Computational Modeling of Retinal Damage Thresholds

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Abstract

The Scalable Effects Simulation Environment(SESE), is the computational Biophysics software contracted by Nanohmics we used for our research. The goal was to find the minimum energy necessary to damage the retina from 2 laser sources, a 532 nm He-Ne source, and Supercontinuum Laser(SCL) source at 400-1400nm. We needed a 10 times damage ratio for significance. Our data did not show this trend.

Introduction

The American National Standards Institute(ANSI) laser safety standards are used to determine how much energy from a specific laser source will damage your retina. ANSI approximates the damage from a supercontinuum source considering only the most damaging wavelength. Using SESE, we evaluated the discrepancy in ANSI's estimation by considering the contributions from every wavelength.

Methods

SESE numerically solves 12 different partial differential equations concerning the mechanical, optical, and thermodynamic properties of the object into a 3D array of voxels used for visualization. Using SESE's Natick-spp simulation we modeled the 2 laser sources incident on the eye and collected data for 100 millisecond pulses duration followed by 200 millisecond cool-down. We took measurements for 3 different voxel resolution and compared those values with the expected value of ten times

Retinal Model

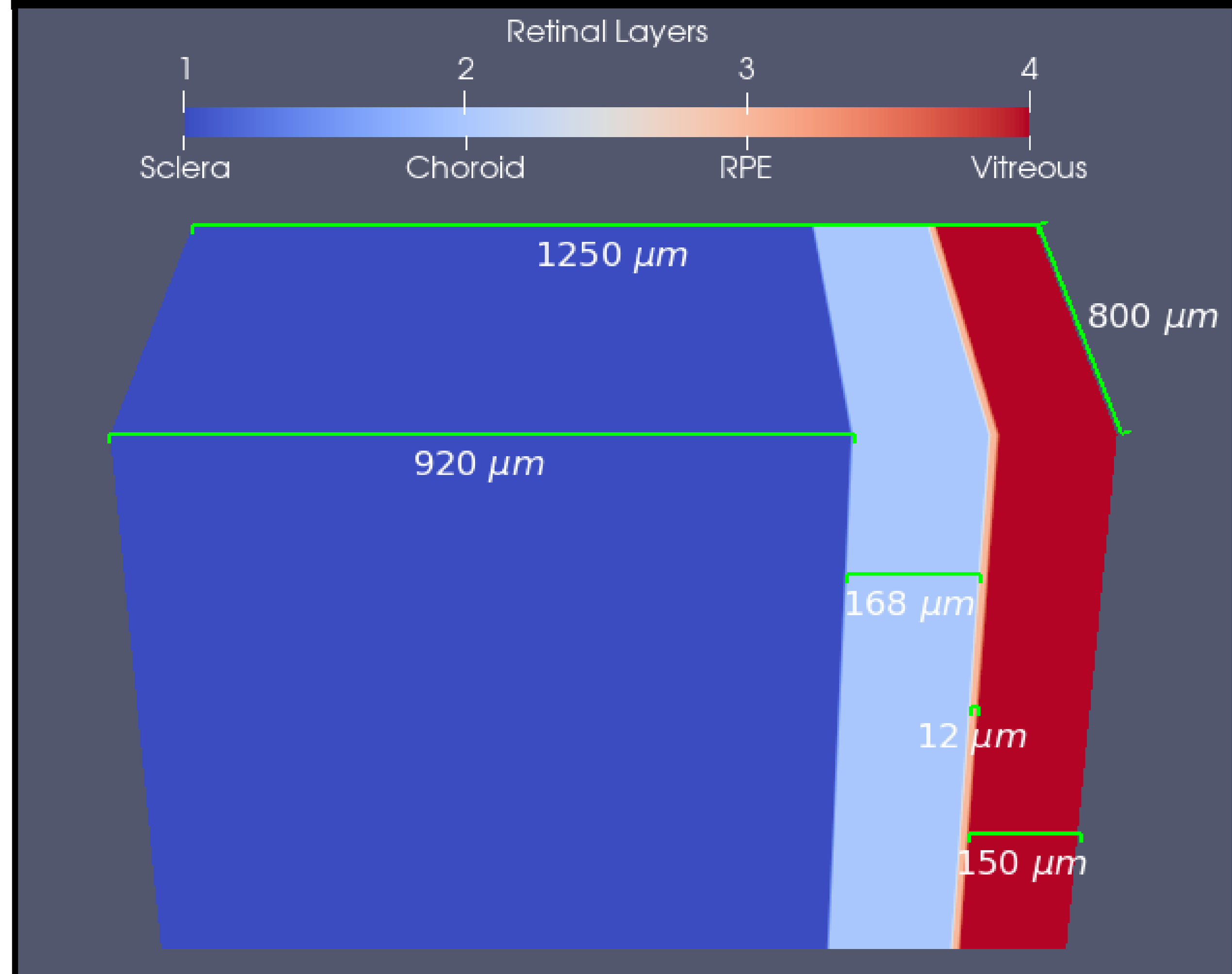

Fig.1: Computational model of the Retina

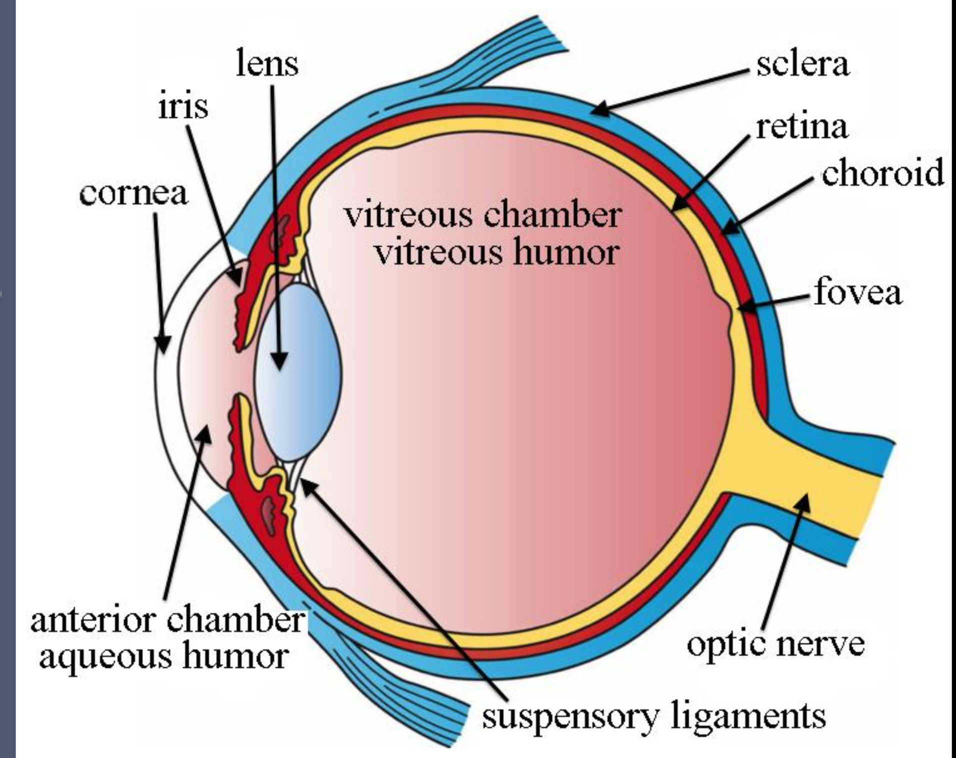

