Teaching clinical refraction and ophthalmic optics to ophthalmology residents

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Teaching clinical refraction and ophthalmic optics to ophthalmology residents can be both a pleasure and a challenge. The residents are generally quite bright and learn quickly, but the demands on their time are huge, and unless they can be taught effectively and efficiently, enthusiasm never develops for clinical refraction and ophthalmic optics. Ophthalmic practice, especially in academic medical centers, has evolved such that clinical refractions are often delegated to ophthalmic techs and optometrists, with few ophthalmologists on the faculty performing their own refractions, and with little or no feedback to the refractionist regarding the decision-making process, disposition, or clinical course.

When the ophthalmology residents’ mentors and role models do not refract, it is not surprising that the residents themselves see clinical refraction and ophthalmic optics as difficult areas to master and time-consuming to practice, so they often concentrate on cutting corners and using imperfect shortcuts such as the use of pinhole visions. The former requirement of performing at least 1000 refractions during the three-year residency program silently disappeared years ago.

My primary clinical activity is strabismus surgery, but I have had a long-standing passion for ophthalmic optics and clinical refraction, beginning with designing and building an automated refractor in my last year of medical school. I began teaching ophthalmic optics and clinical refraction as a second-year resident, and I am still doing so 41 years later, not only to our own residents but also in basic science courses and board review courses both here and abroad. I have been asked to share the curriculum and teaching techniques that I have found most useful in teaching clinical refraction and ophthalmic optics to ophthalmology residents.

When I was a first-year resident in 1973, on the first day of the residency one of the second-year residents was given 20 minutes to teach the five new first-year residents how to take visual acuities, retinoscope, refract subjectively, and prescribe. The next year, I asked for, and was given, two whole days to do this, and I have done so ever since, usually July 1 and 2. The curriculum for those first two days is as follows:

Day 1:
Lectures on visual acuity theory and clinical practice, including the use of contrast sensitivity, glare testing, and potential acuity testing, and also including myriad uses of the pinhole aperture, with classroom demonstrations – 2.5 hours
Lecture on retinoscopy, and viewing of the 40-minute videotape on retinoscopy that I produced for the American Academy of Ophthalmology in 1986, showing the actual retinoscopic reflexes to be observed during retinoscopy and with problem patients – 2 hours

Practical experience in the clinic, with upper-level residents serving as preceptors, first retinoscopying model eyes mounted on the exam chair’s headrest behind the phoropter, and then retinoscopying each other – 1.75 hours

Practical instruction in using the lensmeter to neutralize lenses and record the results – 0.25 hours

Day 2:

Subjective refraction lectures, and viewing of the videotape on subjective refraction that I produced for the American Academy of Ophthalmology in 1987, emphasizing use of the Jackson cross cylinder – 3 hours

Practical experience in the clinic, with upper-level residents serving as preceptors, refracting each other – 1.75 hours

Lectures on cycloplegia, reading adds, and prescribing – 2 hours

Later, staggered over 7 months each year, finishing before the Ophthalmic Knowledge Assessment Program exam (OKAP Exam) in April or May, I have four 3-hour lecture sessions on ophthalmic optics, following brief notes and extensive diagrams in a 172-page lecture syllabus entitled Ophthalmic Optics and Clinical Refraction that my former fellows and I published in 1999. This year for the first time I am planning a 3-hour laboratory session for the residents to practice calculation of image/object relationships, and confirmation of their results with actual trial lenses on homemade lens benches, as I originally inherited from Paul Boeder, PhD, and perpetuated in the major basic science courses in ophthalmology (Lancaster and Stanford Basic Science Courses) – 15 hours total for ophthalmic optics, heard by each resident an average of two times during their three years of training.

The ophthalmic optics lectures cover the following topics:

- Refraction of light at interfaces ................................................................. 1
- Critical angle.......................................................................................... 2
- Prisms ...................................................................................................... 3
- Calibration of prisms ........................................................................... 3
- Prism diopter ......................................................................................... 4
- Displacement of images by prisms .......................................................... 5
- Prismatic effects of lenses (Prentice’s rule) .................................................. 5
- Prismatic effect of glasses on strabismic deviations ..................................... 6
- Induced prism in anisometropia ................................................................. 7
- Bifocal segments — prismatic effects .......................................................... 8
- Fresnel prisms ....................................................................................... 9
- Oblique Prisms ...................................................................................... 9
- Prisms – chromatic effects .................................................................... 10
- Chromatic aberration of lenses ............................................................... 10
- Vergence .................................................................................................. 11
- Lens power defined in terms of vergence (U+D=V) .................................. 12
- Power of a spherical refracting surface in fluid ....................................... 14
- Power of a thin lens immersed in fluid ..................................................... 14
- Real vs. virtual objects and images ......................................................... 15
Focal points and focal lengths ................................................................. 17
Ray tracing — the central ray ................................................................ 18
Thick lenses ........................................................................................... 20
The schematic eye .................................................................................. 21
Refractive errors .................................................................................... 22
Far points and far lines ......................................................................... 22
Conjugate points and planes .................................................................. 23
Correction of ametropia using the far point concept ................................ 24
Vertex distance conversion .................................................................... 24
Lens effectivity ...................................................................................... 25
Accommodation ..................................................................................... 27
Astigmatism ........................................................................................... 29
Cross diagram of an astigmatic lens ....................................................... 30
Important lens aberrations ..................................................................... 32
Contact lenses — calculation of power .................................................. 34
Intraocular lenses — calculation of power .............................................. 35
Magnification ......................................................................................... 37
  Transverse magnification ................................................................. 37
  Axial magnification ............................................................................ 37
  Angular magnification ........................................................................ 38
    Direct ophthalmoscope .................................................................... 38
    Telescopes ...................................................................................... 39
    Corrected aphakic eye ................................................................. 40
    Ordinary spectacle lenses ............................................................ 41
  Knapp's rule ....................................................................................... 41
Low vision aids ..................................................................................... 42
Accommodation through corrective lenses ............................................. 47
Object - image movement ...................................................................... 49
Image movement caused by introduction of lenses .................................. 50
Mirrors ................................................................................................. 51
Important relationships to remember .................................................... 53

Problems ............................................................................................... 55

Ray Tracing ............................................................................................ 97
Ophthalmic Instruments: Optical Principles ........................................... 99
Physical Optics ...................................................................................... 115

Samples of the PowerPoint lecture materials will be presented to illustrate the
animation and depth of the material presented.
Questions / answers and interactive discussion.