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Illuminated Near Card Assessment of Potential Acuity in Eyes with Cataract

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Objective: This study aimed to determine the accuracy and potential role of the illuminated near card (INC) for predicting visual outcome after cataract surgery in eyes with and without comorbid disease.

Study Design: A consecutive case series.

Participants: A total of 101 preoperative patients with cataracts participated.

Main Outcome Measures: Accuracy of predicted postoperative distance acuity was measured.

Method: The preoperative acuity obtained with the INC was compared by linear regression to the postoperative INC acuity and the postoperative distance acuity for 100 consecutive eyes undergoing cataract surgery. Variables analyzed were preoperative distance acuity and the presence or absence of comorbid disease.

Results: The preoperative INC acuity was significantly predictive of postoperative INC ($P = 0.0005$) and postoperative distance ($P = 0.0007$) acuities for the 100 eyes studied. For the subgroup of 15 eyes with 20/200 or worse, the preoperative INC acuity was not predictive of postoperative INC acuity ($P = 0.8673$) or postoperative distance acuity ($P = 0.8789$). For the 21 eyes with comorbid disease, the predictions were more accurate for postoperative INC acuity ($P < 0.0001$) and postoperative distance acuities ($P < 0.0001$) than for 64 eyes without comorbid disease: postoperative INC acuity ($P = 0.0051$), and postoperative distance acuity ($P = 0.0046$). The INC predicted postoperative distance acuity to within two lines in 98% of eyes when preoperative distance acuity was 20/100 or better. When the preoperative distance acuity was 20/200 or worse, the postoperative distance vision was predicted to within two lines in only 53% of the eyes.

Conclusion: The INC can be a useful adjunct for predicting postoperative distance acuity in eyes with cataract that have preoperative distance acuity of 20/100 or better, particularly in eyes with comorbid disease, in which the clinical judgment of vision potential may be difficult. *Ophthalmology 1998;105:1531–1536*

The accurate prediction of postoperative acuity in eyes with cataract remains a challenge to the clinician. In an article reviewing the literature on potential vision testing from 1975 through 1990, the conclusion was that reported studies did not provide enough evidence to support the use of potential vision testing to detect poor surgical outcomes.[1] Two general trends appeared evident in this review concerning retinometers, visometers, interferometers, and the potential acuity meter (PAM). First, the ability of these tests to accurately identify patients who will have a "good" postoperative acuity (sensitivity) seemed to be better, and more consistent across the studies, than the ability to identify patients with comorbid ocular disease who will have poor postoperative acuity (specificity). Second, potential vision testers were more accurate for patients with mild-to-moderate cataracts than for patients with severe cataracts.

In a recent article, the authors[2] suggested that their results support the usefulness of both the PAM and the laser interferometer in predicting postoperative acuity in moderate cataracts but warned that the results need to be interpreted with caution.[2] In severe cataracts, underestimation of potential vision occurred more often with the PAM than with the laser interferometer. For eyes with concomitant retinal disorders, the laser interferometer overestimated the potential vision more than the PAM test.

In this report, we measured the accuracy of a new potential vision tester, the illuminated near card (INC), to predict postoperative INC and postoperative distance acuities in eyes undergoing cataract surgery.

Subjects and Methods

One hundred one consecutive patients who were to undergo cataract surgery constituted the study group. One eye was eliminated from the study because of the progression of an epiretinal membrane of the macula that severely limited the postoperative acuity. Their ages ranged from 30 to 90 years, and the mean age was 74.5 years. The preoperative distance acuity was 20/100 or better in 85 eyes and 20/200 or worse in 15 eyes. Of the 85 eyes with preoperative distance acuity of 20/100 or better, 64 eyes (75%) had no identifiable disease involving central vision and 21 eyes (25%) had disease involving central vision. The mean preoperative distance acuity was 20/70 for both groups (the 64 eyes without comorbid disease and the 21 eyes with comorbid disease). Of the 21 eyes

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Dr. Hofeldt holds the patent (U.S. patent 5,398,085) on the illuminated near card (INC).

Dr. Weiss has no financial interest in the INC.

