Optometry (2006) 77, 229-234

Effect of heterophoria measurement technique on the clinical accommodative convergence to accommodation ratio

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KEYWORDS:
Accommodation;
AC/A ratio;
Heterophoria;
Repeatability;
Vergence

Abstract

BACKGROUND: Measurement of the stimulus accommodative convergence to accommodation (AC/A) ratio is a standard procedure in clinical optometric practice. Typically, heterophoria is assessed at several accommodative stimulus levels, and the gradient of the vergence to accommodation function computed. A number of procedures are available for the subjective measurement of heterophoria, but it is unclear whether the use of different vergence measurement techniques will alter the obtained AC/A value. Accordingly, the current study compared AC/A ratios measured using 3 clinical subjective heterophoria tests, namely the von Graefe (VG), Maddox Rod (MR), and Modified Thorington (MT) procedures.

METHODS: The AC/A ratio was measured in 60 visually normal subjects between 20 and 25 years of age using each of the 3 procedures listed above. The accommodative stimulus was varied by the introduction of ±1.00 diopter (D) spherical lenses over the distance refractive correction while subjects viewed a target at a viewing distance of 40 cm. To examine the repeatability of each procedure, the AC/A ratio was measured on 2 separate occasions for each measurement technique, with the 2 sessions being separated by at least 24 hours.

RESULTS: Mean values of stimulus AC/A ratio measured using the VG, MR, and MT procedures were 3.47, 2.99, and 2.46Δ/D, respectively. These differences were significant ($p=0.0001$). In addition, the coefficient of repeatability for the 3 techniques was 2.22, 1.99, and 1.20 Δ/D, respectively.

CONCLUSIONS: Ratios obtained using the Modified Thorington technique with ±1.00 D lenses showed the best repeatability, whereas the poorest repeatability was found with the von Graefe technique when only +1.00 D lenses were used to vary the accommodative stimulus. Accordingly, we recommend that that Modified Thorington procedure with ±1.00 D lenses be used to quantify heterophoria during clinical measurement of the stimulus AC/A ratio.

Optometry 2006;77:229-234

Measurement of the stimulus accommodative convergence to accommodation (AC/A) ratio is a standard procedure in clinical optometric practice.[1] Typically, heterophoria is assessed at multiple accommodative stimulus levels, and the gradient of the vergence to accommodation function computed. By keeping the target at a fixed distance, and using spherical lenses to alter the accommodative stimulus, the output of both tonic and proximal vergence will remain relatively constant, whereas disparity vergence is minimized owing to sustained dissociation. Accordingly, the

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1529-1839/06/$ -see front matter
doi:10.1016/j.optm.2006.02.006

change in vergence response resulting from the altered state of accommodation is produced by variations in accommodative convergence alone. This so-called gradient technique provides a more valid measurement of the AC/A than the alternative calculation (or heterophoria) procedure,[1,2] because the latter involves comparison of heterophoria measurements at different target viewing distances that will produce changes in both accommodative and proximal vergence.[3]

A number of procedures are available to the practitioner for the subjective measurement of heterophoria, but it is unclear whether the use of different vergence measurement techniques will alter the obtained AC/A value. Previous studies have observed differences in the repeatability of various techniques for the subjective measurement of heterophoria at near.[4-7] Both Rainey et al.[5] and Morris[6] reported that the Modified Thorington test had a higher level of repeatability than either the Maddox Rod or von Graefe procedures. For a detailed review comparing different methods of measuring the dissociated heterophoria, see Schroeder et al.[4] In addition, Rainey et al.[8] examined the reliability of both the stimulus and response AC/A ratios in 8 adult subjects using the Modified Thorington technique to assess heterophoria. Ratios were computed during 2 separate trials, each of which were separated by at least 48 hours, and the authors observed no significant difference between the mean findings taken during the 2 sessions for either ratio. Similarly, Bruce et al.[9] reported no significant difference between repeated measurements of the response AC/A ratio in 23 subjects. However, there appear to be few data showing differences in the repeatability of the stimulus AC/A ratio when measured using alternative heterophoria tests. Since the different subjective heterophoria techniques have varying degrees of repeatability during successive measurements, these variations may carry over to assessment of the clinical AC/A ratio, which requires multiple heterophoria measurements. Accordingly, the aim of the current study was to compare stimulus AC/A ratios measured using 3 clinical subjective heterophoria procedures, namely the von Graefe (VG), Maddox Rod (MR), and Modified Thorington (MT) procedures.

Methods

The stimulus AC/A ratio was measured in 60 visually normal subjects between 20 and 25 years of age (mean age, 22.4 years) using each of the 3 procedures listed above. All of the subjects were optometry students at the University of Aguascalientes, and all had best-corrected visual acuity of at least 6/6 (20/20) in each eye. None had any manifest ocular disease, strabismus, or decompensated heterophoria. The range of near heterophorias measured through the habitual prescription was 5.5Δ eso to 12.0Δ exo. The accommodative stimulus was varied by the introduction of +1.00 and −1.00 spherical lenses, introduced binocularly over the habitual distance refractive correction while subjects viewed a target at a viewing distance of 40 cm. For all procedures, lenses were introduced using a Bausch & Lomb model RH80 phoropter (Bausch & Lomb, Rochester, New York), and the near target was either mounted or held directly below the phoropter nearpoint rod in primary midline gaze. Subjects were not permitted to touch or hold the near target. Testing always began with the habitual distance refraction in place in the phoropter, followed by introduction of either the +1.00 and −1.00 lenses. The order of these lenses was counterbalanced across subjects. One measurement of heterophoria was recorded for each accommodative stimulus using the 3 procedures outlined below. To examine the repeatability of each procedure, the AC/A ratio was measured on 2 separate occasions for each measurement technique over a total of 6 sessions, with each of these sessions being separated by at least 24 hours. However, the precise time of day when each measurement was taken was not controlled or recorded. The order of performing the various procedures was randomized across subjects. All findings were obtained by the same examiner (J.B.E.) who was not masked to the previous results. However, calculation of AC/A ratios was not carried out until all of the 6 sessions had been completed.

Each session began with a 5-minute period of monocular occlusion, during which time the subject's left eye was fully occluded, and distance fixation was maintained to allow the dissipation of slow disparity vergence.[10,11] This minimized the possible effects of vergence adaptation resulting from visual activities performed before the start of each measurement session. Specific details for the 3 heterophoria measurement procedures are given below.

Von Graefe procedure

While viewing through the habitual distance refractive prescription, a 6Δ base-up prism was introduced before the right eye, and a 12Δ base-in prism before the left eye. Subjects viewed a 7 by 7 block of letters, the size of which was equivalent to 20/20, at a viewing distance of 40 cm. Subjects were instructed to fixate the lower (nonmoving) image and to keep the letters clear at all times. The magnitude of the horizontal prism was altered from base-in to base-out until the subject reported that the 2 images appeared "one directly beneath the other." The heterophoria was recorded as the horizontal prism that brought the diplopic images into precise vertical alignment. A single measurement of heterophoria was taken at each accommodative stimulus level.

Maddox rod

A red Maddox rod, axis horizontal, was introduced before the right eye while subjects observed a penlight at a viewing distance of 40 cm. Subjects indicated the relative position of the red Maddox streak with respect to the penlight. The