

Comparison of Worth 4-dot test and hole-in-the-card test for the detection of the dominant eye under habitual and best refractive correction

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Abstract

Aim: To evaluate 2 tests for detection of the dominant eye — the Worth 4-dot test and the hole-in-the-card test — using habitual and best refractive correction.

Patients and methods: 429 patients without amblyopia were recruited. Refractive error was measured for all patients. Ocular dominance was determined using the hole-in-the-card test and the Worth 4-dot test, using habitual and best refractive correction.

Results: When tested using habitual refractive correction, there was no significant difference in detection of ocular dominance between the Worth 4-dot test and the hole-in-the-card test. However, when using best refractive correction, ocular dominance detected by the Worth 4-dot test differed significantly from that detected by the hole-in-the-card test ($\chi^2 = 15.185$; $p = 0.001$). There was no correlation in the results detected by the 2 tests.

Conclusion: The Worth 4-dot test and the hole-in-the-card test had different ocular dominance results when patients were tested with best refractive correction. This suggests that refractive errors may affect ocular dominance testing.

Introduction

The hole-in-the-card test is considered the gold standard for testing ocular dominance. Traditionally, ocular dominance tests are used in optometry clinics when the clarity of vision in the 2 eyes cannot be balanced by refraction.¹ Recently, Cheng et al compared the near point of convergence with the hole-in-the-card test to test for ocular dominance and found a good concordance between the 2 measures, although the hole-in-the-card test indicated a higher rate of right-eye dominance.² Recent reports have suggested using the Worth 4-dot test to test for ocular dominance before laser surgery for myopia.³ Testing ocular dominance using the patients' habitual refractive correction was preferred as it was felt that there would be less eye fatigue if ocular dominance was retained after laser surgery. No studies have compared the hole-in-the-card test and the Worth 4-dot test. This study was performed to compare the 2 tests using both habitual and best refractive correction.

Patients and methods

429 patients who attended the outpatients clinic at the Shantou University/The Chinese University of Hong Kong Joint Shantou International Eye Center, Shantou, China, for refractive error and itchy eye were recruited between July and December 2004. All enrolled patients underwent a complete ophthalmic examination and ascertainment

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of ocular dominance. The following inclusion criteria were required: orthophoria determined by the cover test, and an optimum distance correction giving visual acuity of 20/20 (6/6) or better in both eyes (absence of amblyopia). Only patients without amblyopia were included in the study to avoid any effect of amblyopia on ocular dominance. Patients were excluded from the study if they had a history of ocular surgery, including cataract or refractive surgery; history of strabismus or ptosis; any clinically significant retinal pathology, glaucoma, optic neuropathy, optic disc anomalies, or other diseases that might affect visual acuity after correction; and presence of marked facial asymmetry. Oral consent was obtained from the patients after explanation of the nature and possible consequences of the study. After screening, only 197 patients fulfilled the inclusion criteria. Not all the volunteers underwent all 4 tests.

Clinical measurements

Ocular dominance was determined using the hole-in-the-card test (Dolman method) and the Worth 4-dot test. In the hole-in-the-card test, each patient was given a piece of cardboard in which there was a central circular hole 3 cm in diameter (Essilor cardhole pole; Essilor, Shanghai, China). Each patient was asked to hold the cardboard with both hands and to view a target 3 m away through the hole with both eyes open. Each eye was then occluded in turn. When the dominant eye was covered, the target could not be seen through the hole but when the non-dominant eye was covered, the dominant eye continued to fix on the target through the aperture. This test is a 'forced choice' test of dominance, which allows only a right or left eye result.

For the Worth 4-dot test, ocular dominance was confirmed by the patient's response to the lowest white round dot's color projected at 3 m, using a red lens in front of the right eye and a green lens in front of the left eye. The dot colors red, green, and undetermined corresponded with right, left or undetermined ocular dominance, respectively. The Worth 4-dot test has the advantage over the hole-in-the-card test of not being affected by hand dominance.

