Illuminated near card assessment of potential visual acuity

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ABSTRACT

Purpose: To determine the accuracy of predicting potential visual acuity in patients having neodymium:YAG (Nd:YAG) laser capsulotomy using a new device, the illuminated near card (INC).

Setting: Private practice, New York, New York.

Methods: Thirty-eight consecutive patients having Nd:YAG laser capsulotomy were studied prospectively by comparing the postoperative distance Snellen acuity to the visual acuity obtained preoperatively using (1) a near vision reading card, (2) the INC, and (3) the INC viewed through a pinhole.

Results: Patients reported that the INC was easy to use; none with a visual acuity better than 20/200 had difficulty finding the illuminated letters through the pinhole. In eyes with a precapsulotomy distance acuity of better than 20/200, the correlation between precapsulotomy and postcapsulotomy acuities was statistically significant ($P < .001$) for the INC viewed through the pinhole. A significant correlation between precapsulotomy and postoperative acuities was not found for the INC viewed alone or for the near card ($P > .05$). In patients with a precapsulotomy distance acuity of 20/200 or worse, the INC with pinhole, the INC, or the near card did not predict postoperative acuity ($P > .05$).

Conclusion: In eyes with a precapsulotomy distance acuity better than 20/200, the INC with pinhole predicted postoperative distance acuity within one Snellen line in 97% of eyes (29/30), which is comparable to reports using other potential acuity testers. The INC viewed through a pinhole improves image resolution by the stenopaic hole without the low light intensity of the reduced aperture. *J Cataract Refract Surg 1996; 22:367–371*

Predicting potential visual acuity in eyes with opaque media is of fundamental importance. Several studies have used interferometers[1–6] and the potential acuity meter (PAM) to predict visual acuity in eyes that develop posterior capsule opacification (PCO) after cataract surgery.[2,4]

Neodymium:YAG (Nd:YAG) laser capsulotomy is a useful model for testing methods of predicting visual acuity in patients with hazy media because visual improvement is immediate; therefore, it is unlikely intervening disease will alter the final result. This article

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describes a technique for measuring potential visual acuity using the intensely illuminated near card (INC)[7] viewed through a pinhole by patients with PCO before they have Nd:YAG capsulotomy.

Materials and Methods

The best Snellen visual acuities at distance were determined before Nd:YAG laser capsulotomy in 38 consecutive eyes (38 patients) with PCO after cataract surgery. Patient age ranged from 49 to 90 years (mean 74 years).

Best distance visual acuities before capsulotomy were better than 20/200 in 30 patients, 20/200 in 5, and 20/400 in 3. In the eyes with better than 20/200 visual acuity, the following concurrent diseases were present: macular degeneration without serious detachment of the sensory retina (n = 5), epiretinal membrane (n = 2), cystoid macular edema (CME) (n = 1), superior quadrantanopia with quadrantic involvement of fixational area (n = 1), and glaucomatous field defect involving the superior central 10 degrees (n = 1).

Pupils were dilated with 1% tropicamide because potential visual acuity testing without dilation results in underprediction.[8] Near visual acuity was measured at a reading distance of 40 cm using a trial frame incorporating the best distance correction and adding +2.50 diopters (D). Credit was given for a line if four of the five letters were seen correctly. Near testing was conducted in the following sequence: (1) a near card (NC) with black letters printed on white paper illuminated by a 60 watt incandescent bulb reading lamp, (2) the INC, and (3) the INC viewed through a pinhole positioned in the trial frame. Refraction was repeated within 10 days after Nd:YAG laser capsulotomy, and distance Snellen acuity was determined.

The lettering of the NC and the INC was identical; that is, the visual angle subtended by each letter at 40 cm was equivalent to the Snellen chart at 20 ft. Capital block letters were used, and each line of letters had a legibility average of 85% based on the relative legibility of 10 letters as reported by Sloan.[9] The notations were in the 20/20 equivalent, and the successive lines of Snellen acuity were 20/25, 20/30, 20/40, 20/50, 20/60, 20/70, 20/80, 20/100, 20/125, 20/150, and 20/200.

