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Role of a Standardized Prism Under Cover Test in the Assessment of Dissociated Vertical Deviation

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Abstract

Background: Dissociated vertical deviation (DVD) is commonly measured using a prism and alternate cover test (PACT), but some providers use a prism under cover test (PUCT). The aim of this study was to compare a standardized PUCT measurement with a PACT measurement, for assessing the magnitude of DVD.

Methods: 36 patients with a clinical diagnosis of DVD underwent measurement of the angle of deviation with the PACT, fixing with the habitually fixing eye, and with PUCT, fixing both right and left eyes. The PUCT was standardized, using a 10-second cover for each prism magnitude, until the deviation was neutralized. The magnitude of hyperdeviation by PACT and PUCT was compared for the non-fixing eye, using paired non-parametric tests. The frequency of discrepancies more than 4 prism diopters (PD) between PACT and PUCT was calculated.

Results: The magnitude of hyperdeviation was greater when measured with PUCT (range 8PD hypodeviation to 20PD hyperdeviation) vs. PACT (18PD hypodeviation to 25PD hyperdeviation) with a median difference of 4.5PD (range –5PD to 21PD); $P < 0.0001$. 18 (50%) of 36 measurements elicited >4PD hyperdeviation (or >4PD less hypodeviation) by PUCT than by PACT.

Conclusions: A standardized 10-second prism under cover test yields greater values than a prism and alternate cover test in the majority of patients with DVD, providing better quantification of the severity of DVD, which may be important for management decisions.

Keywords

DVD; Hypertropia; Prism Under Cover Test

INTRODUCTION

Dissociated vertical deviation (DVD) is characterized by slow upward drifting and excyclodeviation of the hyperdeviating eye.(Brodsky, 1999, Christoff et al., 2014, Helveston, 1980) The deviation may be entirely latent or spontaneously manifest, and is typically bilateral but asymmetric in presentation.(Christoff et al., 2014, Hatt et al., 2015, Helveston,

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1980, Velez, 1988) DVD can be difficult to quantify,(Christoff et al., 2014, Helveston, 1980, Velez, 1988) and currently there is no standardized approach to the clinical assessment of patients with suspected DVD. Most often the magnitude of DVD is quantified using a routine prism and alternate cover test (PACT) in which the occluder is alternated from one eye to the other, until the deviation is neutralized. Nevertheless, the alternative method of prism under cover test (PUCT)(Mehta, 1999) has been suggested as preferred,(Hatt et al., 2015, Mallette et al., 1987, Mehta, 1999) although in previous studies the duration of occlusion has not been standardized.

Few previous studies have compared measurement methods for DVD and none to our knowledge have compared a PACT measurement to the recommended PUCT measurement. The purpose of this present study was therefore to compare a routine PACT measurement and a standardized PUCT measurement in patients with a clinical diagnosis of DVD.

MATERIALS and METHODS:

Approval for this study was obtained from Mayo Clinic Institutional Review Board. The study adhered to the tenets of the Declaration of Helsinki and all data were collected in a manner compliant with the Health Insurance Portability and Accountability Act.

Patients

Patients with a clinical diagnosis of dissociated vertical deviation (DVD) were retrospectively identified from departmental databases. All included patients had ocular alignment measured by both prism and alternate cover test (PACT) and prism under cover test (PUCT), with both measurements performed within a single 10–20 minute clinical examination, by one of two examiners (either a certified orthoptist [LK] or a strabismologist [JMH]). PACT measurements were performed before PUCT measurements. Since DVD typically exists alongside horizontal strabismus, we allowed any co-existing horizontal strabismus. Any previous strabismus surgery (including surgery for DVD) was required to be at least 3 months previously. Data were taken from the first examination at which both PACT and PUCT testing was performed.

Prism and alternate cover test measurements

The routinely used prism and alternate cover test (PACT) was performed in habitual refractive correction at distance (3 meters due to the use of 3 meter examination rooms). The fixing eye was determined based on assessment of fixation preference during cover test, and the deviation was measured by PACT for the non-fixing eye only. The patient was asked to fixate on a standard accommodative target (typically a letter optotype) and loose prisms were introduced in front of the non-fixing eye. Alternating cover of each eye was achieved using an opaque occluder, allowing only enough time for refixation (typically 1 to 2 seconds) and without allowing binocular fixation. The prism strength was progressively increased in front of the previously determined habitually non-fixing eye (during occlusion of the currently fixing eye), until the deviation was neutralized. The vertical and horizontal prism magnitude required to neutralize the deviation were recorded in prism diopters (PD).

Prism under cover test measurements

The prism under cover test (PUCT) (Mehta, 1999) was performed in habitual refractive correction at distance fixation (3 meters) only. Occlusion was achieved using the same opaque occluder as was used for the PACT. When we started performing the PUCT we chose to standardize the duration of occlusion as a 10-second cover so that the test was performed as follows. The patient was asked to fixate an accommodative target at 3 meters and loose prisms were held in front of the right eye, behind the occluder, for a period of 10 seconds. The occluder was then quickly moved to the left eye and the right eye (behind the prism) was observed for any movement. Unlike the testing procedure for the PACT, the occluder was then removed altogether (rather than continually alternated without allowing binocular fixation) and the right eye re-occluded with increased vertical and horizontal prism correction behind the occluder, for a period of 10 seconds. This process was repeated until the fixation movement of the right eye was neutralized. The test was repeated for the left eye. For each eye the vertical and horizontal prism magnitude required to neutralize the deviation were recorded in prism diopters. Both PACT and PUCT measurements were made by a certified orthoptist or strabismologist.

