

Multimodal Views of the Human Retina

ABSTRACT

Aims: To show the relationships between subject-reported measures of vision, the view through an ophthalmoscope, the view through a slit lamp, a photograph of a face, optical coherence tomography (OCT) images, fundus photos, visual field diagrams and Optomap images.

Methodology: Over 1000 clinical ocular measures (taken on one subject over a six-year period of time) were collected, analyzed and summarized. These measures were reduced to 50 images and tables: they were then categorized and filtered, and the essence was put into the figures of this paper.

Results: The results are neatly summarized in Figures 3 and 4.

Conclusions: The eight retina viewing techniques analyzed in this paper can be compared qualitatively, but differences in the techniques preclude precise superposition of the images. A perfect mapping is impossible: because (among other reasons) the algorithms for transforming three-dimensional (3D) shapes into two-dimensional (2D) images are nonlinear and are different for different techniques.

Keywords: retina imaging; OCT; fundus photograph,

1. INTRODUCTION

Our subject, A. Terry Bahill (ATB), has had a dozen eye surgeries over the last half-dozen years. He has been examined and treated by an optometrist, ten ophthalmologists, et al. Over 1000 clinical ocular measurements have been performed on his eyes using various retina viewing techniques [1] [Bahill and Barry, 2013]. These data were analyzed, summarized and reduced to 50 images and tables: these data were categorized, filtered and the essence was put into the figures of this paper. Our objective was to show (in layman's terms) the relationships between the following views of the human retina: through the subject's eye, through an ophthalmoscope, through a slit lamp, through the clinician's eye looking at a face, fundus photos, optical coherence tomography images, visual field diagrams and Optomap images.

1.1. Assumptions

One millimeter on the human adult retina corresponds to 3.5° of visual angle (0.286 mm/deg) (with a range of 3.4° to 3.6°). The optic disk (the image of the optic nerve and blood vessels entering and leaving the retina) can be modeled as a disk with a diameter of 6.3° ($1.8 \text{ mm} \pm 0.3$). A more complex model is that of an ellipse 6.1° (1.75 mm) wide and 6.5° (1.85 mm) high. On the retina, the center of the optic disk is $15.5^\circ \pm 1.1^\circ$ (4.4 mm) nasal and $1.5^\circ \pm 0.9^\circ$ (0.4 mm) superior to the center of the fovea [2, 3] [Rohrschneider 2004; Kolb 2013]. As long ago as 1867 Hulke[4] wrote, "I found the distance of the fovea from the centre of the optic nerve exactly equalled $1\frac{5}{6}''$." The triple prime symbol stands for ligne, which equals 2.26 mm . So his measured distance was $1.83'' \times 2.26 \frac{\text{mm}}{''} \times 3.5 \frac{\text{deg}}{\text{mm}} = 14.5 \text{ degrees}$. This is within one standard deviation of the diameter given above.

1.2 Names of Retina Areas

Different classes of people (e.g. clinicians [like optometrists and ophthalmologists], anatomists, engineers, etc.) have named the areas of the retina differently [5] [Park, 2006]. This has created confusion. Therefore, we created Table 1 and Figure 1 to unravel this muddle.

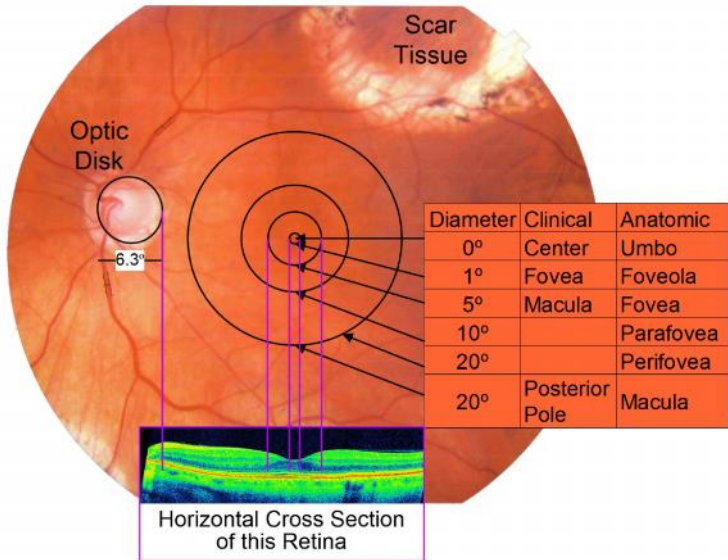
Table 1. Names for Areas of the Retina, from the center outward to the edge