The INC (Figure 1) consists of a 16.0 × 8.0 × 4.0 cm handheld device and a vision chart printed on

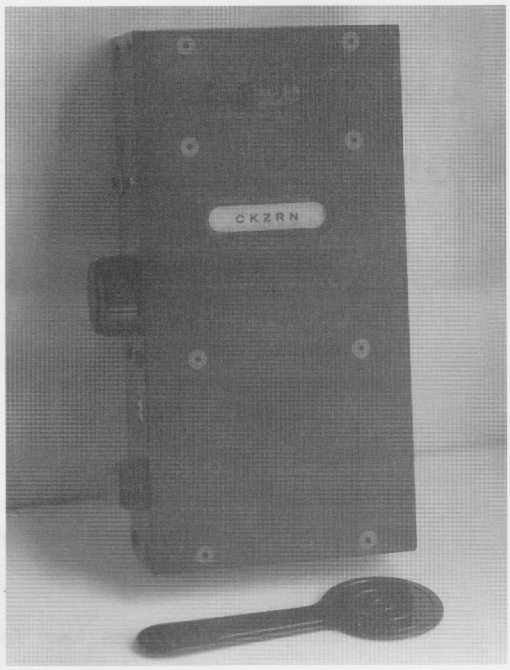

Figure 1. (Hofeldt) The illuminated near card and a multiperforated pinhole disc.

70.0 mm transparent film that is transported across a 7.0 × 38.0 mm viewing window when the examiner manually rotates a sprocket. The light source is a 6.5 × 50.0 mm, 6 volt, white-light, fluorescent bulb mounted beneath the film plane and the power source, a 6 volt rechargeable battery. A 40.0 cm tape that recoils is attached to measure standard reading distance. The pinhole disc is multiperforated with 1.0 mm holes.

Photometric measurements were obtained with the Tektronix Digital Photometer 1 degree narrow luminance probe (model J6523). The luminance at 40 cm was 390 candelas/m^2 (cd/m^2) for the NC, 8200 cd/m^2 for the INC, and 1470 cd/m^2 for the INC measured through the 1.0 mm pinhole.

Results

The patients reported that they found the INC reading test easy, and many expressed surprise at the clarity of the letters viewed through the pinhole. The brightly lit viewing window facilitated letter alignment through the pinhole.

In eyes with a precapsulotomy distance acuity of better than 20/200, the correlation between the precapsulotomy and postcapsulotomy acuities was statistically significant for the INC viewed through a pinhole

($P < .001$; $r = .74$). There was no significant correlation between precapsulotomy and postcapsulotomy acuities for the INC viewed without the pinhole ($r = .42$) or for the NC ($r = .47$).

In patients with a precapsulotomy distance acuity of better than 20/200 (n = 30), the INC with the pinhole (Table 1) predicted postcapsulotomy acuity within one Snellen line in 97% (29/30) and within two lines in all eyes. The INC predicted within one line in 63% of eyes and within two lines in 77%, and the NC predicted within one line in 43% of eyes and within two lines in 67%.

Table 1. Visual acuities and comparison of predicted acuity (INC with pinhole) and attained acuities.