To determine the best refractive correction, a trial lens (Tian Nuo, Lianyungang, China) was inserted according to the maximum plus maximum visual acuity principle. If a patient reported not using spectacles for most of the day, then unaided ocular dominance was tested.

Each of the 2 ocular dominance tests using both types of correction was repeated at least twice to confirm dominance. Most patients were tested in the following order:

- Worth 4-dot test with full correction
- hole-in-the-card test with full correction
- Worth 4-dot test with habitual correction
- hole-in-the-card test with habitual correction.

For both ocular dominance tests, patients with different results on repeated testing were not included in the study. Autorefractometer (KR-8100; Topcon, Tokyo, Japan) was used to obtain at least 3 consecutive refractive error measurements. Three drops of 0.5% Mydrin-P ophthalmic solution (Santen, Osaka, Japan) were instilled 10 minutes apart to induce cycloplegia in each eye. Autorefractometer was measured at least 30 minutes after the last drop of Mydrin-P was instilled. Refraction data were converted to spherical equivalent refraction.

Statistical analysis

Data analysis was performed using the statistical package for the social sciences, version 11.5. A *p* value of <0.05 was considered significant. The chi squared test was used to assess the difference between the 2 measures under both conditions, while the Spearman correlation was used to test their relationship.

Results

429 patients were eligible for the study. The mean age was 16.0 years (SD, 8.5 years). 228 patients (53.1%) were women and 201 (46.9%) were men. There was no significant difference in spherical equivalent between the right eye (-2.32 D; SD, 1.88 D) and the left eye (-2.20 D; SD, 1.93 D).

Table 1 shows the results of the 2 ocular dominance tests when using the patients' habitual correction. When ocular dominance was determined using the hole-in-the-card test, right ocular dominance was present in 45 of 61 patients (73.8%) and left ocular dominance was present in 16 patients (26.2%). The Worth 4-dot test indicated right ocular dominance in 27 of 61 patients (44.3%) and left ocular dominance in 29 patients (47.5%); the other 5 patients (8.2%) had undetermined ocular dominance. For patients whose ocular dominance was determined with habitual correction, the hole-in-the-card test was neither significantly different from the Worth 4-dot test, nor correlated with the Worth 4-dot test.

Table 2 shows the results of the 2 ocular dominance tests when using the patients' full correction. When ocular dominance was determined using the hole-in-the-card test, right ocular dominance was present in 106 of the 140 patients (75.7%) and left ocular dominance was present in 34 patients (24.3%). The Worth 4-dot test indicated right ocular

Table 1. Dominant eyes by Worth 4-dot test and hole-in-the-card test with habitual correction.

Hole-in-the-card test	Worth 4-dot test			Total (%)
	Right eye	Left eye	Undetermined	
Right eye	20	20	5	45 (73.8)
Left eye	7	9	0	16 (26.2)
Total (%)	27 (44.3)	29 (47.5)	5 (8.2)	61 (100)

$\chi^2 = 2.125$, *df* = 2, *p* = 0.346; Spearman's *r* = -0.047, *p* = 0.718.

Table 2. Dominant eyes by Worth 4-dot test and hole-in-the-card test under best correction.

Hole-in-the-card test	Worth 4-dot test			Total (%)
	Right eye	Left eye	Undetermined	
Right eye	50	32	24	106 (75.7)
Left eye	7	23	4	34 (24.3)
Total (%)	57 (40.7)	55 (39.3)	28 (20.0)	140 (100)

$\chi^2 = 15.185$, $df = 2$, $p = 0.001$; Spearman's $r = 0.118$, $p = 0.164$.

Table 3. Dominant eyes by hole-in-the-card test under habitual correction versus best correction.

Best refractive correction	Habitual correction		Total (%)
	Right eye	Left eye	
Right eye	44	4	48 (78.7)
Left eye	1	12	13 (21.3)
Total (%)	45 (73.8)	16 (26.2)	61 (100)

$\chi^2 = 33.066$, $df = 1$, $p < 0.0001$; Spearman's $r = 0.782$, $p < 0.0001$.