Description	Approximate disk diameter	Clinical or Classic name(s)	Anatomical name(s)	Characteristics
Center of foveal pit	0 mm, 0°	Center of foveal	Umbo	
Floor of foveal pit	0.29 mm, 1°	Fovea , fovea centralis[4] [Hulke, 1867]	Foveola	It has red and green cones, but no blue cones, no rods and no vasculature
Capillary free zone	0.6 mm, 2°	Foveal avascular zone	Foveal avascular zone	It has no arterioles or venules
Sloping sides of the foveal pit	1.4 mm, 5°	Macula , macula lutea, yellow spot [4] [Hulke, 1867]	Fovea , fovea centralis	It is the darkly pigmented disk in the center of the retina. It is about the size of the optic disk. It has no rods, only cones.
Ring around the anatomic fovea	2.9 mm, 10°		Parafovea	Its ganglion cell layer is composed of four to seven rows of cells.
Ring around parafovea	5.7 mm, 20 °		Perifovea	Its ganglion cell layer contains two or three rows of cells.
All of the above	5.7 mm, 20°	Posterior pole	Macula , area centralis	
Equator	24 mm, conversion to degrees is meaningless			It is the boundary between the anterior and posterior halves of the eyeball.
The edge of the retina.	30 mm from the center of the fovea.	Ora serrata	Ora serrata	It is on the anterior half of the eyeball. There are no rods or cones anterior to the ora.

For comparison, the optic disk is about 1.8 mm (6.3 °) in diameter.

36
37
38
39
40
41
42
43
44
45
46
47

Column 3 of Table 1 is the classic clinical retina nomenclature, which goes back at least one hundred and fifty years [4] [Hulke, 1867]. Column 4 is the anatomic nomenclature. Dictionaries and encyclopedias usually give the clinical nomenclature. Research papers usually use the anatomic nomenclature. For the last two centuries, the clinical macula (the darkly pigmented 5° disk in the center of the retina) has been called the yellow spot or the macula lutea [4] [Hulke, 1867]. Perhaps with red-free light or certain preparations it may appear yellow. However, in fundus photos, it looks dark red. A large number of papers describe the macula lutea as a 5° oval-shaped yellow spot in the center of the retina and then they proceed to show a fundus photo with a 5° dark red disk marked as the macula. The Cirrus OCT macular cube ILM-RPE thickness box has three concentric circles with diameters of 1, 3 and 6 mm, which correspond respectively to the anatomic fovea, parafoveal ring and perifoveal ring: the anatomic macula disk encompasses all three of these.



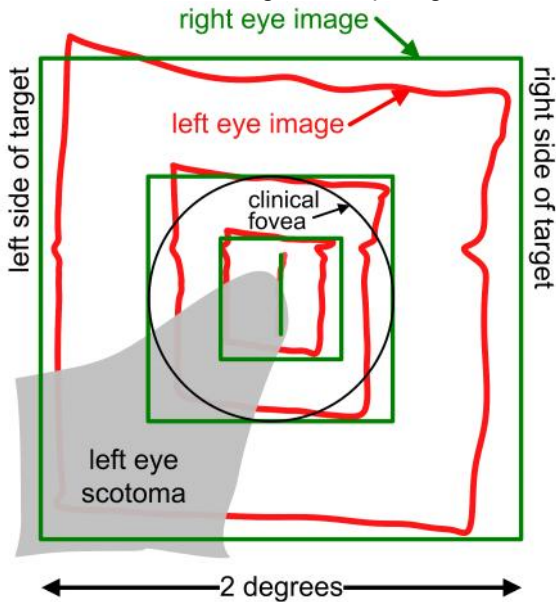
49
50

Fig. 1. Names for areas of the retina.

51 **2. Methods**

52 **2.1 Seeing the Retina**

53 In this paper, we will consider the following techniques for seeing a person's retina: subject-reported vision, an
54 ophthalmoscope, a slit lamp, fundus photos, OCT, visual field diagrams and the Optomap instrument. First, in Figure 2,
55 we show the subject's reported vision of a black-line target composed of concentric squares. The right eye's image (thin
56 green lines) is the same as the visual target. The left eye's image (thick red lines) shows the distortion due to a wrinkled
57 retina (macular pucker). The scotoma in the lower-left quadrant probably resulted from peeling the ILM. Deriving this
58 figure was complex and time consuming. This figure is the result of dozens of experiments over several years. None of
59 our other retina viewing Techniques give resolution this fine.



60
61
62

Fig. 2. The subject's viewpoint of a black-line target composed of concentric squares.

