Recommended Reading for an Optics Refresh

It's difficult to remember all aspects of your training – let alone know how to correctly apply optics principles to the innovative products offered by industry. Have no fear: the Handbook of Visual Optics is here!

By Pablo Artal

Having worked in the field of ophthalmology for many years, it has always struck me as strange that many of my colleagues possess only a poor understanding of the basic principles of optics. And I am afraid that the lack of knowledge extends beyond researchers and technicians to ophthalmologists. All too often, both researchers and clinicians make important mistakes about which they are completely unaware. Now, we have access to a comprehensive reference source that collates all the basic – as well as up-to-date and useful – information in a single work (1). Hopefully, the new resource will greatly reduce the frequency of certain common errors.

At a Glance

- *Many who work in ophthalmology have an imperfect understanding of the basic principles of optics*
- *A lack of optics knowledge can be particularly problematic when introducing new technology, and may lead to sub-optimal clinical decisions*
- *A new resource – the Handbook of Visual Optics – brings together summaries of all key topics, including the most recent research*
- *The two-volume resource aims to be a valuable reference work for clinicians, technicians, scientists and companies working in the field of ophthalmology.*

Forgotten fundamentals

Over the years, I have seen several errors repeatedly being made in the field.

Problem one. Clinicians may report aspects of visual performance, such as contrast sensitivity, without also considering the effect of luminance and patient pupil size in their tests. These two very simple measurements are frequently overlooked – yet the effect of luminance on pupil size can significantly affect test results, especially when measuring near vision in presbyopic eyes. It is unfortunate, then, that many clinicians would not be able to specify the luminance of the charts they use when measuring visual acuity. Furthermore, they usually don't appreciate that the luminance value can change over time – today's value might be only a fraction of that calibrated two years ago. In my experience, poor appreciation of the effects of luminance and pupil size is evident not only in clinical reports but also in research papers – yet it is very simple to check! Similarly, not everybody is comfortable with photometry, but it's important to understand the technology, if you are to accurately measure light levels in your clinic.

Problem two. Another typical oversight occurs in the refractive surgery arena. My impression is that many ophthalmologists have only a superficial understanding of the concept of optical aberrations. Hence, I often see mistakes in this area – even in published papers. For example, an aberration measurement from a patient means nothing on its own, as a given aberration measurement can mean very different things in eyes with 6 mm or 3 mm pupils. Therefore, any aberration measurement should be related to the diameter of the pupil. Failure to do this is a very common source of error.

Problem three. The concepts of scatter and straylight are also poorly understood; people tend to confuse retinal scatter with aberrations and refractive error. I believe that there is significant confusion in this area, particularly regarding measurement methods, and the effect of visual scatter on contrast sensitivity and visual acuity. Though scatter affects contrast sensitivity, it probably affects visual acuity less – something that is not always appreciated.

Problem four. The phenomena of aberrations and refractive error themselves can cause problems for some practitioners. Measurement of refractive error obviously will be affected by aberrations, and this can be confusing when treating presbyopia: for example, when implanting IOLs that increase depth of focus, or when undertaking corneal haze treatments with a small aperture. I often see incorrect figures reported in these circumstances.

> *"I think there is a lack of real understanding of what aberration is and how it is usually reported."*

Problem five. Finally, defining the angles in the eye for refractive surgery is another problematic issue. Clearly, correct procedure in this arena is essential if ophthalmologists are to correctly center corneal interventions, or optimally center IOLs in cataract surgery. In particular, people are often unclear as to the reference points of the different axes:

should one refer to the center of the pupil or to the corneal apex? It can be very confusing, not least because the notation is complicated, and there is no standard nomenclature in the literature.

The good book

Anyone who thought, during training, that ophthalmology would give them an easy life will have been disappointed – but help is now at hand! Putting the Handbook of Visual Optics (Volumes I and II) together required a delicate balance between focusing on the basics and including the very latest research – and I hope we have succeeded. Certainly, I am very pleased with the contents – for example, the first two chapters are authored by a pair of outstanding contributors; in Chapter 1, Gerald Westheimer (University of California, Berkeley, USA) provides a very nice historical perspective on developments in ophthalmology during the twentieth century – he is well into his nineties now, but he is still amazing! And in Chapter 2, David Williams (University of Rochester, New York, USA) gives us his views on the future of physiological optics, which of course is highly relevant to practical ophthalmology. These two chapters are really good reads, and help ensure that the first volume really has something for everyone.

After the introductory chapters, there is a series of 'tutorials' on various topics that are fundamental to ophthalmology, which is why I see ophthalmologists being among the key readers of the handbook. Nevertheless, the information in these chapters – depending on the precise topic – will also benefit those in the research and technical arenas, such as engineers and designers of ophthalmological instruments and devices. Such individuals are technically very capable, but perhaps less familiar with the basics of the visual system in terms of its anatomy and operation. And that's why the Handbook covers not only technological aspects (such as optics, aberrations, photometry, visual stimuli, and basics of optical instruments), but also a good summary of ocular anatomy and embryology, how the visual system works, and visual psychophysical methods. We've included a range of tutorial-type chapters covering the eye as an optical instrument; I believe we address everything of importance with regards to the optical properties of the eye, including the cornea, lens, angles, refractive error, aberrations, customized model, scatter, accommodation, movements, ageing, polarization and more.

Both technology and biophysical aspects are built up logically from the very basics, giving numerous points of access to people with different backgrounds, so I hope the Handbook will be useful to a broad range of readers – not only clinicians, technicians and scientists, but also others in industry. In the latter context, I believe it can help companies better position their products; sometimes the operation of a new product is described as though it were miraculous – but you don't need miracles to explain ophthalmologic devices, you just need to understand the basic principles of optics!

No excuses

I honestly believe that ophthalmologists with a clear understanding of the basic principles will be better able to make important clinical decisions. And I think that it is even more important for clinicians to ensure they have a full and complete understanding of basic principles when they are implementing new technology; for example, premium multifocal IOLs, corneal inlays, or topo-guided LASIK. Unfortunately, I have seen many instances where clinicians attempt to use new technology without a sufficiently clear understanding of the scientific basis for the new device, which is good for neither the patient nor the doctor.

In short, there are no longer any excuses for ophthalmologists to have a poor understanding of the principles behind even the most sophisticated new technology!

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Reference

1. *P. Artal, "Handbook of Visual Optics, Vols I and II", CRC Press, April 2017. ISBN 9781482237924.*