The base-to-base induced-tropia prism test for detection of amblyopia: A pilot study

Konstantina Koklanis, PhD, Thong Le, BOrth, OphthSci(Hons), and Zoran Georgievski, BAppSc(Orth)(Hons)

PURPOSE
To investigate the accuracy of the base-to-base prism test (BBPT), which entails inducing an esotropia with the use of base-in prisms before each eye, in the diagnosis of amblyopia.

METHODS
Participants were consecutive patients recruited from a pediatric ophthalmology practice who were able to perform logMAR acuity testing. All participants underwent an orthoptic examination, including logMAR visual acuity testing, and a sensorimotor evaluation. Patients with an interocular difference of 2 or more lines were considered to have amblyopia. Fixation preference was assessed by use of both the vertical fixation test and the BBPT. The agreement between the BBPT and visual acuity was analyzed and compared with the agreement between the vertical fixation test and visual acuity.

RESULTS
Fifty-one consecutive patients aged 4 to 17 (mean, 9.8 years; SD ± 3.4) were included, of whom 11 were diagnosed with amblyopia. Kappa analysis showed moderate but significant agreement between the BBPT and logMAR (κ = 0.453, p = 0.001), whereas the vertical fixation test demonstrated only a fair agreement (κ = 0.254, p = 0.061). The overall sensitivity for the BBPT was 72.7% (95% confidence interval [95% CI], 43.4%-90.3%) but only 40% for the vertical fixation test (95% CI, 16.8%-69.7%). For the BBPT, specificity was 80% (95% CI, 65.2%-89.5%); for the vertical fixation test, 78% (95% CI, 63.3%-88.0%).

CONCLUSIONS
The BBPT appears to be more sensitive than the vertical fixation test for detecting amblyopia in our patient population. The 2 tests had similar specificity. (J AAPOS 2010;14:484-487)

Determining monocular visual acuity is a definitive part of the detection, assessment, and management of amblyopia. However, a quantifiable measurement is not always obtainable in children. Clinicians therefore often rely on binocular fixation preference to estimate visual function. The assessment of fixation preference involves objectively comparing the fixation of each eye such that alternation is indicative of equal vision; a preference to fixate with one eye as opposed to the other is indicative of amblyopia. This method is generally only an option in the presence of manifest strabismus of greater than 10 D. For patients with a microtropia or orthotropia, a prism-induced tropia test is used as an alternative to assess fixation preference. The most commonly used technique involves inducing a vertical strabismus using a prism of at least 10 D base down and applying a cover test to grade fixation. In a number of studies, the investigators have questioned the ability of an induced tropia test to detect amblyopia. Although some suggest the test is reliable, others have found poor correlation of amblyopia with prism-induced fixation preference. This variability is consistent with the lack of agreement between studies in which authors investigated the reliability of fixation preference in individuals with strabismus.

At the Royal Children’s Hospital in Melbourne, we have been using a prism-induced tropia test designed by one of the authors (ZG), termed the base-to-base prism test (BBPT). The test entails optically inducing a horizontal strabismus by the use of loose base-in prisms before each eye. It is thought that this technique may provide a more accurate indication of amblyopia because the horizontal movement produced is easier to view in young children as compared with the smaller vertical movement when a 10 D base down is used and may be more valuable in patients with a microtropia, in whom the sensory adaptations occur along the horizontal meridian. This pilot study aims to investigate the accuracy of the BBPT in the diagnosis of amblyopia.

Methods
The study protocol was approved by the Institutional Review Board of the Royal Children’s Hospital in Melbourne. All participants were consecutive patients at the Royal Children’s Hospital...
in Melbourne and underwent an orthoptic examination, including assessment of best-corrected visual acuity, cover test (for both near and far accommodative targets), assessment of ocular movements, and testing for convergence (using a fixation target) and stereopsis (Lang II Stereotest). Funduscopic examination and refraction was also performed for all new patients or for those who had not undergone these examinations within 12 months. Best-corrected visual acuity was measured with the use of the logMAR chart at 3 m; the eye assessed first was randomized to eliminate the effect of fatigue or practice. Patients were only invited to participate if they were able to perform logMAR acuity testing. No age restrictions were otherwise included.

Participants were included in the study as patients if they were diagnosed with amblyopia (defined as 2 or more lines of interocular difference) and had no ocular conditions other than refractive error and/or microtropia. Participants were included as control patients if they had no ocular pathology and no significant refractive error (defined as hypermetropia, myopia, or astigmatism ≥1 D) or anisometropia (>1.50 D). Patients with a manifest strabismus greater than 10 D, retinal pathology, or gross motility defects were excluded.