63 Next, in Figure 3, we compare several other techniques for evaluating the anatomy and physiology of the retina. The
64 clinician's view of the subject's face is shown in the top row of Figure 3. The image of the subject's right eye (OD) is on
65 the left side of the figure, the subject's nose is in the middle of the figure, and the image of the subject's left eye (OS) is on
66 the right side of the figure. With the exception of this top row in Figure 3, all of the data in this paper are for one subject,
67 ATB. Figure 3 shows, from top to bottom, the clinician's view of the subject's face, OCT images of the right and left
68 retinas, cross sections of the retinas, fundus photos of the retinas and visual fields for the left and right eyes. For each
69 row, the nose is in the middle and the temples are on the outsides. Each column of Figure 3 has the foveae roughly
70 aligned. The big blue arrows show corresponding locations in the different diagrams. For the right eye, the blue alignment

arrow connects the temporal edges of the optic disk in the OCT image and in the fundus photo: this is meant to draw attention to the edge of the fovea in the cross section of the retina. For the left eye, this arrow connects, more naturally, the centers of the optic disks. The blue arrows show corresponding locations. Significant points were lined up as well as possible. However, a perfect mapping is impossible: because (among other reasons) the algorithms for transforming three-dimensional (3D) information onto two-dimensional (2D) images are nonlinear and are different for different techniques¹. Furthermore, the magnification scales are different for each diagram in this paper. Rows two to five are for the same subject, ATB.

¹ There are hundreds of algorithms for transforming three-dimensional information (as on the earth or a globe) onto a two dimensional plane (such as a map or an image). One of the oldest is the Mercator projection. Google Earth uses a Simple Cylindrical projection. Each of these ophthalmic instruments uses some algorithmic projection, but we do not know which algorithm is used by which instrument.