Analysis

The magnitude of vertical deviation at distance fixation by PACT and PUCT, was compared for the non-fixing eye, using signed rank tests. Differences were calculated as PUCT minus PACT. Since we did not routinely perform PACT measurements fixing both right and fixing left eyes, we were unable to compare PACT and PUCT measurements for each eye separately. Any hypodeviation was recorded as a negative value. In addition, the frequency of discrepancies of more than 4 PD between PACT and PUCT measurements was calculated. The threshold of 4PD was chosen somewhat arbitrarily, but it has been previously proposed in a Cochrane review of treatment for DVD (Hatt et al., 2015) and we felt this magnitude of difference could be considered clinically important.

RESULTS

Thirty-six patients were identified and included in the study. Median age was 29 (range 11 to 64) years and 18 (50%) were female. All patients had co-existing horizontal strabismus: 20 (56%) had current esotropia and 16 (44%) current exotropia. Previous strabismus surgery had been performed on 32 (86%), including 11 (31%) who had undergone previous DVD surgery. For 23 (64%) the non-fixing eye was the right eye.

PACT versus PUCT

The PACT values in the non-fixing eye ranged from 18PD hypodeviation to 25PD hyperdeviation (median 1PD hyperdeviation, quartiles 2PD hypodeviation, 4PD hyperdeviation) and the PUCT values ranged from 8PD hypodeviation to 20PD hyperdeviation (median 7PD hyperdeviation, quartiles 2PD hyperdeviation, 12PD hyperdeviation) (Figure 1). On average, the PUCT values were greater than PACT values (mean difference 6.3 PD; median difference 4.5PD, range -5PD to 21PD; $P < 0.0001$). We created a Bland-Altman plot (Figure 2) which showed that the magnitude of difference between PACT and PUCT was not related to the magnitude of the deviation.

Differences between PACT and PUCT more than 4PD

Eighteen (50%) of 36 measurements elicited >4PD hyperdeviation (or >4PD less hypodeviation) by PUCT than by PACT. Nine (25%) were greater by 5PD to 9PD, 5 (14%) were greater by 10PD to 14PD, and 4 (11%) were greater by 15PD or more (maximum 21PD greater by PUCT). One (3%) measurement showed >4PD (5PD) hyperdeviation by PACT than by PUCT.

Of the 17 (47%) measurements where PUCT and PACT were within 4PD, 4 showed zero difference between measurements and the remaining 13 showed greater hyperdeviation by PUCT. Using a threshold for difference of 1PD the PUCT yielded greater hyperdeviation in 31 (86%) of 36 measurements.

DISCUSSION

In this study comparing a routine PACT measurement with a standardized PUCT measurement for quantifying DVD, we found the PUCT measurement yielded a significantly greater magnitude of hyperdeviation (including less hypodeviation) in the majority of cases. Half of PUCT values were greater than PACT values by more than 4PD. These findings suggest the PUCT uncovers more of the total DVD than a PACT measurement.

We are unaware of any previous studies comparing measurement methods for quantifying the magnitude of DVD. Nevertheless, it has been noted in previous studies that the measurement of DVD is challenging, (Christoff et al., 2014, Helveston, 1980, Velez, 1988) with Raab (Raab, 1985) going as far as to say that it is not possible to measure DVD using a prism and alternate cover test (PACT) since there is no definitive end point. In an attempt to overcome this limitation of the PACT, Mallette et al (Mallette et al., 1987) described a different prism and cover method for measuring DVD, that has since become known as the prism under cover test (PUCT). (Hatt et al., 2015, Mehta, 1999) In this present study we further standardized the previously described PUCT method by defining the duration of cover as 10 seconds, and found that when performed in such a way, the PUCT yielded greater hyperdeviation values than a PACT.

Our finding that the PUCT elicits a greater magnitude of hyperdeviation than the PACT in patients with DVD suggests that the PUCT provides a better approximation of the magnitude of DVD. We speculate that prolonged occlusion of one eye when performing the PUCT allows more of the dissociated vertical deviation to be uncovered, by eliminating refixation of the deviating eye until the end of each 10-second episode of occlusion. By contrast the PACT requires repetitive refixation throughout testing. Alternatively it could be that the process of repeating 10-second periods of occlusion uncovers more hyperdeviation with the PUCT, but since the PUCT also allows binocular interaction between episodes of occlusion, we believe that prolonged occlusion for 10-seconds without refixation, is the critical factor. We had only one case where the PACT value was larger than the PUCT value, and this was most likely due to test retest variability, whereas our overall results of mean difference cannot be attributed to test-retest variability. Whatever the mechanism, because the PUCT elicits more of the hyperdeviation, we suggest that the PUCT should be the standard clinical

method of measurement, or at the very least be performed alongside the PACT, and should also be used in future studies of DVD.(Hatt et al., 2015) Better approximation of DVD magnitude may impact management decisions such as whether or not to intervene surgically, and if so how much surgery to perform. Future studies comparing PACT and PUCT measurements and their impact on clinical decision-making would be of value.