	Visual Acuity			Snellen Lines	
Patient	Preop	Postop	INC PH, Predicted	Improvement	Difference Between Postop and INC PH
1	20/30	20/20	20/25	2	1
2	20/40	20/40	20/30	0	1
3	20/40	20/30	20/30	1	1
4	20/40	20/30	20/30	1	1
5	20/40	20/25	20/25	2	0
6	20/40	20/25	20/25	2	0
7	20/40	20/25	20/25	2	0
8	20/40	20/20	20/25	3	1
9	20/50	20/30	20/25	2	1
10	20/50	20/20	20/25	4	1
11	20/50	20/30	20/30	2	0
12	20/50	20/30	20/25	2	1
13	20/50	20/20	20/30	4	2
14	20/50	20/30	20/30	2	0
15	20/60	20/30	20/25	3	1
16	20/60	20/30	20/30	3	0
17	20/60	20/25	20/25	4	0
18	20/60	20/30	20/25	3	1
19	20/60	20/20	20/25	5	1
20	20/70	20/40	20/30	3	1
21	20/70	20/20	20/25	6	1
22	20/70	20/25	20/30	5	1
23	20/70	20/30	20/25	4	1
24	20/80	20/60	20/70	2	1
25	20/80	20/40	20/40	4	0
26	20/80	20/60	20/60	2	0
27	20/80	20/30	20/30	5	0
28	20/100	20/40	20/50	5	1
29	20/100	20/40	20/40	5	0
30	20/100	20/30	20/40	6	1
31	20/200	20/25	20/200	10	10
32	20/200	20/30	20/200	9	9
33	20/200	20/30	20/25	9	1
34	20/200	20/30	20/60	9	3
35	20/200	20/30	20/40	9	1
36	20/400	20/25	20/150	11	9
37	20/400	20/30	20/200	10	9
38	20/400	20/20	20/200	12	11

INC PH = illuminated near card with pinhole

Mean lines of inaccuracy (mean Snellen line difference between predicted and achieved acuities) for eyes with better than 20/200 distance acuity were 0.7, 1.6, and 2.4 for the INC with pinhole, the INC, and the NC, respectively. In eyes with better than 20/200 precapsulotomy visual acuity, the difference between acuity predicted by the INC with pinhole and attained acuity was within one Snellen line in 97% of the total group and in all eyes with concurrent macular or optic nerve disease.

The relationship between the visual acuity predicted by the INC with a pinhole and the acuity achieved after capsulotomy is shown in Figure 2. The regression line intercepts the axis of the ordinates at a point greater than zero, indicating a slight underestimation in eyes with a lower precapsulotomy visual acuity.

In patients with a precapsulotomy visual acuity of 20/200 or worse (n = 8), the INC with a pinhole predicted postcapsulotomy acuity to within two Snellen lines or less in 25%, the INC predicted to within two lines or less in 13%, and the NC predicted within two

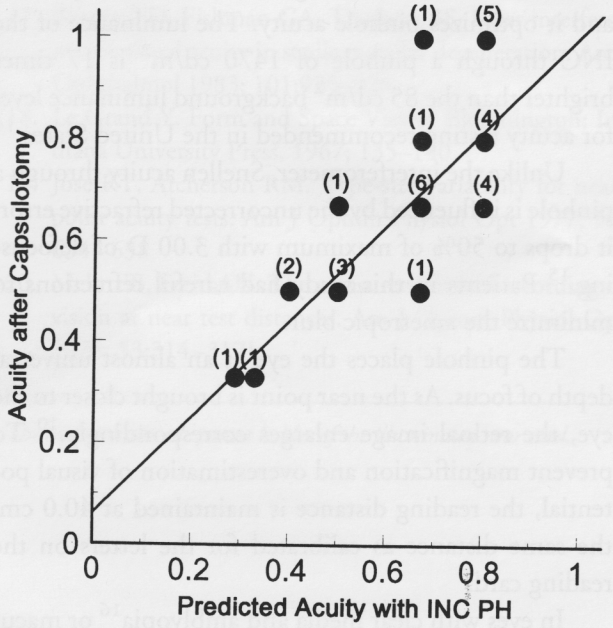

Figure 2. (Hofeldt) Linear regression of Snellen acuities (decimal scale) in 30 patients with better than 20/200 precapsulotomy acuity. The numbers in parentheses represent the frequency distribution.

lines in no case. There was no statistically significant ($P > .05$) linear relationship between precapsulotomy and postcapsulotomy acuities for any near testing conditions for patients with a precapsulotomy visual acuity of 20/200 or worse.