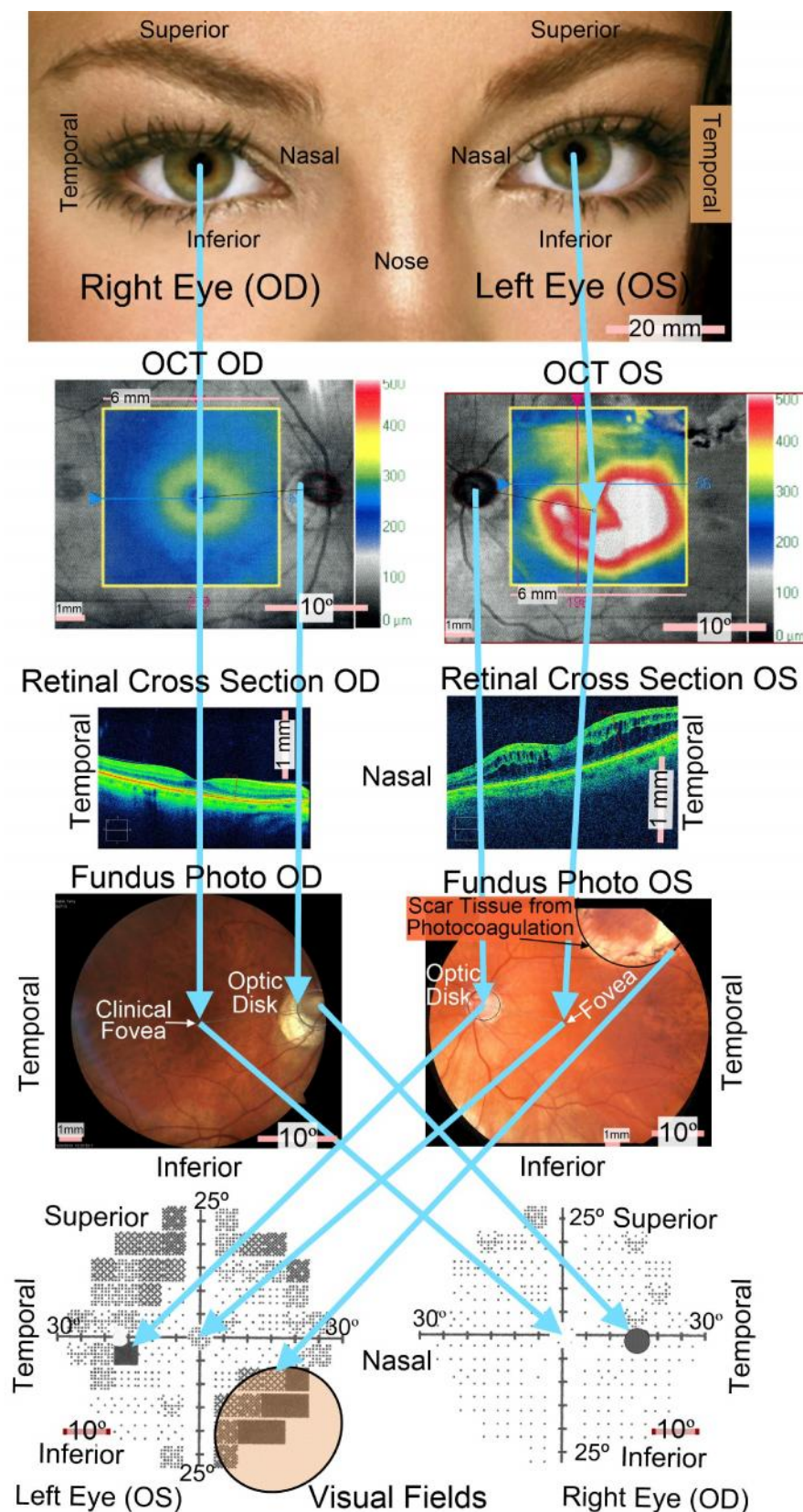


Fig. 3. Shown from top to bottom are the clinician's view of the subject's face, OCT images of the right and left retinas, cross sections of the retinas, fundus photos of the retinas and visual fields for the left and right eyes.

2.2 Fundus Photos

The fourth row of Figure 3 shows fundus photos of our subject's right and left retinas. A **fundus camera** is designed to photograph the interior surface of the eye, including the retina, optic disc, blood vessels, macula and fundus. It produces

an upright image of the retina. These images are displayed from the viewpoint of the clinician looking into the subject's face. Therefore, objects that are anatomically in the top part of the retina will appear in the top of the fundus photo. Objects in the nasal part of the retina will appear in the nasal part of the fundus photo. The ugly ring in the superior-temporal region of the left eye's fundus photo is scar tissue caused by laser photocoagulation. Because this subject was myopic, the optic disk has a white crescent around it, which is prominent in the right eye. On fundus photos, arteries are lighter, smaller and less tortuous than veins.

2.3 Visual Field Diagrams

Visual field diagrams show what the subject sees when looking forward out of one eye or the other (monocular viewing). Visual field diagrams are printed from the viewpoint of the subject looking out. This causes a 180° horizontal rotation from the fundus photos. The visual field diagrams of the two eyes are usually plotted side by side, with the left eye on the left of the diagram and the right eye on the right of the diagram, as in the fifth row of Figure 3. This puts the temporal parts of the visual fields on the sides of the diagram and the nasal parts in the middle. Things that are in the top part of the visual field will appear in the top of the visual field diagram. Anatomically, the center of the optic nerve (the blind spot) is on average 15.5° nasal and 1.5° superior to the center of the fovea. So visually, the blind spot will be about 15.5° temporal of the center of the fovea as indicated with the solid black circles. The dark squares are areas where the subject does not see. The large dark area in the inferior-nasal region of the left eye's visual field corresponds to the scar tissue in the superior-temporal region of the left eye's fundus photo. In contrast to the other retina viewing techniques, a visual field plot is linear, because the targets are projected onto a horopter screen (roughly speaking, a section of a sphere.)

2.4 OCT Images

Optical Coherence Tomography (OCT) images follow the display conventions previously described for fundus photos. An OCT instrument images the retina by measuring the echo time delay and magnitude of backscattered or back-reflected light. It uses an interferometer, where a beam of broadband, low-coherence light from a super luminescent diode is directed through a beam splitter or fiber coupler. One beam is focused on the subject's retina, and the other directed at a reference mirror. Light from the incident beam is reflected off retinal structures at different axial depths and merged with light reflected from the reference mirror. All of this information is put into a three dimensional model in the computer. This model can then be enlarged, rotated, sectioned, etc.

The OCT diagrams in the second row of Figure 3 show the optic disk and blood vessels radiating from it on the nasal edge for both eyes. The superimposed central square shows the thickness of the retina (specifically the distance between the ILM and the RPE). The intersection of the red and blue hairlines indicates the center of the fovea, as detected by the computer: for the left eye, this point is wrong, probably because the instrument defines the fovea as the area with where the retina is the thinnest and this eye's thickness is altered by edema. Next, row 3 of Figure 3 shows a cross section of the retina passing through the fovea. For the OS there is fluid (macular edema) under the retina: this appears as black columns above the yellow RPE line.

We have used three different OCT systems: Heidelberg Engineering, the Optos Optomap and Zeiss Cirrus. The following describes the calibration measures for the Zeiss Cirrus OCT. In a Macular Cube 512 x 128 diagram (second row of Figure 3), the ILM-RPE box overlaid on the fundus photo is 6 by 6 mm. On an ILM-RPE Thickness diagram (not shown in Figure 3), the diameter of the center circle is 1 mm, or 3.5°. The other circles have diameters of 3 and 6 mm. Finally, on an HD 5 Line Raster (not shown in Figure 3), the scan angle, line spacing and length are printed: the default values are 0°, 0.25 mm and 6 mm.

