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Raytracing in the Compensation of the Peripheral Optics of the Eye

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Background

Many people with a visual impairment have only peripheral vision. For normal eyes peripheral vision is mainly used for orientation and motion detection with less demands on image quality. When the central vision is lost, an improvement of the residual vision is most wanted.

Methods

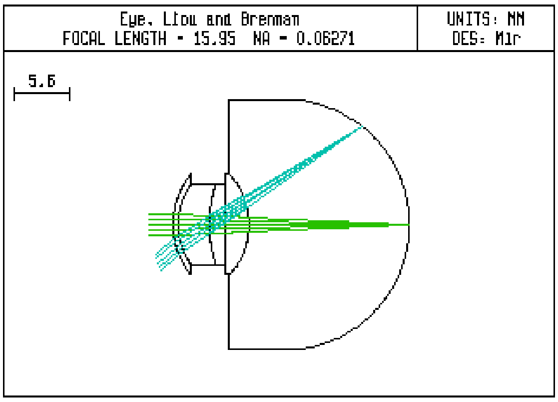
We simulated the paths of peripheral rays through the eye by means of raytracing. Five programs were compared. The OSLO raytracing software proved to be not only the best one in these circumstances but we also found it very well suited to our purpose. Remaining uncertainties are entirely due to a lack of input data about the peripheral part of the optical system of the eye. We designed compensatory optics on the basis of the test results.

Results

Lenses have been manufactured in accordance with the calculations made by the program for angles of incidence of 20, 40, and 60 degrees. The lenses are high compensation astigmatic lenses. The results of perimeter examinations of changes in peripheral vision using attachment optics were inconclusive, while tests of the lenses as attachments in front of a fundus camera produced successful preliminary results.

Discussion

In humans, sharp vision only occurs in very small angels centrally. Despite the fact that many individuals with loss of central vision are obliged to use peripheral parts of the retina, optical studies of the remaining visual field have so far been insufficient. Refractometers and other objective methods of evaluating the refraction of the eye provide reliable values only on or near the optical axis. Raytracing software seems to be a possible method of calculating required compensatory optics for the eye. However, in the course of our work with raytracing be have become aware of the fact that there is very limited knowledge of the peripheral optics of the eye. Knowledge about the eye lens and its gradient index structure is particularly critical to the precision of theoretical calculations. This awareness has encouraged us in our plans to develop measuring instruments for the peripheral area.



The model eye of Lui and Brennan is used in the example from the OSLO raytracing program

Conclusions

Most raytracing programs are not usable for studying the peripheral optics of the human eye. With OSLO, we have come so far that the greatest uncertainty about the results is due to insufficient input data, i.e. the present lack of knowledge about the optical structure of the eye. It is evident that new measuring instruments are needed in order to generate improved knowledge of the peripheral optics of the eye.

We have shown that it is possible to incorporate a gradient index lens in a raytracing program, to calculate correction lenses for peripheral vision, and to manufacture a first generation of such lenses.

The next step is to make individual measurements of several eyes and their off-axis aberrations.