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Table 1. Percent Difference between INC Acuities and Postoperative Distance Acuity

	Preoperative Acuity 20/100 or Better						Preoperative Acuity 20/200 or Worse (n = 15)	
	Eyes with and without Comorbid Disease (n = 85)		*Eyes without Comorbid Disease (n = 64)*		*Eyes with Comorbid Disease (n = 21)*			
	Mean	*% difference**	*Mean*	*% difference**	*Mean*	*% difference**	*Mean*	*% difference**
Preoperative INC	20/30	−5.6%	20/29	−8.1%	20/35	+1.8%	20/58	−51.6%
Postoperative INC	20/27	+2.8%	20/26	+4.0%	20/33	+7.1%	20/27	+2.8%
Postoperative distance	20/28		20/27		20/36		20/28	

*INC acuity better than distance acuity (plus %); INC acuity worse than distance acuity (minus %)

with comorbid disease, the following diseases were identified: (1) nonexudative age-related macular degeneration in 9 eyes, (2) epiretinal membrane of the macula in 3 eyes, (3) macular dystrophy in 2 eyes, (4) glaucoma with a scotoma involving the macular area in 3 eyes, (5) diabetic maculopathy in 2 eyes, and (6) nystagmus in 2 eyes, 1 of which had albinism.

The INC (Gulden Ophthalmics, Elkins Park, PA) has been described previously.[3] The device is a hand-held instrument containing a brightly transilluminated vision chart that is transported across a 7-mm by 38-mm viewing window. The visual angle subtended by each letter at 16 inches equals the visual angles subtended at 20 feet. Capital letters are used, and each line of letters has a legibility average of 85% based on the relative legibility of ten letters as described by Sloan.[4] The notations are in the 20/20 Snellen equivalent, and the successive lines of acuity are 20/20, 20/25, 20/30, 20/40, 20/50, 20/60, 20/80, 20/100, and 20/200 (20/125 and 20/160 were not included). The light source is a 6.5-mm ×50-mm, 6 V, white light fluorescent bulb mounted beneath the film plane. Using a 1.0-mm pinhole, the luminance at 16 inches is 460 millilamberts (1464 cd/m^2). A 16-inch recoiling tape attached to the instrument is used to maintain the standard reading distance.

The best preoperative and postoperative distance acuities were obtained by refraction in a 20-foot lane using an American Optical (Buffalo, NY) projector chart with luminance of 30 millilamberts (95 cd/m^2). The preoperative and postoperative INC acuities were determined with the pupil dilated. A trial lens frame was used to hold a multiperforated pinhole disc of 1.0-mm apertures, the lenses for the distance correction, and a near lens of plus 2.50 diopters. The INC was held by the examiner 16 inches from the patient. Credit was given for the line only if four of the five letters were seen correctly. The preoperative INC acuities were recorded in a data file separate from the patient's chart and unavailable to the examiners during the postoperative period. The decision to perform surgery was not based on the INC acuity. The best INC and distance acuities obtained by the fourth month after surgery were the postoperative acuities used. In four eyes (4%), the posterior capsule was not clear and yttrium–aluminum–garnet (YAG) laser capsulotomy was performed before the best postoperative acuity was determined.

Linear regression parameters were used to measure how well preoperative INC logarithm of the minimum angle of resolution (logMAR) acuity predicted postoperative INC and postoperative distance logMAR acuities and how well postoperative INC and postoperative distance logMAR acuities agreed. The regression coefficient, β (slope of the regression line), and the respective probability value were calculated using the SAS program (SAS Institute; Cary, NC) for each group. In determining the sensitivity and specificity rates, it has been the convention[1] to classify eyes with worse than 20/40 postoperative distance acuity as "negative" and to classify eyes with 20/40 or better postoperative distance acuity as "positive." The sensitivity rate is the percent of eyes with good central acuity detected by the INC test and calculated by dividing the number of true-positives by the number of true-positives plus the number of false-negatives. The specificity rate is the percent of eyes with poor central acuity detected by the INC test and calculated by dividing the number of true-negatives by the number of true-negatives plus the number of false-positives.