However, correlation between these various OCT instruments compare favorably for normal eyes but they differ significantly for abnormal eyes. The two Zeiss instruments, Cirrus and Stratus, had a standard deviation of the mean difference between measurements of central macular subfield thickness of 20 µm [6] [Lammer, et al., 2011]. Ophthalmologists feel that a 10% difference between images is noteworthy. A study of four different models of OCTs devices found an average difference in retinal thickness of 50 µm and a repeatability of 60 µm [7] [Giammaria, et al., 2011].

3. Results

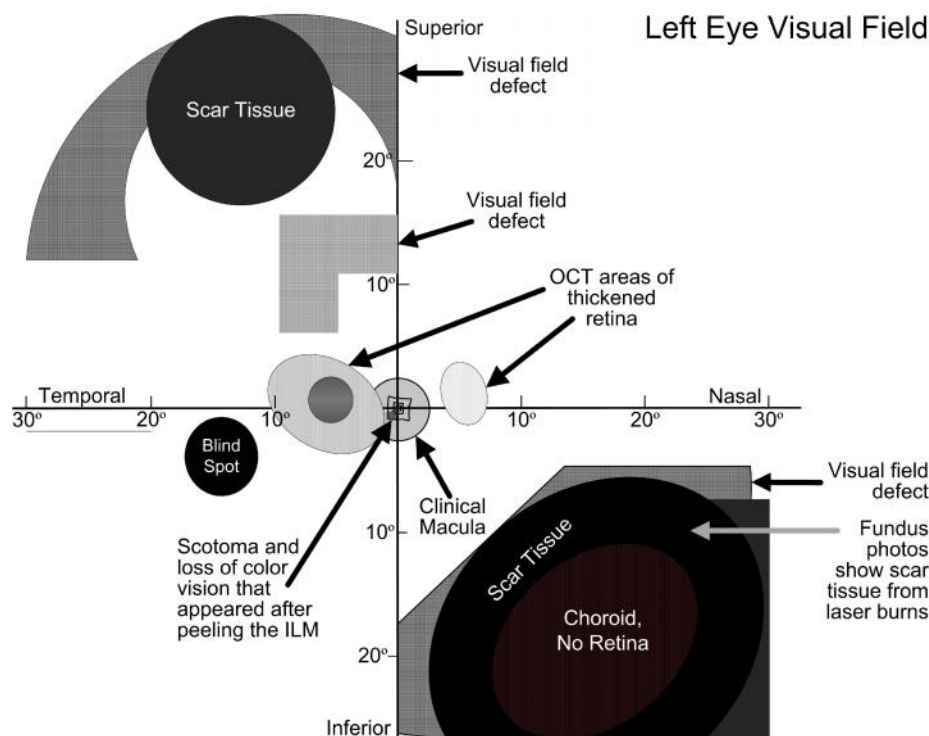
3.1 Putting Fundus Photo Information on a Visual Field Diagram

A lens flips an image horizontally and inverts it vertically. A fundus photo is taken by a camera looking into the eye and a visual field diagram is derived by the subject looking out of the eye. So to compare a visual field diagram with a fundus photo you must flip the image horizontally and invert it. To flip it horizontally you can move from a position in front of the subject to a position behind the subject. This is the 180° horizontal rotation. However, you did not stand on your head when you went behind the subject, so you must still invert the vertical aspect information. The following section describes the procedure that was used to overlay information from fundus photos and OCT images onto visual field diagrams.

So how did we superimpose fundus photo information onto a visual field diagram? First, we resized one of the images (fundus photo or visual field) so that they had the same scale (degrees of visual angle per millimeter of display). To do the

calibration, if we had a clear outline of the optic disk, then we assumed that it was 6.3 degrees in diameter. Otherwise, we assumed that the width of the central retinal artery was $166 \pm 15 \mu\text{m}$ and the width of the central retinal vein was $246 \pm 18 \mu\text{m}$ [8] [Taarnhøj, 2006], but these measures had a lot of variability. Next, we flipped the fundus photo vertically and put the optic disk from the fundus photo on top of the blind spot in the visual field diagram. Then, to get the rotation correct, we put the fovea from the fundus photo on top of the fixation point (usually the center of the diagram) in the visual field diagram. This process is illustrated in Figures 2 and 3.

151



152
153
154

Fig. 4. A visual field diagram for the left eye with fundus photo and OCT information overlaid.

