From physics to practice: How principles of optics create the necessary foundation for quality ophthalmic care

by Seamus Sweeney MD

Quality of Vision – essential optics for the cataract and refractive surgeon
Jack T Holladay MD MSEE FACS
SLACK Incorporated, 2007

Few parts of the body illustrate principles of physics as clearly as the eye. Every medical student does, or at least did, study physics. But perhaps only ophthalmologists – and oncologists – really use the discipline.

Fundamentally, optics are at the heart of ophthalmology. It is little wonder that the Reverend Thomas Paley used the eye as evidence of the existence of a designer God.

In a quote that prefaces the first chapter of this book, Charles Darwin wrote that, “To suppose the eye with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems to me, at least, a purely extravagant and absurd notion.”

Ever since, evolutionary theorists have taken up the challenge of how a “blind watchmaker” could have used the apparently random process of random selection to form such complex structures, with multiple self-correcting mechanisms. Witness the title of Richard Dawkins’ famous book against Paley and the idea of “intelligent design,” The Blind Watchmaker.

Optics may be the science that underlies ophthalmology – and the science that sets ophthalmology apart from other clinical disciplines – but there is a definite practical application to all ophthalmologic practice. As optics and optical principles underlie quality of vision, an understanding of these principles is required for all clinicians involved. This book begins with a clear explanation of the underlying principles of the optics of the human eye, and then extends them to clinical applications with particular reference to cataract and refractive surgery.

The first section of the book includes an extensive biography of Jack Holladay. It is interesting to know, but hardly strictly necessary for anyone reading this book, that in 1961 Dr Holladay’s family moved to Dallas, Texas, where he began his sophomore year at South Oak Cliff High School, or that in 1988 his son Taylor’s baseball team won the Major League Championship (in Little League Baseball).

Such information may have no bearing on the matter at hand, but I always like to read about the personal lives of the people whose work I am considering. It is as unhelpful as deriving from first principles in a vacuum. Evidence-based practice in a vacuum is as unhelpful as deriving from first principles in a vacuum.

As mentioned above, the first chapter is devoted to what is hopefully a refresher course for the target audience in optics. We then have chapters on more specific aspects of optical theory in practice. First we have a chapter on astigmatism analysis, and how vector analysis to chart residual astigmatic error can improve the accuracy of refractive surgery. Then we have a chapter on the use of an aspheric intraocular lens post corneal refractive surgery which can help reduce spherical aberration.

The following chapters are all similarly practical and rooted in showing how optic principles guide good practice. We have examples of calculation when calculation is required. Dr Holladay discusses the physical basis of the devices and machinery which so populate the world of ophthalmic surgery.

The final chapter, on neural adaptation, is particularly fascinating. Dr Holladay describes the work of Dr Pablo Artal and colleagues in Spain on the relationship between visual acuity and point spread function. They found that it was not those with the best point spread function who had the best visual acuity, but those with the best neural processing that filtered and enhanced the optical aberrations. This research points to a radical reassessment of our understanding of ophthalmic problems and may lead to new therapeutic modalities in the future.

So the book combines basic principles, clinical applications, and current and future research questions. It is a short, relatively small book, succinct and to the point, with copious tables and diagrams to illustrate various concepts. These are in both black and white and in colour. It is portable, and in an age of blockbuster hardbacks it is refreshing to find a light book that will not overburden shelf space. It will serve both as a useful aide-memoire for clinicians, a practical vade-mecum and an interesting read for those interested in future applications of optical and perceptual theory to clinical practice.