Results

In this study, the postoperative INC and the postoperative distance acuities were significantly related ($\beta = 0.970$, $P < 0.0001$). The mean postoperative INC acuity was 20/27, and the mean postoperative distance acuity was 20/28 (Table 1). In the 100 eyes, the preoperative INC acuity was significantly predictive of postoperative INC acuity ($\beta = 0.178$, $P = 0.0005$) and postoperative distance acuity ($\beta = 0.200$, $P = 0.0007$, Fig 1). The mean lines of predictive inaccuracy (i.e., the line difference between the preoperative INC acuity and the postoperative distance acuity), when plotted against the preoperative distance acuity, showed that the mean lines of predictive inaccuracy increased as preoperative distance acuity decreased (Fig 2). The mean lines of predictive inaccuracy were less than 1 line for eyes with 20/100 or better preoperative distance acuity, increased to 2.22 lines for eyes with 20/200 preoperative distance acuity, and increased to 4.83 lines for eyes with 20/400 preoperative distance acuity. Because the mean

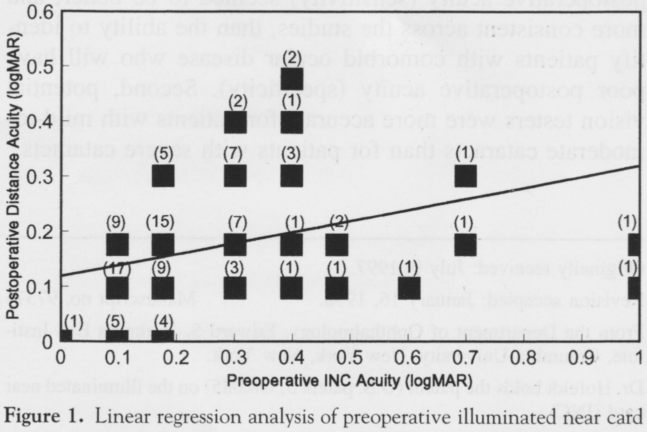

Figure 1. Linear regression analysis of preoperative illuminated near card and postoperative distance acuities of 100 patients with preoperative distance acuity of 20/30 to 20/400 ($\beta = 0.200$, $P = 0.0007$). Numbers in parentheses are the number of eyes with shared data points.

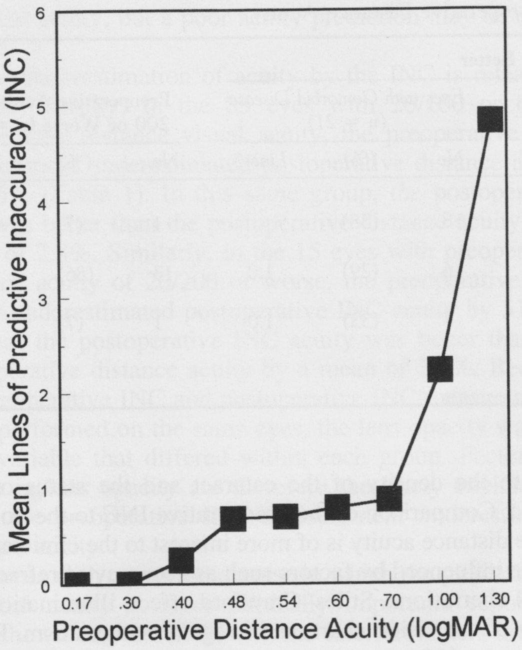

Figure 2. Line graph showing the relationship between the preoperative distance acuity and the mean lines of inaccuracy in predicting the postoperative distance acuity using the illuminated near card.

lines of predictive inaccuracy markedly increased after 20/100 preoperative distance acuity, the data were divided at that acuity for regression analysis to determine the predictability of the postoperative acuity with the INC for these two subgroups.

For the 85 eyes with preoperative distance acuity of 20/100 or better, the preoperative INC acuity was predictive of postoperative INC ($\beta = 0.538$, $P < 0.0001$) and postoperative distance acuity ($\beta = 0.647$, $P < 0.0001$, Fig 3). The mean preoperative INC acuity was 20/30 Snellen, and the mean postoperative distance acuity was 20/28 Snellen, an underestimation of 0.25 mean line or 5.6% (Table 1). In these eyes, the preoperative INC and the postoperative distance acuities were within one line of letters in 88% (75 of 85 eyes) and within two lines of letters in 98% (83 of 85 eyes). The breakdown of postoperative distance vision predictions by same-line accuracy, underestimation, and overestimation is listed in Table 2.