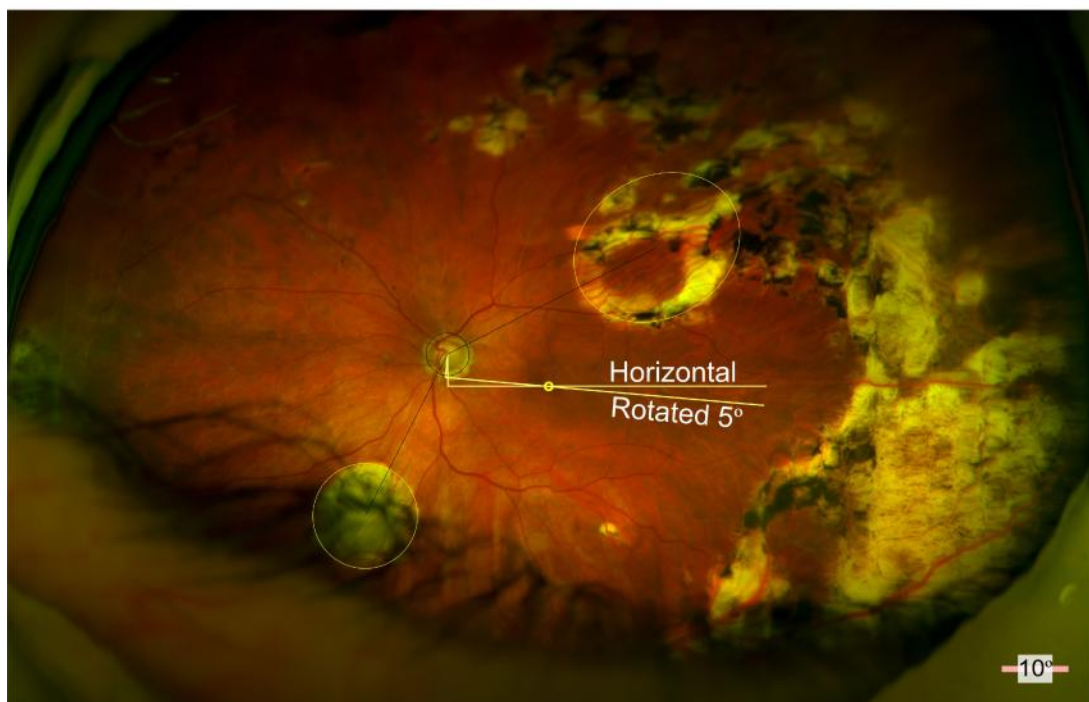
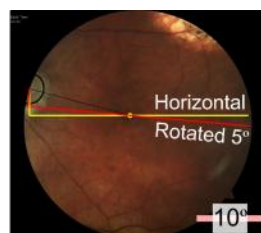


Fig. 5. Fundus photo (top) and Optomap image (bottom) of the left eye. Both pictures show the effects of cyclorotation of the eye. Circles surround scar tissue, the optic disk and the fovea.

Figure 5 was designed to show the effects of cyclorotation: it has a traditional fundus photo (top) and an image from a new instrument called the Optomap (bottom), which will be discussed in our Wide-field Imagery section. In both of these images, if we assume that the eye is not rotated, then the optic disk appears to be 15° nasal and 4° superior to the fovea. This vertical distance is larger than the normal $1.5^\circ \pm 0.9^\circ$. Therefore, we re-examined this fundus photo assuming that the eye was cyclorotated by 5° . Now, the optic disk appears to be 15.3° nasal and 2.7° superior to the fovea, which is closer to normal. Fundus photos, visual field diagrams and Optomap images all showed this same cyclorotation effect. This effect was not as prominent in OCT images, because the OCT fixation target was a ten-degree asterisk, which gave cyclorotation clues. All of these measurements were made without spectacles, with monocular viewing.

This section has shown fundus photo information and OCT information being overlaid onto a visual field diagram. If we put this all together, we can show what we believe our subject sees with his left eye as illustrated with Figure 4.

In retrospect, we can see hints of the macular scotoma in many visual field diagrams like those of Figures 2 and 3, or perhaps it is just that we see what we believe.

3.2 Wide-field Imagery

We used a new instrument to image the retina, the Optomap®, which produces images similar to those of a fundus camera. The bottom of Figure 5 shows an image computed by this instrument. Compared to fundus photographs, Optomap images (1) have a larger field of view, (2) show features in front of the eye, like eyelashes and eyelids, (3) have greater resolution of arteries and veins and (4) can show arteries and veins in the choroid. Information from these images can be superimposed on visual field diagrams the same as OCT and fundus photo information. However, the Optomap images are not linear, because they use a nonlinear transformation from a three-dimensional retina to a two-dimensional image. We do not know how this transformation compares to those of fundus photos and OCT images.