Discussion

The pinhole is one of the oldest and most useful and instructive optical devices.[10] According to Lebensohn,[10] the most effective pinhole diameter is between 0.94 mm and 1.75 mm. The minimum useful diameter of the stenopaic hole is set by diffraction. When the diameter is less than 0.50 mm, a vitiating blur is evident.[10,11]

A disadvantage of the small aperture pinhole is the light reduction because visual acuity varies with retinal illumination. At low intensities, visual acuity increases slowly in proportion to the logarithm of the illumination. At higher intensities it increases nearly 10 times more rapidly, and at the highest illumination it remains constant, regardless of the changes in the logarithm of the illumination.[12]

The lack of decreased retinal illumination with the PAM appears to be the major reason this instrument is more effective than a conventional pinhole.[13] The intense lighting of the INC supplements the decreased retinal illumination resulting from the reduced aperture, and it optimizes pinhole acuity. The luminance of the INC through a pinhole of 1470 cd/m^2 is 17 times brighter than the 85 cd/m^2 background luminance level for acuity testing recommended in the United States.[14]

Unlike the interferometer, Snellen acuity through a pinhole is influenced by the uncorrected refractive error; it drops to 50% of maximum with 3.00 D of defocusing.[15] Patients in this study had careful refractions to minimize the ametropic blur.

The pinhole places the eye at an almost universal depth of focus. As the near point is brought closer to the eye, the retinal image enlarges correspondingly.[10] To prevent magnification and overestimation of visual potential, the reading distance is maintained at 40.0 cm, the same distance as calibrated for the letters on the reading card.

In eyes with clear media and amblyopia[16] or macular degeneration,[17] overestimation of letter acuity has been found when interferometry is used. Halliday and Ross[15] suggested that the overoptimistic interferometer predictions in patients with macular disease or amblyopia may be explained by data[18] that show that grating acuity as a function of the distance from the fovea decreases more slowly than letter recognition. Thus, a potential acuity technique using letters would be more representative of macular function than a technique using fringe patterns.

Predicting potential visual acuity improvement after Nd:YAG laser capsulotomy has been reported by Faulkner,[1,2] Lang and Lindstrom,[3] Spurny and coauthors,[4] Hanna and coauthors,[5] and Strong.[6] They reported the following percentages of predicting within one Snellen line of visual acuity achieved after capsulotomy: Rodenstock laser interferometer (Retinometer) 97% (29/30),[2] 93% (39/42),[6] and 38% (44/115);[3] Haag-Streit incandescent light interferometer (Lotmar Visometer) 97% (29/30),[2] 64% (27/42),[6] and 60% (9/15);[4] Site incandescent light interferometer 79% (11/14)[6] and 52% (11/21);[5] PAM 53% (8/15)[4] and 33% (10/30).[2] These studies suggest that the interferometer predicts potential visual acuity better than the PAM.

In a study of 22 eyes, Strong[6] found the laser interferometer predicted the potential visual acuity better than the incandescent light interferometer, with the greatest difference in the subgroup with a precapsulotomy visual acuity of 20/60 or worse. The Retinometer predicted within one Snellen line in 91% of eyes and within two lines in 100%; the Lotmar Visometer predicted within one line in 50% and within two lines in 77% of eyes.

My INC with pinhole predictions in eyes with better than 20/200 visual acuity were comparable to Strong's[6] interferometry data in eyes with a precapsulotomy visual acuity of 20/60 or better (within one line or less: 97%, INC with pinhole; 95%, Retinometer) and better than the 80% predicted by the Lotmar Visometer.

I could not compare my results with all of Strong's[6] data because he did not report the number of eyes with a visual acuity worse than 20/200, and these eyes greatly influenced my data. In my series, eight eyes had a visual acuity of 20/200 or worse; the INC with a pinhole predicted acuity to within two lines in only two of these eyes.

The INC supplies uniformly and intensely illuminated test letters, and its bright window allows patients to locate easily the Snellen letters through the pinhole.