Within the group of 85 eyes with preoperative distance acuity of 20/100 or better, we found a difference in the predictability of postoperative distance acuity based on the absence (64 eyes) or the presence (21 eyes) of comorbid disease. For the 64 eyes with 20/100 or better preoperative distance acuity and no identifiable disease affecting central vision, the preoperative INC acuity was significantly predictive of postoperative INC acuity ($\beta = 0.217$, $P = 0.0051$) and postoperative distance acuity ($\beta = 0.291$, $P = 0.0046$). The mean preoperative INC acuity was 20/29 Snellen, and the mean postoperative distance acuity was 20/27 Snellen, an underestimation of 0.36 mean line or 8.1% (Table 1). In these eyes, the preoperative INC and the postoperative distance acuities were within one line of letters in 87% (58 of 64 eyes) and within two lines of letters in 97% (62 of 64 eyes). The breakdown of postoperative predictions by same-line accuracy, underestimation, and overestimation is listed in Table 2. The largest underestimation was by four lines, and the largest overestimation was by one line. For the 21 eyes with 20/100 or better preoperative distance acuity and disease affecting the central vision, the preoperative INC acuity was predictive of postoperative INC acuity ($\beta = 0.833$, $P < 0.0001$) and postoperative distance acuity ($\beta = 0.908$, $P < 0.0001$, Fig 3). The preoperative mean INC acuity was 20/35 Snellen, and the mean postoperative distance acuity was 20/36, an overestimation by 0.05 mean line or 1.8% (Table 1). In this subgroup, the predicted acuity with the INC was within one line of the postoperative distance acuity in all eyes (Table 2).

For the 85 eyes with preoperative distance acuity of 20/100 or better, there were 76 true-positives and 5 false-negatives, yielding a sensitivity rate of 94% (the ability of the INC to identify eyes with 20/40 or better potential vision). There were three true-negatives and one false-positive, which yielded a specificity rate of 75% (the ability of the INC to identify eyes with <20/40 potential vision).

For the 15 eyes with preoperative distance acuities of 20/200 or worse, the preoperative INC acuity was not significantly predictive of postoperative INC acuity ($\beta = 0.0134$, $P = 0.8674$) or postoperative distance acuity ($\beta = 0.0133$, $P = 0.8789$). The mean preoperative INC acuity was 20/58 Snellen, and the mean postoperative distance acuity was 20/28 Snellen, an underestimation of 3.3 mean lines or 51.6% (Table 1). The postoperative distance acuity was predicted to within one line in 33% and within two lines in 53% of eyes in this group. The lines of difference between preoperative INC and postoperative distance acuity ranged from one line of overestimation to ten lines of underestimation. The breakdown of the postoperative predictions by same-line accuracy, underestimation, and overestimation is listed in Table 2.

Discussion

The effectiveness of the INC for predicting postoperative acuity in patients with cataracts is based on three optical

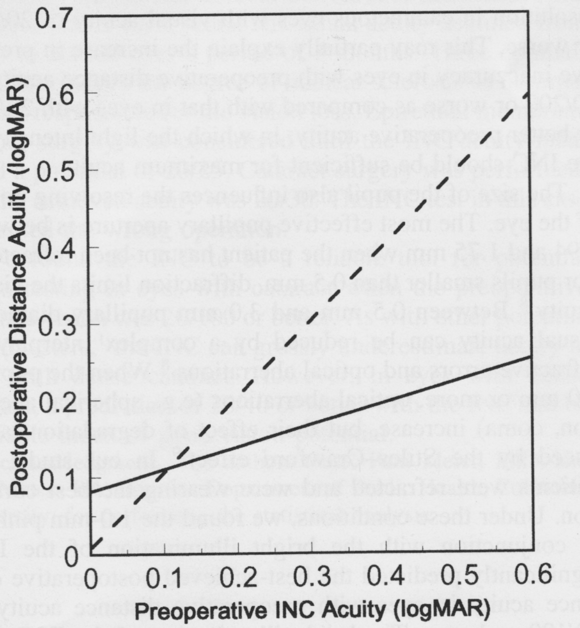

Figure 3. Regression lines illustrating the predictability of postoperative distance acuity with the illuminated near card (INC). Notice that the slope ($\beta = 0.908$, $P = 0.0001$, n = 21) of the regression line for the INC predicting postoperative distance acuity in the subgroup of 21 eyes with comorbid disease (dashed line) is steeper than the slope ($\beta = 0.647$, $P = 0.0001$, n = 85) for the whole group of eyes with 20/100 or better preoperative distance acuity (solid line).