The fields of view of our Optomap images were about 25 optic disk diameters horizontally and 15 disk diameters vertically. Assuming the diameter of the optic disk is six degrees, this gives a field of view of 150° by 80° . Three images of

normal subjects from the Optos website had fields of view, on average, of 23 disk diameters horizontally and 17 disk diameters vertically: this gives a field of view of 140° by 100°.

Figure 5 shows an Optomap image of the left eye and its retina (bottom part of the figure). The unrealistic colors result from using only two scanning lasers: a green laser with a 532 nm wavelength and red laser at 633 nm. The Optomap image shows the optic disk and blood vessels radiating from it. The lower eyelid with its eyelashes is on the top of the image and (because there is an inverting lens between the front of the eye and the retina) the superior part of the retina is also on the top of the image. The left eye image shows scar tissue caused by the laser photocoagulation and cryopexy freezing procedures. In the superior temporal left eye image there is a ring of scar tissue about 20° in diameter. Inside of this ring, there is no retina: therefore, the eight wavy red lines are choroid blood vessels.

3.3 Comparison of techniques

Table 2 is a cursory comparison of the retina viewing techniques that were discussed in this paper. Of course, the numbers are just suggestive. For example, there are many manufactures of fundus cameras: most of them have different fields of view and resolutions. You can use them with or without pupil dilation. Older ones did not produce digital images. Patents on aspects of fundus cameras run back into the 1920s.

Table 2. Retina viewing techniques						
Instrument→ Metric ↓	Subject-reported vision	Ophthalmoscope	Slit lamp	Fundus camera	OCT	Optomap
Invented	2 million years ago	1850	1920s	1950s	1990s	2000s
Typical field of view	150° Horz by 135° Vert	20°	2° by 60°	30° to 50°	40°	150° Horz by 80° Vert
Produces digital image	no	no	yes	yes	yes	yes
Produces true color image	yes	yes	yes	yes	no	maybe
Linear	yes	yes	yes	weakly	claims to be	no
Binocular, can it evaluate both eyes at the same time	yes	no	yes	no	no	no
The next four rows use a 0 to 10 scale where 10 is the best.						
Resolution	10	4	6	7	8	9
Usefulness	2	3	6	6	8	9
Patient comfort (without pupil dilation)	10	4	6	7	8	8
Patient comfort (with dilation). Patients dislike dilation and its effects.	not applicable	3	2	4	5	5

Table 3 shows which techniques can evaluate which symptoms. Bahill and Barry [1] [2013] give a detailed explanation of each of these symptoms. The right column, doctor's exam, means his or her summary after talking with the patient and reviewing all of the patient's record. The doctor's diagnosis and prognosis could be flawed due to lack of time, incorrect test results, failure to notice information, lack of knowledge, poor decision making, mistakes, and different nomenclature. The doctor's report could be better or worse than any instrument.

213
214

Table 3. Which Viewing Techniques Detect and Evaluate Which Symptoms?										
The scale goes from 1 to 10, with a 10 indicating the best detectability for each symptom. Blank cells are zeroes.										
Techniques→ Symptoms ↓	Subjects report	Ophthalmoscope	Slit lamp	Fundus camera	OCT	Optomap	Snellen chart	Fluorescein angiography	Visual fields test*	Phoropter Doctors exam
Pain in the eye	10									4
in the brain	10									1
Poor visual acuity due to										
wrinkled retina	10 Fig. 2	3	4	6	5	8	4	6	7	9 9
peripheral scar tissue	7	8	5	10 Fig. 3	9 Fig. 3	10 Fig. 5		8	9 Figs. 3 & 4	9
macular scars and holes	9	6	4	8	8	8	7	6	4	7
foveal scotoma	10 Fig. 2						5	2		
retinal edema	1	3	4	4	10 Fig. 3	5	5	7	5	9 9
macular edema	1	3	3	2	10	6	2	3	3	5
color blindness	8									5
Left eye misalignment (phoria)	10									8 9
Double vision (diplopia)	10									8 9
Lack of depth perception (no stereopsis)	9									
Non-circular and non-responsive (tonic) pupil	5		5							9
Light sensitivity	8	5	5	3						6
*A Macular 10-2 Threshold visual fields test would do better.										

215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234

In the future, manufacturers will probably add software programs so that their instruments can measure more and more of the symptoms in Table 3. For example, the manufacturer could easily add a program to the Optomap so that it could detect non-circular or non-responsive pupils.