Fixation preference was assessed (with spectacle correction where appropriate) by the use of both the BBPT and the vertical fixation test as described by Frank and Harley, Nelson and Olitsky. This involved placing a 12 D base down prism in front of one eye and then the other while the patient was fixating on a penlight at near. An optically induced esotropia will become apparent and one of three possible observations regarding the fixation preference will be made: right fixation preference (B), a conjugate movement of the eyes to the right (recall that with interposition of a prism, the eye will move towards the apex to take up fixation) indicating likelihood of left amblyopia; right fixation preference (C), a conjugate movement of the eyes to the left indicating likelihood of right amblyopia; or no fixation preference, alternation of conjugate gaze and hence fixation indicating likely equal vision or absence of clinically significant amblyopia.

**FIG 1.** The Base to Base Prism Test, BBPT. A patient with no observable manifest deviation (A) has base in prisms of 12 D to 15 D placed before each eye while fixating on a penlight at near. An optically induced esotropia will become apparent and one of three possible observations regarding the fixation preference will be made: right fixation preference (B), a conjugate movement of the eyes to the right (recall that with interposition of a prism, the eye will move towards the apex to take up fixation) indicating likelihood of left amblyopia; right fixation preference (C), a conjugate movement of the eyes to the left indicating likelihood of right amblyopia; or no fixation preference, alternation of conjugate gaze and hence fixation indicating likely equal vision or absence of clinically significant amblyopia.

**FIG 2.** BBPT performed on a young child.
the prism, a conjugate movement of the eyes occurs towards the apex of the prism of the fixing eye and an optically induced esotropia becomes apparent. Fixation preference is observed beneath the prisms. A conjugate movement to the right is indicative of right fixation preference and likely left amblyopia, whereas a conjugate movement to the left is indicative of left fixation preference and likely right amblyopia. Alternation of conjugate gaze indicates no fixation preference and thereby equal vision and or no clinically significant amblyopia. No cover test is applied to further grade fixation preference.

In addition to the BBPT, a modified BBPT was performed with two 15° base in prisms, one before each eye, to determine whether this would yield a different result; however, identical prisms are not generally used clinically because they are not available in a single set of loose prisms.

The vertical fixation test was performed by the examiner who conducted the visual acuity examination. The BBPT was performed by an independent observer who was blinded to the patient’s history and the initial examination results, including the visual acuity result and vertical fixation test outcome.

A kappa analysis with SPSS 14.0 (SPSS, Chicago, IL) was performed to assess the agreement between the induced prism test and visual acuity. The sensitivity, specificity, and positive and negative predictive values also were calculated.

## Results

A total of 51 participants between the ages of 4 and 17 (mean, 9.8 years; SD ± 3.4) were included in the study. Of the 51 participants, 40 were orthotropic, 4 had a divergence excess exotropia but were orthotropic at near, and 7 were diagnosed with a microtropia. Best-corrected visual acuity ranged from 20/15 to 20/300. Twenty-two children had significant refractive errors. The spherical equivalent ranged from +6.25 D to −10.00 D (mean of absolute value, 2.54 D; SD ± 0.31). Of these, 7 participants demonstrated anisometropia greater than 1.50 D. In total, 18 patients had no refractive error or other pathology.

Using logMAR acuity, 11 of the participants (21.6%) were diagnosed with amblyopia or an interocular difference of 2 or more lines. Of these, 6 demonstrated a 2-line difference, 2 a 3-line difference, and 3 a 4-line difference or greater. All patients with amblyopia had undergone or were undergoing occlusion treatment. Visual acuity ranged from 20/32 to 20/300 (mean, logMAR 0.37 [equivalent to approximately 20/50]), with a median logMAR of 0.3 (equivalent to 20/40). The BBPT and vertical prism test both identified 16 (31.4%) participants with amblyopia; however, the 16 participants identified with amblyopia were not identical. The overall sensitivity for the BBPT was 72.7% (95% confidence interval [95% CI], 43.4%-90.3%) but only 40% (95% CI, 16.8%-69.7%) for the vertical fixation test. Table 1 lists the results of BBPT and LogMAR findings. For the BBPT, specificity was 80% (95% CI, 65.2%-89.5%); for the vertical fixation test, 78% (95% CI, 63.3%-88.0%).

