Apparent Accommodation in Pseudophakic Eyes as Measured With Visually Evoked Potentials

Shuichi Yamamoto* and Emiko Adachi-Usami†

We measured apparent accommodation with pattern reversal visually evoked cortical potentials in 27 pseudophakic eyes after the implantation of posterior chamber intraocular lenses. The patients ranged in age from 47–83 years. The amplitude of accommodation was not significantly different between pseudophakic eyes and normal phakic eyes. Apparent accommodation was inversely proportional to the pupillary diameter and was significantly correlated with corneal astigmatism. No significant relationship was noted between apparent accommodation and age of patients, corrected visual acuity, or refractive error. Invest Ophthalmol Vis Sci 33:443-446, 1992

Aphakic or pseudophakic patients who have good near vision wearing corrective lenses for distance are experiencing the phenomenon of apparent accommodation.1 Reports on apparent accommodation in pseudophakic eyes after the implantation of anterior chamber or posterior chamber intraocular lenses have used subjective measurements but the origin of this phenomenon remains unclear.2,3 In 1981, Millodot and Newton4 and Sokol and Moskowitz5 reported objective measurement of accommodation using visually evoked cortical potentials (VECPs). In addition, we reported that the pattern VECPs to transient stimuli could be used to objectively measure the amplitude of accommodation,6,8 and we found a significant correlation between the objective amplitude and the subjective amplitude in normal subjects and in patients with diabetes. In the present study, we evaluated the amplitude of accommodation in pseudophakic eyes objectively using pattern VECPs. Also, to understand the possible mechanisms of apparent accommodation, we examined the effects of pupillary size and astigmatism on the apparent accommodation of pseudophakic eyes.

Materials and Methods

The pattern VECPs were recorded from 27 eyes of 25 patients who had undergone a successful extracapsular cataract extraction and implantation of a posterior-style intraocular lens at Chiba University eye clinic. All operations were performed by the same surgeon. The patients ranged in age from 47–83 years (mean age, 64.2 ± 10.6 SD). Each had a corrected visual acuity of 7/10 or better. Results from the pseudophakic eyes were compared with those from 28 eyes of age-matched normal controls (mean age, 65.5 ± 10.2). Informed consent was obtained from each subject after the nature of the procedures had been explained.

A black and white checkerboard pattern, reversed at 3 reversals/s, was generated on a television monitor. The mean luminance of the pattern was 39 cd/m², and the contrast was 80%. From the viewing distance of 50 cm, the field size was 27° × 39° and the check size was 14’. A silver cup electrode was placed at Oz for the recording, with a reference electrode at the earlobe. The responses were amplified with a preamplifier that had a bandpass filter of 1.5–100 Hz. A total of 100 responses were averaged in each run. A small circle of 10 min was placed in the center of the monitor for fixation.

Each subject first wore a lens for distance correction at 5 m for the eye examined. For each recording, ophthalmic lenses were placed in front of the eye, starting with a +2 diopter lens, which corresponded to the observing distance of 50 cm. The power then was changed in 1 D steps with a minus lens until the VECP became unrecordable. The amplitude of the first positive component with approximately 100 msec peak latency (P100) was measured. The amplitude relative to the one for zero diopter was then plotted against the lens power, and a linear regression line was calculated. Extrapolation to zero amplitude defined lens power necessary for the zero amplitude point. The zero amplitude lens power plus +2 D, which corresponded to the 50 cm of the observing distance, was defined as the objective amplitude of accommodation.
The amplitude of the P<sub>100</sub> component attenuated linearly with the increased minus lens power in every subject. Figure 1A shows actual VECP recordings from the pseudophakic eye of a 59-year-old man who received a posterior chamber intraocular lens implant. The relative amplitude of the P<sub>100</sub> is plotted against the lens power in Figure 1B. The amplitude of the P<sub>100</sub> was highest with the +2 D lens and decreased as the power of minus lenses increased. By extrapolating the regression line, the objective amplitude of accommodation was defined as 5.2 D.