As can be seen in Table 3, each technique primarily illuminates a different symptom. We were surprised at the lack of overlap. These dozen symptoms seemed like a dozen different problems. This is like the story of seven blind men describing an elephant: each had a different view. But now we can understand the relationships between these problems. We can understand this medical history as a system, instead of a dozen isolated events. Table 4 shows how treating one symptom affects other symptoms. Tables 3 and 4 and Figure 3 brought it all together as one system, instead of a dozen unrelated symptoms. For years, we had a dozen doctors and a dozen symptoms: each doctor treated his most familiar symptoms, one at a time, with his most familiar retina viewing techniques. This shows the need for face-to-face communication between the ophthalmologists and optometrists. If we had understood this *system* years ago, the treatment would surely have been different. The patient's eye is a system: it is not a collection of a dozen contradictory symptoms and measures.

235
236

Table 4. Systems analysis of this case study				
The event in this column	prompted the action in this column,	which produced the outcome in this column.	This later ameliorating action	produced this final outcome.
Cataract growth	original cataract operation	pain in the front of the eye	replacing the intraocular lens (IOL)	eliminated pain in the iris
	original cataract operation	light sensitivity and a non-circular, non-responsive (tonic) pupil	none is known	permanent damage to iris
Retinal detachment (probably precipitated by the above operation.)	many retina operations	macular edema	peeling the ILM	foveal scotoma, color blindness and poor visual acuity. Subsequent Durezol drops reduced edema.
	implanting a scleral buckle	inflammation and pain on the back of the eye	removing exposed sutures on the back of the eye	eliminated pain from the exposed sutures
	implanting a scleral buckle	pain on the front of the eye	removing the suture knot may help	unresolved pain
	implanting a scleral buckle	phoria, diplopia and pain in the brain	prescribing spectacles with prisms	reduced the brain pain
Second detachment	retina operation	wrinkled retina	none is known	permanent damage to retina

237

238

4. Conclusion

239
240
241
242
243
244

Figure 1 and Table 1 have clarified some very confusing nomenclature that exists in the retina literature: this table has no internal contradictions. Figure 3 and Table 2 have explained the relationships between subject-reported vision, a view through an ophthalmoscope, a view through a slit lamp, a photograph of a face, optical coherence tomography (OCT) images, fundus photos, visual field diagrams and Optomap images all on one unique subject: the subject is unique and the analysis is original. Finally, Tables 3 and 4 showed how the subject's dozen different symptoms were really only parts of *one system*.

245
246
247
248
249
250

COMPETING INTERESTS

Neither author has any conflicts of interest with regards to this paper: furthermore, we believe that there is nothing that could be construed as a conflict of interest. This research was not funded by any organization.

251

Consent

252

The patient has given his informed consent for this report to be published.

REFERENCES

1. Bahill AT, Barry P. Subject-optometrist-ophthalmologist-engineer interactions on cataract and detached retina surgeries, submitted to *Ophthalmology Review*.
2. Rohrschneider K. Determination of the location of the fovea on the fundus, *Investigative Ophthalmology & Visual Science*, 2004; 45, 9; 3257-3258.
3. Kolb H, Nelson R, Fernandez E, Jones BW (editors). *Webvision: The Organization of the Retina and Visual System*, <http://webvision.med.utah.edu/book/>, accessed 3/31/2013.
4. Hulke JW. On the anatomy of the fovea centralis of the human retina, *Philosophical Transactions of the Royal Society of London*, 1867: 157; 109-115, Stable URL: <http://www.jstor.org/stable/108970>, accessed: 4/4/2013.
5. Park SS. The anatomy and cell biology of the retina, in *Duane's Foundations of Clinical Ophthalmology*, Volume 1, Chapter 19, Lippincott Williams & Wilkins, 2006.
<http://www.oculist.net/downaton502/prof/ebook/duanes/pages/v7/v7c019.html>, accessed 4/4/2013.
6. Lammer J, Scholda C, Prunte C, Benesch T, Schmidt-Erfurth U, Bolz M. Retinal Thickness and Volume Measurements in Diabetic Macular Edema: A Comparison of Four Optical Coherence Tomography Systems. *Retina*. 2011, 31(1):48-55.
7. Giammaria D, Ioni A, Bartoli B, Cofini V, Pellegrini G, Giannotti B. Comparison of Macular Thickness Measurements Between Time-Domain and Spectral-Domain Optical Coherence Tomographies in Eyes with and Without Macular Abnormalities. *Retina*. 2011, 31(4):707-716.
8. Taarnhøj N, Larsen M, Sander B, Kyvik KO, Kessel L, Hougaard JL, Sørensen T. Heritability of retinal vessel diameters and blood pressure: a twin study, *Invest. Ophthalmol. Vis. Sci.* 2006; 47, 8; 3539-3544

ACRONYMS

HD	High Definition
ILM	Inner Limiting Membrane
OCT	Optical Coherence Tomography
OS	Left eye
OD	Right eye
RPE	Retina Pigment Epithelium