Table 2. Preoperative INC Prediction of Postoperative Distance Acuity

	Preoperative Acuity 20/100 or Better									Preoperative Acuity 20/200 or Worse (n = 15)		
	Eyes with and without Comorbid Disease (n = 85)			Eyes without Comorbid Disease (n = 64)			Eyes with Comorbid Disease (n = 21)					
	No.	(%)	Lines*	No.	(%)	Lines*	No.	(%)	Lines*	No.	(%)	Lines*
Achieved equals predicted acuity	35	(41)		28	(44)		8	(38)		1	(7)	
Achieved better than predicted acuity	30	(35)	1.4	24	(38)	1.5	6	(29)	1.0	13	(86)	3.7
Achieved worse than predicted acuity	20	(24)	1.0	12	(19)	1.0	7	(33)	1.0	1	(7)	1.0

*Mean lines difference between predicted and achieved distance acuity.

principles: visual angle (same relative letter size as Snellen letters at 20 feet), bright illumination, and a small artificial pupillary aperture. Aging of the crystalline lens reduces light transmission through the lens, and by 60 years of age the lens transmits only 20% of the incident light.[5] The transmittance is reduced to less than 2% for 470-nm light in cataracts associated with visual acuity of 20/200.[5] The background luminance of the INC measured through a 1.0-mm aperture is 460 millilamberts (1464 cd/m^2). When transmittance of the incident light is reduced to 2% through the cataractous lens associated with visual acuity of 20/200, calculations show that approximately 9.3 millilamberts (29 cd/m^2) of the light are transmitted to the retina from the INC. Because 10 millilamberts (32 cd/m^2) of luminance are required for maximum acuity in the normal eye,[6] the light intensity of the INC may not be sufficient for optimal image resolution in cataractous eyes with visual acuity of 20/200 or worse. This may partially explain the increase in predictive inaccuracy in eyes with preoperative distance acuity of 20/200 or worse as compared with that in eyes with 20/100 or better preoperative acuity, in which the light intensity of the INC should be sufficient for maximum acuity.

The size of the pupil also influences the resolving power of the eye. The most effective pupillary aperture is between 0.94 and 1.75 mm when the patient has not been refracted.[7] For pupils smaller than 0.5 mm, diffraction limits the visual acuity.[8] Between 0.5 mm and 3.0 mm pupillary diameter, visual acuity can be reduced by a complex interplay of refractive errors and optical aberrations.[8] When the pupil is 3.0 mm or more, optical aberrations (e.g., spherical aberration, coma) increase, but their effect of degradation is reduced by the Stiles–Crawford effect.[9] In our study, the patients were refracted and were wearing the best correction. Under these conditions, we found the 1.0-mm pinhole in conjunction with the bright illumination of the INC significantly predicted the best-achieved postoperative distance acuity in eyes with preoperative distance acuity of 20/100 or better. The bright illumination of the INC supplements for the light attenuated by the cataract and the reduction in the luminance by the 1.0 mm-pinhole aperture.

We compared preoperative INC acuity to both the postoperative INC and the postoperative distance acuities. Comparison of the preoperative and postoperative INC acuities is a useful experimental value because it reduces the variables to the density of the cataract and the status of the macula. Comparison of the preoperative INC to the postoperative distance acuity is of more interest to the clinician but may be influenced by factors such as accuracy of refraction, optical aberrations, Stiles–Crawford effect, illumination intensity of the vision chart, and irregular astigmatism. However, in the 100 eyes studied, we found a striking similarity between the postoperative INC and the postoperative distance acuities (β = 0.970, P <0.0001), which suggests these factors play a relatively minor role in degrading the distance acuity. We found the postoperative INC and the distance acuity were the same line in 59%, within one line in 99%, and within two lines in 100% of eyes. Others also have found an excellent agreement between INC and distance acuities. In 36 eyes with clear media and glaucoma, investigators found that the INC and distance acuities were the same line in 92% and within one line in 100% (Asbell PA, et al. Poster #253, American Academy of Ophthalmology, 1996).

