilatation, we found better scores in 25% without dilatation and in 19.1% with dilatation. In 55.9% the scores were equal. The best correlation between AVMFT and poBCVA was found if the dilated and the non-dilated scores were identical. In the other two subgroups the better AVMVT score showed better correlation with poBCVA (see Table 5). That is why we propose trying AVMFT first without dilatation and – only if a bad score is reached – repeating it after pupil dilatation.

In comparison, AVMFT and the Lotmar-light interferometer showed similar correlation coefficients with the postoperative VA. In the presence of a dense cataract both tests tend to be too pessimistic. This finding supports previous studies on the Lotmar-light interferometer and VMFT accuracy (Goldmann et al. 1980; Bryant 1985; Vryghem et al. 2004). It is also known that in cases of mature cataracts and posterior subcapsular cataracts the preoperative optical biometry commonly leads to measurement acquisition failures (Freeman & Pesudovs 2005).

An adapted form of the Vryghem macular function test is an uncomplicated test that is easy and quick to perform. However, many patients need encouragement to find 'their' new reading distance at about 12 cm. AVMFT was twice as fast to perform compared to Lotmar-light interferometry.

AVMFT is as reliable as Lotmar-light interferometry in predicting

postoperative VA after cataract surgery. Moreover, it is cheaper, faster and easier to perform. We believe that it can be used as a first-choice potential visual test before cataract surgery. Nevertheless, it is important to realize that VA alone is an inadequate measure of visual impairment and that the decision to perform cataract surgery should not be based solely on predicted VA (Lee et al. 1993; Monestam & Wachtmeister 1999; Mozaffarieh et al. 2005). Patient satisfaction, rather than simply poBCVA, should be our goal (Lee & Schachat 1995).

Conclusion

Our findings suggest that AVMFT is as reliable as the Lotmar-light interferometer in predicting postoperative VA after uneventful cataract surgery. We believe that it can replace the Lotmar-light interferometer as the first-choice potential visual test. A good predicted postoperative VA is a reliable marker of a high probability of good postoperative VA. A bad predicted VA, especially if a dense or subcapsular cataract is present, may not be a reliable finding.

As for any VA predicting test, AVMFT results must always be correlated with the overall clinical picture, including detectable or previously known ocular comorbidities, the patient's general condition, activities and visual needs and complaints. Used in this way, we believe that AVMFT can help to inform our patients and to set realistic expectations.

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