It should be remembered that the magnitude of hyperdeviation in a patient with DVD does not necessarily represent the magnitude of DVD itself. Patients with DVD frequently have co-existing vertical strabismus caused by oblique muscle dysfunction for example, and it is currently not possible to quantify the element of hyperdeviation attributable solely to DVD as separate from that due to any co-existing vertical strabismus.(Hatt et al., 2015, Tarczy-Hornoch & Guyton, 2008)Although a classic hyperdeviation produces a hypodeviation of the same magnitude in the opposite eye, bilateral DVD confounds the measurement of any such hypodeviation. Therefore any vertical deviation measured in a patient with a diagnosis of DVD is by necessity a composite of DVD and any co-existent vertical strabismus.

Although some authors have advocated the reversed fixation test,(Brodsky & Fray, 2007, Brodsky et al., 2005) Tarczy-Hornoch and Guyton have pointed out that the reversed fixation test “is a measure of the sum of the magnitudes of the monocular dissociated deviations” (Tarczy-Hornoch & Guyton, 2008) and not the amount of DVD in each eye. An advantage of the PUCT we describe is that it provides a measure of the total vertical deviation, representing the magnitude of deviation in each eye separately. It has been previously suggested that DVD may be quantified using the simultaneous prism cover test,(Velez, 1988) although this test would fail to detect any latent component. In other studies, DVD has been measured using video-oculography,(Ghadban et al., 2015) but such testing methods are often not readily available to the clinician. We recommend a standardized PUCT as the current method of choice for quantifying the magnitude of DVD in a clinical setting.

The patient population included in this present study was typical of that seen in most clinical practices, in that at the time of DVD evaluation most had undergone previous surgery for co-existing horizontal strabismus. However, some patients had also undergone previous surgery for DVD. We elected to include such patients in this study despite the fact that in some cases the non-fixing eye (included in the study) now had a hypodeviation. It is interesting to note that even in hypodeviated eyes the PUCT measurement resulted in relatively more hyperdeviation (less hypodeviation) compared with the PACT measurement, suggesting the on-going presence of latent DVD in eyes that have a surgically induced hypodeviation. This finding suggests that DVD is often not eliminated by surgical correction, but simply reduced in magnitude.

There are some limitations to our study. First, while we standardized the duration of occlusion for the PUCT as a 10-second cover, we did not completely standardize the duration of occlusion, or use prolonged occlusion for PACT measurements. It is possible that we would have found PACT and PUCT values to be more similar had we performed the PACT using more than usual occlusion of one eye. Nevertheless, the aim of this present study was not to compare the PUCT to a modified PACT (with prolonged occlusion of each eye), but rather to compare the PUCT to a routine PACT measurement performed by more

rapidly alternating the occluder from one eye to the other (allowing only enough time for refixation, typically 1 to 2 seconds), until neutralization of the deviation. It would not be practical to perform multiple 10-second periods of alternating occlusion for each of multiple prism strengths and for each eye separately. Second, the PUCT was always performed after the PACT and therefore larger magnitude deviations by PUCT could be attributable to the effects of increasing dissociation. Although we feel this is unlikely since there was time to resume binocular fixation between tests, repeating this study with testing order randomized would help confirm or refute our findings. Third, we arbitrarily chose 10 seconds as the duration of each occlusion when performing the PUCT, but it is unknown whether occluding for this period of time is optimal. Equivalent results may be achieved with a shorter period of occlusion or, conversely, greater degrees of hyperdeviation may be uncovered with even more prolonged periods of occlusion. Lastly, we recognize that while the PUCT may be preferable for achieving a more representative measurement of DVD, it may not always be practical to perform in young children who are not able to sit still and maintain fixation for prolonged periods of time. In the present study we did not have sufficient numbers to perform sub-group analyses in children versus adults.

A standardized PUCT yields greater magnitudes of hyperdeviation in patients with DVD, better representing the severity of DVD than the routine PACT. Improved assessment of the angle of deviation using the PUCT in patients with DVD may be important for management decisions and for surgical planning.

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Figure 1:

Scatterplot showing prism alternate cover test (PACT) and standardized 10-second prism under cover test (PUCT) values for the non-fixing eye at distance fixation, in 36 patients with dissociated vertical deviation. Hypodeviations were assigned a negative value. All but five patients showed greater hyperdeviation (or less hypodeviation) using the PUCT.

Figure 2:

Bland-Altman plot showing differences between prism alternate cover test (PACT) measurements and standardized 10-second prism under cover test (PUCT) measurements in 36 patients with dissociated vertical deviation. PUCT values were on average greater than PACT values (mean 6.3 PD), and there was no evidence of greater difference with greater magnitude of hyperdeviation.