In eyes with cataract, there is a limit to the usefulness of the INC for predicting postoperative distance acuity. The improvement in retinal image resolution by the bright illumination of the INC and the pinhole viewing aperture diminished as lens opacification increased, as measured by the degree of preoperative distance vision impairment (Fig 2). For the entire group consisting of 100 eyes, we found the prediction of postoperative distance acuity was statistically significant. However, when dividing the data into two subgroups based on mean lines of predictive inaccuracy, we showed by regression analysis that the INC was more predictive of postoperative acuity in eyes with preoperative distance acuity of 20/100 or better (P <0.0001) than in eyes with preoperative distance acuity of 20/200 or worse (P = 0.8789). In eyes with preoperative distance acuity of 20/100 or better, the postoperative distance acuity was predicted to within one line in 88% of eyes and within two lines in 98% of eyes. In eyes with preoperative INC acuity of 20/200 and worse, the postoperative distance acuity was not statistically predictive. However, in 53% of these eyes (8 of 15), the postoperative distance acuity was predicted within two lines. In seven of these eight eyes, the INC predicted and the patient achieved 20/40 or better acuity. Thus, in eyes with 20/200 or worse preoperative distance acuity, a preoperative INC acuity of 20/40 or better can be a reliable index of potential acuity, but a poor acuity prediction may be disregarded.

The underestimation of acuity by the INC is related to the lens opacity. In the 85 eyes with 20/100 or better preoperative distance visual acuity, the preoperative INC measurement underestimated postoperative distance acuity by 5.6% (Table 1). In this same group, the postoperative INC was better than the postoperative distance acuity by a mean of 2.8%. Similarly, in the 15 eyes with preoperative distance acuity of 20/200 or worse, the preoperative INC acuity underestimated postoperative INC acuity by 51.6%, whereas the postoperative INC acuity was better than the postoperative distance acuity by a mean of 2.8%. Because the preoperative INC and postoperative INC measurements were performed on the same eyes, the lens opacity was the only variable that differed within each group. Factors inherent in lens opacity are therefore the likely explanation when the preoperative INC measurement underestimates distance acuity.

In eyes with comorbid disease in which the prediction of potential acuity is more clinically important, reports[2,10] have shown that the PAM and the interferometers are less predictive than in eyes without comorbid disease. In contrast, we found that the INC acuity was more predictive of postoperative distance acuity in eyes with comorbid disease ($P < 0.0001$) than in eyes without comorbid disease ($P = 0.0046$). The increased accuracy of the INC in eyes with comorbid diseases may be explained partially by the shift in the acuity-luminance curve known to occur in eyes with macular disease. In normal eyes, the decimal acuity is directly proportional to the logarithm of background luminance of the acuity chart in the intermediate range of intensities (0.1–10 millilamberts, 0.32–32 cd/m^2).[6] At luminance of approximately 10 millilamberts, acuity reaches a maximum value and shows no further increase with increasing luminance in the normal eye.[6] In eyes with macular disease, the luminance required for maximum acuity can be much higher than in normal eyes. Some patients with macular disease required as much as 1000 millilamberts (3183 cd/m^2) of background luminance to obtain maximum acuity.[6] The background luminance of the INC is 460 millilamberts, or 46 times the level for maximum acuity in the normal eye. In the group of 21 eyes with comorbid disease, the mean preoperative visual acuity was 20/70, and in these eyes more light would be expected to penetrate the cataract than the limiting luminance of 9.3 millilamberts associated with a cataract that reduces the acuity to 20/200. The higher predictability of postoperative distance acuity in eyes with comorbid disease compared with that in eyes without comorbid disease (Fig 3) may be caused by increased acuity resulting from the shift in the acuity-luminance that occurs in eyes with macular disease under bright illumination. The factors causing underestimation in eyes with lens opacity and without comorbid disease may be compensated by the improved acuity resulting from bright illumination in eyes with comorbid disease. This may explain why the potential acuity was overestimated more often than underestimated in eyes with comorbid disease and underestimated more than overestimated in eyes without comorbid disease (Table 2).