Table 4. Dominant eyes by Worth 4-dot test under habitual correction versus best correction.

	Right eye	Left eye	Undetermined	Total (%)
Habitual correction	27 (43.5)	29 (46.8)	6 (9.7)	62 (100)
Best correction	28 (45.2)	27 (45.2)	7 (11.3)	62 (100)

$\chi^2 = 32.205$, $df = 4$, $p < 0.0001$; Spearman's $r = 0.517$, $p < 0.0001$.

dominance in 57 patients (40.7%) and left ocular dominance in 55 patients (39.3%); the other 28 patients (20.0%) had undetermined ocular dominance. For patients whose ocular dominance was determined under full correction, the hole-in-the-card test was significantly different from the Worth 4-dot test ($\chi^2 = 15.185$, $df = 2$, $p = 0.001$), but it was not significantly correlated with the Worth 4-dot test.

Table 3 shows the results of the hole-in-the-card test when using the patients' habitual and full correction. When ocular dominance was determined under habitual correction, right ocular dominance was present in 45 of the 61 patients (73.8%) and left ocular dominance was determined in 16 patients (26.2%). Under full correction, the results indicated right ocular dominance in 48 patients (78.7%) and left ocular dominance in 13 patients (21.3%). For patients whose ocular dominance could be determined using the hole-in-the-card test using habitual and full correction, the results were significantly different for the 2 conditions ($\chi^2 = 33.066$, $df = 1$, $p < 0.0001$) and the 2 conditions were also significantly correlated (Spearman's $r = 0.782$, $p < 0.0001$).

Table 4 shows the results of the ocular dominance tests using the Worth 4-dot test using the patients' habitual and full correction. When ocular dominance was determined using habitual correction, right ocular dominance was present in 27 of 62 patients (43.5%) and left ocular dominance was present in 29 patients (46.8%); the other 6 patients (9.7%) had undetermined ocular dominance. Using full correction, the results indicated right ocular dominance in 28 patients (45.2%) and left ocular dominance in 27

patients (43.5%); the other 7 patients (11.3%) had undetermined ocular dominance. For patients whose ocular dominance could be determined using the Worth 4-dot test using habitual and full correction, the results were significantly different ($\chi^2 = 32.205$, $df = 4$, $p < 0.0001$), and were also significantly correlated (Spearman's $r = 0.517$, $p < 0.0001$).

Discussion

There are many ways to test for ocular dominance, and most of the studies indicate that the different tests are significantly correlated.^{2,4} This study compared the Worth 4-dot test with the hole-in-the-card test and the results indicate that the outcomes are not correlated. The results of the 2 tests differed significantly depending on the patients' refractive error.

The hole-in-the-card test was associated with a higher rate of right ocular dominance compared with the Worth 4-dot test. This has also been noted in other studies,^{1,4,5} and may be related to hand dominance. Therefore, an indication of ocular dominance can be found by noting which hand a patient uses to accept the cardboard.⁶ It is generally believed that the dominant eye is on the same side as the dominant hand.⁷ Genetic research indicates that hand and ocular dominance may be associated with heredity and population distribution.⁵ However, some patients may hold the cardboard much closer to the right eye than to the left eye, resulting in false right ocular dominance.

The Worth 4-dot test is a sensory fusion test. The color of the white dot, as perceived by the patients, indicates the

dominant eye, as each eye uses a different color lens. Since the brain can combine the images from each side, the dominant eye's color will impose on the other eye. If a distinct color cannot be seen, ocular dominance must be noted as undetermined. However, the result may be affected by the defocus of the 2 eyes. When a 0.25 D lens was inserted into one eye, patients switched their ocular dominance. However, some patients were not sensitive to the lens power change. For the former patients whose ocular dominance changed

with the insertion of the lens, it is possible that the eye with a refractive focus closest to the retina will be the dominant eye. For the patients who were not sensitive to the lens power change, further study is required to detect patients who are not affected by the change in focus.

This study also showed that, whichever test was used, best refractive correction provided different results to habitual refractive correction.

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