The INC with a pinhole accurately predicted postcapsulotomy visual acuity when the best corrected precapsulotomy acuity was better than 20/200. In this acuity range, the INC with pinhole predicts postcapsulotomy visual acuity as well as interferometry.

As with other potential acuity testing devices, the INC is less accurate in eyes in which the media is opaque. However, its accuracy was not reduced in the limited number of eyes with concurrent diseases (e.g., "dry" macular degeneration, epiretinal membrane, CME, glaucomatous field defect, field defect splitting fixation).

In eyes with a precapsulotomy visual acuity of 20/200 or worse, the INC with the pinhole is not accurate. Yet, despite this limitation, the INC provides a quick and simple way to establish potential visual acuity before capsulotomy. A readily available alternative to the INC is to focus an intense illumination beam on a reading card held at 40 cm. There is a great variability in type size for commercial near vision cards.[19] A card designated in meter units should be used when each millimeter of letter height equals 0.7 m.[20]

References

1. Faulkner HW. The laser interferometer in predicting efficacy of secondary posterior capsulotomy. Am Intra-Ocular Implant Soc J 1982; 8:136–140
2. Faulkner W. Predicting acuities in capsulotomy patients: interferometers and potential acuity meter. Am Intra-Ocular Implant Soc J 1983; 9:434–437
3. Lang TA, Lindstrom RL. Efficacy of laser interferometry in predicting visual result of YAG laser posterior capsulotomy. Am Intra-Ocular Implant Soc J 1985; 11:367–371
4. Spurny RC, Zaldivar R, Belcher CD III, Simmons RJ. Instruments for predicting visual acuity; a clinical comparison. Arch Ophthalmol 1986; 104:196–200
5. Hanna IT, Sigurdsson H, Baines PS, Roxburgh STD. The role of white light interferometry in predicting visual acuity following posterior capsulotomy. Eye 1989; 3:468–471
6. Strong N. Interferometer assessment of potential visual acuity before YAG capsulotomy: relative performance of three instruments. Graefes Arch Clin Exp Ophthalmol 1992; 230:42–46
7. Hofeldt AJ. Illuminated near card. U.S. Patent No. 5,398,085, 1995
8. Faulkner W. Laser interferometric prediction of postoperative visual acuity in patients with cataracts. Am J Ophthalmol 1983; 95:626–636
9. Sloan LL. New test charts for the measurement of visual acuity at far and near distances. Am J Ophthalmol 1959; 48:807–813
10. Lebensohn JE. The pinhole test. Am J Ophthalmol 1950; 33:1612–1614
11. 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: 70–76
12. Hecht S. The relation between visual acuity and illumination. J Gen Physiol 1928; 11:255–281
13. Minkowski JS, Palese M, Guyton DL. Potential acuity meter using a minute aerial pinhole aperture. Ophthalmology 1983; 90:1360–1368
14. Sheedy JE, Bailey IL, Raasch TW. Visual acuity and chart luminance. Am J Optom Physiol Opt 1984; 61:595–600
15. Halliday BL, Ross JE. Comparison of 2 interferometers for predicting visual acuity in patients with cataract. Br J Ophthalmol 1983; 67:273–277
16. Gstalder RJ, Green DG. Laser interferometric acuity in amblyopia. J Pediatr Ophthalmol 1971; 8:251–256
17. Bloom TD, Fishman GA, Traubert BS. Laser interferometric visual acuity in senile macular degeneration. Arch Ophthalmol 1983; 101:925–926
18. Le Grand Y. Form and Space Vision. Bloomington: Indiana University Press, 1967; 135–140
19. Jose RT, Atcherson RM. Type-size variability for near-point acuity tests. Am J Optom Physiol Opt 1977; 54: 634–638
20. Mehr EB, Freid AN. The measurement and recording of vision at near test distances. Am J Optom Physiol Opt 1976; 53:314–317[1]

The author is the sole patent holder of the illuminated near card.