As listed in Table 1, in eyes with clear media the postoperative INC was better than the postoperative distance acuity by a larger amount in eyes with comorbid disease (7.1%) than in eyes without comorbid disease (4%). This finding supports the concept that the improved acuity occurring in eyes with macular disease may be related to the shift in the acuity-luminance curve that occurs at high luminance levels in these eyes.

In the literature review of potential vision testers,[1] the conclusion reached was that the utility of these tests was limited to cases in which the cataract was not dense. "In such situations, the ophthalmologist can visualize the fundus and determine from clinical examination whether cataract surgery is likely to improve vision.''[1] This may be true if the appearance of the macula is normal, but if the macula appears abnormal, the clinician can only conjecture the benefits of cataract surgery based on clinical experience. Eyes with comorbid diseases are not uncommon. In other studies, approximately 30%,[10] 33%,[2] and 63%[11] of eyes undergoing cataract surgery had comorbid disease. In our series, 25% (21 eyes) of the eyes with preoperative acuity of 20/100 or better had clinical evidence of a disease in addition to cataract that could limit macular function. In these 21 eyes with preoperative evidence of impaired central acuity, the INC predicted all cases within 1 line of achieved acuity. In the clinical setting of eyes with comorbid disease, we predict that the INC will be the most useful to clinicians.

Since completion of our study, we have seen a case that emphasizes the importance of potential vision testing in eyes with maculopathy. The patient is a 38-year-old male with proliferative diabetic retinopathy in his right eye complicated by premacular fibrosis and vitreous membranes that had been stable for 2 years. His visual acuity declined from 20/30 to 20/200 over a period of 3 months. Three ophthalmologists judged the degree of nuclear sclerosis as minimal and not responsible for the vision loss. Epiretinal membrane peeling surgery was considered until the INC acuity measured a potential of 20/25. Cataract surgery was performed, and the achieved acuity was 20/30. The INC test in this case prevented the wrong operation.

We found the INC to be a reliable tool for potential vision testing in eyes with cataract when the preoperative distance vision was 20/100 or better. As with other potential vision testers,[1] the INC can grossly underestimate acuity in eyes with dense cataract. However, in eyes with dense cataract, a prediction of 20/40 or better with the INC can be a reliable index of good vision potential.

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References

1. Cataract Management Guideline Panel. Appendix F. Literature review: potential vision testing. Ophthalmology 1993; 100(8 Suppl):150S–60S.
2. Lasa MSM, Datiles MB III, Freidlin V. Potential vision tests in patients with cataracts. Ophthalmology 1995;102:1007–11.

3. Hofeldt AJ. Illuminated near card assessment of potential visual acuity. J Cataract Refract Surg 1996;22:367–71.
4. Sloan LL. New test charts for the measurement of visual acuity at far and near distances. Am J Ophthalmol 1959;48: 807–13.
5. Sadun AA, Libondi T. Transmission of light through cataracts. Am J Ophthalmol 1990;110:710–2.
6. Sloan LL, Habel A, Feiock K. High illumination as an auxiliary reading aid in diseases of the macula. Am J Ophthalmol 1973;76:745–57.
7. Lebensohn JE. The pinhole test [editorial]. Am J Ophthalmol 1950;33:1612–4.
8. Holladay JT, Lynn MJ, Waring GO III, et al. The relationship of visual acuity, refractive error, and pupil size after radial keratotomy. Arch Ophthalmol 1991;109:70–6.
9. Westheimer G. Visual acuity. In: Hart W, Jr, ed. Adler's Physiology of the Eye: Clinical Application, 9th ed. St. Louis: Mosby Year Book, 1992;533.
10. Spurny RC, Zaldivar R, Belcher CD III, Simmons RJ. Instruments for predicting visual acuity. A clinical comparison. Arch Ophthalmol 1986;104:196–200.
11. Minkowski JS, Palese M, Guyton DL. Potential acuity meter using a minute aerial pinhole aperture. Ophthalmology 1983; 90:1360–8.