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# **CORNEAL CONTRIBUTION TO THE WAVEFRONT ABERRATION OF THE EYE**

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October 15, 1999

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This dissertation  
is dedicated to the man  
I love and respect most in all the world—my father:

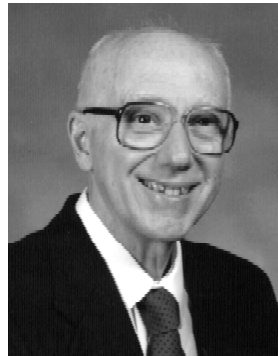
*Thomas Oakley Salmon, Jr.*

For his love, integrity, and wisdom, I am deeply thankful.

IN MEMORIUM

**RAYMOND F. SEARS**

(November 14, 1921 - June 2, 1999)



Ray Sears'  
steadfast prayer,  
love and Christian example  
will always be remembered and treasured.

---

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## Doctoral Committee

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Larry N. Thibos, Ph.D., Chairman

Arthur Bradley, Ph.D.

Douglas G. Horner, O.D., Ph.D.

Raymond A. Applegate, O.D., Ph.D.

P. Sarita Soni, O.D., M.S.

## Indiana University Faculty

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# Preface

My appreciation for visual optics began when, as an eighth-grade student, my father took me to visit the local optometrist to be fit with contact lenses. When I stepped out of his office, I was astounded at what I could now see—every leaf in the trees and every brick in the buildings! My experience with contact lenses eventually led to an interest in optometry as a career. As a first-year optometry student, my favorite subject was optics, and since optometry school, my favorite part of clinical practice has been contact lenses. My interest in contact lenses developed into an interest in corneal optics at the same time that refractive surgery and measurement of corneal topography were becoming popular. Graduate courses in Fourier optics and optics of the human eye, as well as a memorable scientific meeting at the *Instituto de Optica* (CSIC) in Madrid, Spain, in 1995, stimulated a keen interest in new technologies and new research questions about optics of the human eye. Given my continuing deep interest in visual optics, the development of new clinical problems associated with refractive surgery, and the availability of critical new research tools, I found myself in a wonderful position to pursue a fascinating topic for my doctoral research—the corneal contribution to the wavefront aberration of the eye. The Ph.D. course has been long and challenging, but it has also been fun. Hopefully, this dissertation will convey, not just what I learned and the techniques I developed, but also the pleasure I had in doing this research.

*“Ears that hear and eyes that see—the LORD has made them both.”*

(Proverbs 20:12)

Thomas O. Salmon, O.D.

## **CORNEAL CONTRIBUTION TO THE WAVEFRONT ABERRATION OF THE EYE**

Chairman: Larry N. Thibos, Ph.D.

Professor of Optometry, Indiana University School of Optometry

Introduction: The wavefront aberration function is one of the most informative descriptors of optical performance, and new techniques have recently been developed to measure this function in living human eyes. Corneal refractive surgery is creating a population of patients with abnormally large aberrations, and the key to improving optical results is a better understanding of the eye's aberrations. The purpose of this research was to determine the corneal contribution to the aberrations of three normal human eyes. Methods: An EyeSys computerized videokeratoscope was used to measure corneal topography, and the corneal wavefront aberration was computed. A Shack-Hartmann wavefront sensor was used to measure the ocular wavefront aberration. Corneal and ocular aberration data were fitted to Zernike polynomials, and corresponding coefficients were compared to determine the relationship between corneal, internal and total ocular aberrations. Results: Contrary to what other researchers had hypothesized, I did not find a general pattern of aberration balancing between the cornea and internal elements of the eye. Instead, within a range of normal values, the relationship between the optical elements varied with each eye. Conclusion: We cannot know the relationship between the corneal and ocular wave aberration functions without individually measuring these functions for each eye. Recent improvements in corneal topographers have made it clinically feasible to measure the corneal wavefront aberration function. Better correction of ocular aberrations will require new clinical instruments that can measure the wavefront aberration of the whole eye as well.

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