Saccadic Lens Instability Increases with Accommodative Stimulus in Presbyopes

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INTRODUCTION

The etiology of presbyopia remains unclear. Presbyopia could occur consequent to loss of ciliary muscle function or loss of lens function. Recent literature suggests loss of lens compliance as the primary pathology. However, the extent to which ciliary muscle contraction during accommodation is preserved in the presbyopic eye has been debated. 2-3 Lens instability during and after saccadic eye movement may reflect ciliary muscle function and zonular tension. The dual Purkinje image (dPi) eye tracker can be used to evaluate this instability through the “lens wobble artifact”. 4 The amplitude of the lens wobble may indirectly reflect the extent of ciliary muscle contraction. In this study, saccadic lens wobble was quantified in presbyopes with accommodative stimuli of 9 different amplitudes.

METHODS

Ten presbyopic subjects participated. Subjects executed 32 4-degree saccades at one second intervals between targets arranged in a cross on illuminated cards at each of 9 viewing distances ranging from 0.5 to 8 D accommodative demands. Viewing was binocular; targets were aligned with a 2.5 degree (2.5x phylephenlein) left eye. Testing was also performed in the dilated eye of a 49 year old subject without and on another occasion with two drops of tropicamide administered to paralyze accommodation. Lens wobble could be directly recorded in one of the presbyopic subjects by video-based tracking of a corneal cataract using an infrared sensitive video camera with a 60 Hz frame rate. The dPi eye Purkinje (P) image channels that sampled P1 position signals (H1/V1) and since the reference position between P1 and P4 signal (H4/V4) were recorded at 360 Hz. To exclude the possibility that the post-saccadic lens wobble artifacts originate from saccadic eye movement “dynamic overloads”, the artifacts were extracted by subtraction of H1/V1 from H4/V4 (Fig. 1).

RESULTS

The ratio of the subtracted profile amplitude to saccade amplitude was analyzed as a function of increasing accommodative stimulus. A ray tracing eye model (Advanced Human Eye Model, AHEM, Breault Research) was also employed to model P1 and P4 shifts for a range of lenses translations and rotations.

DISCUSSION

The lens wobble artifact provides the opportunity to understand the consequences of ciliary muscle function in presbyopic eyes. Subtraction of H1/V1 and H4/V4 traces provides a useful, quantitative measure of this artifact. This study shows larger lens wobble artifacts occur with increasing accommodative demands in presbyopes, indicating increased lens instability. Lens wobble following saccades likely results from ciliary muscle contraction and reduced zonular tension. Eye modeling suggests that the lens wobble could occur from either lens translation or lens rotation. Therefore, the results suggest, as shown in prior studies 1-2, that ciliary muscle contraction continues to occur in the presbyopic eye with accommodative effort.

REFERENCES

4. Deubel, H., & Bridgeman, B. (1995). Fourth Purkinje image signals and rotations. The relative positions of the Purkinje images (red: P1; blue: P4) were identified so their movements can be measured and quantified. (B) Ray tracing analysis of movements of P1 and P4 with either lens translation or lens rotation shows the extent of lens wobble artifact in degrees. In contrast, to achieve a lens wobble artifact of 4°, the lens needs to either translate ±0.125 mm or rotate ±52°.

ACKNOWLEDGEMENTS

This project was funded in part by a sVRSG from UHCO to LH. Thanks to Dorothy Win-Hall for the clinical assistance and to Dr. Harald Bedell for help in developing the project.

DISCLOSURE

LH. None; SBS; None; AG; None; WJD, Breault Research Organization, Inc., E.

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