Convergence Accommodation to Convergence (CA/C) Ratio in Patients with Intermittent Exotropia and Decompensated Exophoria

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Abstract

Purpose: To evaluate the convergence accommodation to convergence (CA/C) ratio in strabismic patients and to clarify its clinical implications.

Methods: Seventy-eight consecutive patients (mean age: 12.9 ± 6.0 years) with intermittent exotropia and decompensated exophoria who showed binocular fusion at least at near viewing were recruited. The CA/C ratio was estimated by measuring accommodative responses induced by horizontal prisms with different magnitudes under accommodation feedback open-loop conditions. The CA/C ratios were compared with accommodative convergence to accommodation (AC/A) ratios and other clinical parameters.

Results: A linear regression analysis indicated that the mean (±SD) CA/C ratio was 0.080 ± 0.043 D/prism diopter or 0.48 ± 0.26 D/meter angle. There was no inverse or reciprocal relationship between CA/C and AC/A ratios. The patients with lower CA/C ratios tended to have smaller tonic accommodation under binocular viewing conditions and larger exodeviation at near viewing.

Conclusions: The CA/C ratio, like the AC/A ratio, is an independent parameter that characterizes clinical features. A lower CA/C may be beneficial for the vergence control system to compensate for ocular misalignment with minimum degradation of accommodation accuracy.

Key Words: accommodation, binocularity, convergence accommodation, fusion, strabismus

Introduction

When visual information regarding optical defocus (blur) is eliminated, for example, with pinholes, a fusional disparity induces an accommodative response. This response is due to synkinesis of oculomotor near-responses and implies crosslink interactions between accommodation and vergence control systems. The degree to which fusional vergence influences accommodation is known as the convergence accommodation to convergence (CA/C) ratio (D/prism diopters or D/meter angle), and the degree to which accommodation influences convergence is known as the accommodative convergence to accommodation (AC/A) ratio. However, CA/C ratios have attracted less attention from clinicians than AC/A ratios, mainly because of the difficulty of the measurement technique of CA/C ratios.

Tsuetaki et al. proposed a clinical method to measure the CA/C ratio with a defocused, 0.2 cycles/degree difference-of-Gaussian, target. Using a similar target, CA/C ratios have been investigated in infants, preschool children, and myopic patients, and in subjects with asthenopia induced by using a 3-dimensional head-mounted display. However, CA/C ratios have not been analyzed in strabismic patients to our knowledge, although such patients may have abnormal CA/C ratios since they some-
times show abnormal AC/A ratios\textsuperscript{14} and have a large ocular misalignment requiring compensation.

In this study, we reported CA/C ratios in strabismic patients who showed constant binocular fusion at least at near viewing and compared them with AC/A ratios and other clinical parameters. We then tried to clarify the clinical implications of CA/C ratios in strabismic patients.

**Methods**

**Patients**

The subjects were 78 consecutive patients with intermittent exotropia and decompensated exophoria (symptomatic patients who do not show manifest deviation during clinical examinations) who consulted the Strabismus Clinic, Hospital of Okayama University Medical School, in January–December, 2001. The following patients were excluded: (1) patients who did not show constant binocular single vision at near viewing, (2) those with poor stereopsis (>240s), (3) those with amblyopia, (4) those with anisometropia >1.0D, (5) those with nystagmus, (6) those diagnosed with pseudomyopia in exodeviation, (7) those with other ophthalmologic disorders, (8) those in whom consistent refractometry was difficult because of a narrow lid fissure or long eyelashes, and (9) those who were too young to sufficiently cooperate in the examinations.

The age of the patients ranged from 7 to 39 years and averaged 13.0 ± 6.0 years. The far deviations of the patients ranged from −50 to 0 prism diopters (PD) and averaged −19.0 ± 10.3PD (here, “minus” indicates exodeviation, and “plus” indicates esodeviation). The near deviations ranged from −45 to −3 PD and averaged −22.5 ± 9.3 PD. The mean refractive error of the right eye was −1.51 ± 2.22 D (range: −7.00 to +6.75 D). Of the patients, 29 (37%) had a history of surgical correction of strabismus. As normal controls, we also measured CA/C ratios in 10 subjects with no ophthalmological disorders (mean ± SD age: 25.1 ± 9.7 years).

In compliance with the Helsinki Declaration, the objective and methods of the study were explained to the subjects in advance, and their voluntary cooperation was obtained.

**Measurement of CA/C Ratios**

A pseudo-Gaussian or a difference-of-Gaussian target with a low spatial frequency has been reported to be useful for measuring CA/C ratios.\textsuperscript{6,7,15} This target at once has a clear center of figure and does not markedly change the marginal blur even when the focus is deviated, so it is considered to open only the accommodation feedback-loop while keeping the vergence loop closed. We made a pseudo-Gaussian target (Fig. 1) with a light emitting diode (LED) placed 40cm before the eyes and a diffusing screen placed 2.0cm in front of the LED (the spatial frequency of this target was about 0.2 cycles/degree from the subject’s eye positions).

Subjects were instructed to binocularly focus on this target in the dark. Horizontal prisms with different powers (Fresnel Prism Trial Set, Fresnel Prism and Lens Company, Eden Prairie, MN, USA) were successively inserted in front of the left eye, and accommodative changes of the right eye were measured using an open-field type, infrared autore-