The mean amplitude of accommodation determined with VECPs was 5.14 ± 0.32 D in pseudophakic eyes and 5.87 ± 0.40 D in normal phakic eyes. No significant difference was found between the two groups (Fig. 2). Previously, we reported that the amplitude of accommodation measured by pattern VECPs is 2.54 D higher than the subjective one obtained by the near-point rule. Accordingly, the amplitude of apparent accommodation found here corresponded to 2.60 ± 0.32 D in pseudophakic eyes and to 3.33 ± 0.40 D in normal phakic eyes.

The effect of pupillary size on accommodation was studied in five pseudophakic patients. Their pupillary diameters were changed with the use of artificial pupils of different sizes (1, 2, 3, and 4 mm) after the instillation of 1% cyclopentolate. Figure 3 depicts the objective amplitude of accommodation versus pupillary diameter. The amplitude significantly decreased with diameter. A regression line fitted among the data points had a correlation coefficient of r = −0.64, which showed a significant relationship between accommodation and pupillary diameter (P < 0.01).

In Figure 4, corneal astigmatism of the pseudophakic eyes was compared to the objective amplitude of apparent accommodation. Below 3 D of astigmatism, the correlation between them was significant, with a correlation coefficient of r = 0.62 (P < 0.01). No significant correlation was noted between apparent accommodation and age of patients, corrected visual acuity, or refractive error.
Discussion

The absence of a crystalline lens in a pseudophakic eye makes assessing apparent accommodation objectively with an infrared optometer impossible. Furthermore, subjective methods, such as the near-point rule, provide unstable results in elderly patients because of rapid movement of the test target, the change of the visual angle, and the delay of the patient's response. Defocusing changes amplitude and peak latencies of pattern VECPs. Therefore, several authors have reported the use of pattern VECPs for objective measurements of refraction\(^9\)\(^,\)\(^10\) and accommodation.\(^4\)\(^,\)\(^5\)

Millodot and Newton\(^4\) applied steady-state pattern VECPs for objective measurements of accommodation and demonstrated the attenuation of accommodation with advancing age. Sokol and Moskowitz\(^5\) showed that the peak latency of the pattern VECPs could be an accurate estimate of accommodation. We have employed transient reversal stimuli to analyze not only the amplitude but also the peak latencies.\(^6\)\(^,\)\(^8\)

Results of our previous studies showed that quantitative objective measurements with pattern transient VECPs were possible, but VECP estimates were 2.54 D higher than the subjective ones.\(^8\) Responses of VECPs still remain with reduced amplitude even when retinal blur becomes dominant. These might be the reasons for the difference of 2.54 D between the VECP method and the subjective method.

In the present study, we demonstrated apparent accommodation in pseudophakic eyes objectively using pattern VECPs. Depth of field has been thought to be one cause of apparent accommodation.\(^11\) Depth of field is closely related to the depth of focus, which is the dioptric range over which an image can depart from an ideal focal plane without subjective blur. When refractive power is constant, depth of field is negatively correlated with pupillary diameter. Our results showed objectively that the amplitude of apparent accommodation was inversely proportional to pupillary diameter.

Uemura et al\(^12\) also documented an opposite correlation between apparent accommodation and cylindrical power using a constant dioptric stimulus near-point ruler. In a myopic corneal astigmatic eye, there are two focal lines. The possibility that one meridian of the eye has an increased focus near the retina shows that apparent accommodation can be caused with no change of refraction. In our study, the amplitude of accommodation defined by pattern VECPs and corneal astigmatism were significantly correlated below 3 D of astigmatism.

These findings confirmed objectively that depth of field and corneal astigmatism were mechanisms that may account for the apparent accommodation.
Key words: apparent accommodation, pseudophakic eye, pattern visually evoked cortical potential, depth of field, corneal astigmatism

References