Kappa analysis showed a moderate but significant agreement between the BBPT and logMAR (κ = 0.453, p = 0.001), whereas the vertical fixation test only demonstrated a fair agreement (κ = 0.254, p = 0.061). Given that a large number (n = 16) of participants demonstrated an interocular difference of one line but less than two and that some evidence suggests this cohort may reduce the accuracy of fixation preference testing,1,5 we reanalyzed the data with these participants removed. This method yielded greater agreement between the BBPT and logMAR (κ = 0.626, p = ≤ 0.001) and between the vertical fixation test and logMAR (κ = 0.530, p = ≤ 0.001).

Little difference was found between the BBPT using the 15° and 12° prisms and the modified BBPT using two 15° prisms, which also was performed on all 51 participants. The modified BBPT demonstrated a significant moderate agreement (κ = 0.488, p = 0.001). Sensitivity was at 72.7% (95% CI, 43.4%-90.3%) and specificity at 82.5% (95% CI, 68.1%-91.3%). Of the 51 participants, only 3 (5.9%) yielded a different response. A summary of these findings is in Table 2.

## Discussion

Fixation preference testing of strabismic patients is commonly used to estimate visual function in preverbal children. In the absence of an observable manifest strabismus, a preferential-looking technique or a prism-induced tropia test is used to detect a fixation preference. However, preferential looking techniques have been shown to underestimate the presence of amblyopia,12 and the value of testing fixation preference remains questionable.

We prospectively evaluated the accuracy of the BBPT in the assessment of amblyopia and found that the BBPT has
moderate agreement with logMAR acuity, the gold standard test for amblyopia, with good specificity and sensitivity and had greater accuracy than the vertical fixation test. Our findings contrast with those that suggest a poor correlation between visual acuity and fixation preference\(^7,8\) and are consistent with other studies reporting a good correlation between tests of fixation and visual acuity.\(^1,4,6\)

The BBPT had several differences with the vertical fixation test that may have been advantageous: (1) horizontal movements are easier to view than small vertical movements, (2) relatively equal size prisms in front of each eye may limit an apparent fixation preference caused by a prism artifact, and (3) the horizontal shift of the image aligns it with where sensory adaptations occur in microtropia.

However, the vertical fixation test was performed in a nonstandard manner, in which the examiner simply observed for a fixation preference rather than performing a cover test. The results also were scored as a binary choice, not allowing for subjective grading of “holds well” or “holds momentarily,” described in detail in the literature, is subjective and open to observer interpretation. This strategy may have reduced the accuracy of the vertical fixation test, although the BBPT was performed with the use of the same forced choice strategy.

It is important to note that the examiner performing the vertical fixation test was not unmasked to the visual acuity results, potentially introducing bias. Furthermore, whereas the examiner performing the BBPT was masked to the visual acuity and medical history, we did not control for the clinician’s knowledge of the child or family and awareness of a previous history of amblyopia.

We found that the accuracy of the BBPT improved when participants with between 1 and 2 lines of interocular difference were removed from the analysis. These participants were too often demonstrating a false positive, possibly attributable to the difference in vision.

The appreciation of diplopia also may have influenced the sensitivity of the BBPT. Although participants were not asked about this, it is conceivable that some patients with amblyopia may still perceive diplopia and look between the images, thereby simulating alternation or no fixation preference and yielding a negative result despite the presence of amblyopia.

Finally, the age range of the patients included in this study and the small proportion of participants diagnosed with amblyopia limit the findings. The BBPT is generally used in preverbal or uncooperative children, but logMAR visual acuity testing cannot be performed to validate a test in this group. Previous studies investigating the fixation preference with prism induced tropias\(^1,2,4,6\) assessed younger patients but required a variety of visual acuity tests. By selecting patients who were cooperative and able to perform a reliable linear visual acuity test, our mean age was greater than the mean age of the target population for this test. Nevertheless, we believe the importance of validating this test against the gold-standard outweighs this issue and that fixation preference may not change with age.

In conclusion, The BBPT was more sensitive at detecting amblyopia than the vertical fixation test, with similar specificity. In the absence of gold standard clinical tests in preverbal children, the inducing of horizontal strabismus to evaluate fixation and amblyopia appears useful. Future studies, with a larger cohort of participants, could investigate the effects of various other grading systems on the BBPT and in comparing the BBPT to the conventional vertical fixation test.

**References**