Ophthalmology is losing sight of optics.

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Commentary

Imagine this

An eye surgeon is ready to perform cataract surgery and replace a damaged crystalline eye lens by an implant. He is looking at the implant and has a suspicion that something is wrong. According to the specifications this lens should have a refractive index of 1.63 and a focal length of about 16 millimeters in an aqueous environment (with an index of about 1.33). This surgeon has a keen interest in optics, and knows that the ratio, focal-length-in-water-divided-by-that-in-air should be (1.63-1) divided by (1.63-1.33), so that the focal length in air should be about 8 millimeters, that is, about 1 centimeter. He holds the lens above the table and aims it at a ceiling lamp, moving the lens up and down until a sharp image of the lamp is formed on the surface of the table. The lens should be about a centimeter above the table in order to yield a clear image. However, he finds that this distance is much larger than that. He concludes that the company must have sent the wrong implant. The company is contacted, the surgery is postponed, and everything works out in the end. Knowledge of optics saved the day.

An ophthalmologist has a diabetic patient who is careless with his diet and insulin injections. Stern warnings have been issued: “You are risking blindness resulting from diabetic retinopathy”, but these alarming words are falling on deaf ears. Then, a new eye model arrives at her ophthalmology office. She decides to show it to this patient. The model illustrates the formation of an image at a screen, serving as a replica of a retina. It is situated in a dark room with a brightly lit object situated so that a clear image of this object is formed on the screen. Directly in front of this screen is a network of tiny tubes through which a pump circulates a red fluid. These tubes are spread out so that the image is not blocked by it. When a button is pressed, this network of tubes can be bypassed by one bulging highly transparent tube on the other side of the screen, so that the red fluid fills the bulging tube. The patient admires the model and focuses on the clear image at the screen. Now, the doctor presses the button leading the fluid to the bulging tube, so that the image is completely blocked by the red fluid in the bulging tube. This is an eye-opening experience for the patient. Now he clearly understands his problem and is convinced of the need to take control of his diabetes before it is too late.

A patient visits her ophthalmologist and insists she needs new spectacles, because sometimes her vision is less than ideal. The doctor checks her eyes and detects mild cataracts in both eyes. “There is nothing wrong with the prescription of your glasses,” says the doctor, but the patient does not believe him. The doctor shows her a cataract-eye-model in a special dimly lit room where the model is set up. It is about ten times bigger than an actual human eye. It is open at the top and, at the back, has a screen, acting as the retina. A thick lens, situated in a slot in the middle, represents the crystalline eye lens. It can be easily replaced by another lens. The image on the retina is of an object in the front of the room. This object is transparent and made from reflecting material. The object can be illuminated by a lamp behind it, which also transmits light directly towards the screen, or, by a lamp situated next to the eye model so that light reflected from the object is directed to the screen. The doctor puts a clear lens in the slot and shows both images, the one formed by reflection and the other formed by transmission. Both images are clear. Now he places a milky lens in the slot and shows again the reflected image, which is clear, and the image with the light shining through it. The last image is not clear because of scattering. The patient understands the problem now clearly. “If the cataracts get worse”, explains her doctor, “you may need surgery. For now, avoid getting too much light into your eyes.”

Discussion

My background is in liquid crystal physics, biophysics and fluorescence. I am familiar with the book by Donders [1]. My impression was that professor Donders was a typical ophthalmologist, and, extrapolating from there, that ophthalmologists are interested in the optics of the eye. However, that does not seem to be quite true. Years ago, I was invited to give a talk at the Eye Institute of a nearby university. My host was interested in the biochemistry of the cornea and the crystalline eye lens. He wanted me to talk about work I did on lipids [2,3]. The visit was really nice; I got a tour, and, met with the researchers at this Eye Institute. On my way home, I wondered why there was nobody working on the optics of the eye. Recently, when I was involved with teaching Clinical Optics, I came up with The Restored Eye Model [4]. I contacted this host again and suggested that I visit him and talk about this model with a group at the eye institute, hoping to receive some feedback. He was not interested. He explained that ophthalmologists are not really interested in the optics of the eye; instead they study the physiology, biochemistry and genetics of the cornea, the crystalline eye lens or the retina. I examined the websites of a large number of eye institutes and confirmed that ophthalmologists are indeed not interested in optics. That is a mistake, ophthalmologists should not ignore optics. After all, the purpose of the eye is to make images at the retina. Optics has an impact on most eye diseases, their diagnosis and treatment.

My Recommendations are:

- Teach ophthalmology residents a highly focused course in geometrical optics. They probably had a general course in optics before medical school, but such courses devote much time to physical optics, which is irrelevant for ophthalmology. The important concepts are thin lenses, ray tracing, lens equations, two-lens system where the image formed by the first lens is the object for the second lens, real and virtual images, real and virtual objects, details of image formation by a refracting sphere, and related topics. The goal must be to understand the optics of the human eye. This goal can be achieved in a very short time.

- This course should be very practical and should require the students to do a project such as designing a model like the ones mentioned above.
- Each eye institute should have an optics specialist on staff who can teach the course and consult with the other scientists and doctors at the institute.

References

1. FranciscusCornelis Donders. Accommodation and Refraction of the Eye. RE Krieger Publishing Company, 1979.
2. Van der Meer W, Pottel H, Herreman W, et al. Effect of orientational order on the decay of the fluorescence anisotropy in membrane suspensions. A new approximate solution of the rotational diffusion equation. Biophys. J. 1984;46:515-23.
3. W J van Blitterswijk, B W van der Meer, H Hilkmann. Quantitative contributions of cholesterol and the individual classes of phospholipids and their degree of fatty acyl (un)saturation to membrane fluidity measured by fluorescence polarization. Biochemistry. 1987;26:1746-56.
4. B.Wieb Van Der Meer. The restored eye model. Japanese Journal of Ophthalmology and Research. 2019;1:1002.

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