The Effect of Phenylephrine Hydrochloride on the Resting Point of Accommodation
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Previous models for ocular accommodation have suggested a dual sympathetic/parasympathetic innervation to the ciliary muscle. Such models would predict that sympathomimetic drugs should change the resting point or dark focus of accommodation. The effect of an alpha-adrenergic agonist (10% phenylephrine hydrochloride) on accommodation was examined; the results show a decrease in the near point of accommodation, without a change in the resting point of accommodation. These results suggest that the accommodative state of the eye is not the result of a simple balance between sympathetic and parasympathetic innervation as proposed by previous models of accommodation. Invest Ophthalmol Vis Sci 24:393-395, 1983

The role of the sympathetic division of the autonomic supply in accommodation of the eye has been the subject of controversy since the middle of the last century. The classical viewpoint as proposed by Helmholtz, holds that there is no sympathetic supply to the ciliary muscle and that the refractive power of the crystalline lens is increased for near vision as a result of parasympathetic action. Relaxation of the ciliary muscle and the elasticity of the lens capsule focus the eye for optical infinity in the case of emmetropia.

However, there are many who believe that the ciliary body also receives sympathetic innervation. Comprehensive review of studies suggesting dual innervation to the ciliary muscle is outside the scope of this introduction, but reviews have been presented by Cogan and more recently by Toates. One aspect of the controversy has been concerned with whether the sympathetic innervation is to the fibers of the ciliary muscle or whether the effect of sympathetic innervation is due to direct action on the vascular supply to the ciliary body and only indirectly on the lens capsule.

There has been recent interest in the state of accommodation of the eye in the absence of an appropriate stimulus. The state of focus of the eye under these conditions has been referred to as the resting point of accommodation (RPA) or dark focus of accommodation, and has been linked to night, empty field, and instrument myopia. Leibowitz and Owens investigated the effect of pupil size on the far point of accommodation (FPA) with repeated instillation of 10% phenylephrine hydrochloride (PHC1) and incidentally reported no significant change in the RPA. The study by Leibowitz and Owens was concerned primarily with the effect of spherical aberration on the FPA at high luminance level, and no measurement of the NPA was reported. It was, therefore, not possible to confirm that the ciliary body was affected by the drug treatment. Topical administration of PHCl has been shown to reduce the amplitude of accommodation in man, and the absence of any effect of 10% PHCl on the RPA appears inconsistent with existing models of accommodation based on a dual sympathetic/parasympathetic innervation. The purpose of the present investigation was to establish if stimulation of the sympathetic innervation to the ciliary body caused any change in the RPA. We found no effect of PHCl on the RPA, despite a decrease in the near point of accommodation (NPA).
Materials and Methods

Measurement of the accommodative state was obtained with a laser optometer based on the Badal principle. A diverging beam from 0.5 mW HeNe laser was directed to the surface of a gold-painted drum rotating at 1 rpm. A correction of +0.32 diopters (D) was applied for chromatic aberration and allowance made for the plane of stationarity. A bracketing procedure was used to determine the point of minimal speckle motion, and about ten presentations were normally required to determine the accommodative state.

The stimulus used for measurement of the FPA was a 6/9 Snellen letter with a background luminance of 3 cd/m² at a distance of 3.3 m. A lens of +0.32 D was included before the measured eye, which placed the target at optical infinity. The laser speckle pattern was superimposed on the Snellen letter by means of a beam splitter, and each presentation of the speckle pattern was limited to 0.5 sec to minimize the possibility of the speckle pattern itself acting as a stimulus to accommodation.

Standard subjective refraction techniques were used to determine the distance refractive correction for each subject, and the appropriate corrective lens was included before the measured eye.

Pupil diameter was measured with a television-based pupilometer, and the NPA was determined as the closest distance to which a line target could be approached to the eye without noticeable blur. The RPA was determined with the laser optometer after 5 min in complete darkness.

On the day of each experimental trial, one drop of 0.5% proparacaine hydrochloride was instilled into each eye, followed 5 min later by two drops of 10% PHCl (NeoSynephrine, Winthrop). The FPA, the NPA, and the RPA were determined at approximately hourly intervals for the duration of each trial.

Results

The drug treatment produced mydriasis (Fig. 1) and reduced the NPA (Fig. 2) in all subjects. For subject RB, NPA results are given for both a 3-mm artificial pupil.
artificial pupil and a natural pupil. The reduction in the NPA with the 3 mm pupil was 2.50D. It was 3.00D for the natural pupil. Similar results with natural pupils were obtained for the other subjects with BB showing a 2.75D reduction and LG a 2.50 reduction. The NPA data were analysed by Friedman two-way analysis of variance, showing the reduction in NPA to be a significant effect ($\chi^2 = 9.87$ with 4df; $P < 0.05$).

FPA and RPA are shown in Fig. 3. A typical accommodative lag of 1.00D was exhibited by all subjects. The RPA for RB and BB was 2.50D and for LG 2.00D. The FPA and RPA showed no significant variation during the course of changes in pupil diameters and NPA. The reduction in RPA exhibited by LG after 6 hrs was attributed to fatigue effects.

Discussion

We found no change in the RPA associated with the reduced NPA. In the case of LG, the RPA and reduced NPA were both about 2.00D, ie, the eye was focussed to a point approximately 50 cm from the subject for both situations. We regard as significant the fact that the NPA was reduced, yet no change in the RPA occurred. The interactions of pupil diameter and accommodation are well documented, and we chose to use an artificial pupil in only one subject for measurement of the NPA. The use of a 3-mm pupil for subject RB gave an increase of 0.50D in the NPA due to an increase in the depth of field produced by the artificial pupil. Allowing up to 1.00D for these effects, the true accommodation loss in all subjects was between 1.50D and 2.00D. This loss is somewhat greater than that obtained by Biggs et al who recorded a mean reduction in accommodation of 0.65D following repeated instillation of 10% PHCl. We attribute this difference to our use of proparacaine, which would increase absorption of the PHCl.

If the RPA represents the equilibrium position in the absence of an accommodative stimulus, it would be expected that any change in ciliary muscle tonus as a result of sympathetic or parasympathetic innervation would cause a change in the RPA. For the sympathomimetic drug used in this study (an alpha-adrenergic agonist), a shift of the RPA towards optical infinity would be predicted. The absence of any change in the RPA indicates that increased sympathetic activity produced by PHCl is not reflected in a change in tension in the zonular fibers to the crystalline lens when a stimulus to accommodation is absent. With an adequate stimulus to accommodation as produced during measurement of the NPA, the tension in the zonular fibers is increased, causing a reduction in the NPA. This suggests that RPA does not reflect a simple balance between the sympathetic and parasympathetic supply to the ciliary body. On the basis of existing models of accommodation (eg, Toates), any disturbance of muscle tonus resulting from sympathetic or parasympathetic innervation would be expected to produce a change in the tension of the zonular fibers and, hence, a change in the RPA.

Our results are difficult to explain in terms of a vascular response of the ciliary body. It would seem most unlikely that vascular changes could account for a 2.00D loss of accommodation at the near point, yet produce no concurrent change in the RPA.

We believe these results indicate a sympathetic receptor in the ciliary muscle. The fact that the change in accommodative state with PHCl depended on a suitable near stimulus to accommodation, suggests that this sympathetic response requires concurrent parasympathetic stimulation to be effective. That is, there exists a threshold of parasympathetic action that is necessary before the sympathetic response can manifest as a change in the accommodative state of the eye.

Key words: accommodation, resting point of accommodation, dark focus, sympathetic innervation, laser optometer, refraction

References