Fig.2: Physical model of the retina

Results and analysis

The ratio of minimum energy to damage the retina for the SCL versus the He-Ne source we obtained was $\frac{D_{SCL}}{D_{He-Ne}} \pm \Delta\frac{D_{SCL}}{D_{He-Ne}} = 4.61 \pm 0.31$. This was not the ratio of ten we wanted, and our Z score was 17.4 standard deviations away from the mean. This exceeds the two standard deviations maximum for the measurement to agree and two possible errors are unaccounted for. Optical and mechanical effects at near minimum visible lesion(MVL) level damage have been studied and they could increase the energy necessary for damage from the SCL source.

Table 1: Minimum energy necessary for retinal damage

Damage Data	2 micron	5 micron	10 micron
532 nm	0.123mJ	0.140mJ	0.150mJ
400-1400nm	0.619mJ	0.629mJ	0.647mJ

Table 2: Absorption Coefficients for 532 nm Laser Source

Retinal Layer	Absorption(cm^-1)
Sclera(Whites of eye)	16,000
Choroid(Blood vessels)	12,160
RPE(Melanocytes)	151,200
Vitreous(Clear gel)	0

Conclusion

The goal of our research was to determine whether ANSI's estimates for retinal damage, by considering the most damaging wavelength was accurate. Our data indicates that ANSI's estimate is accurate and considering the most damaging wavelength is a viable method in determining damage thresholds on the retina. Research concerning retinal damage is important for the safety of anyone working with powerful laser sources, such as people who work in the medical field, industry, and fiber optics.

References

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