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A Patient's Viewpoint of Cataract and Detached Retina Surgeries

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ABSTRACT

Aims: The purpose of this paper is to (1) describe the changing details of a complex medical case study allowing the reader to continually diagnose complications resulting from cataract and retinal detachment surgeries, (2) explain good and bad aspects of communications between patients, optometrists, ophthalmologists and systems engineers and (3) show a patient's view of a detaching retina.

Methodology: This paper was written from the patient's point of view of the interactions between the patient, the optometrist and the ophthalmologists during a dozen eye surgeries for cataracts and retinal detachments. It was excerpted from the patient's notes (including test results, charts and images), surgical reports, letters to the doctors and their referral reports. This paper was written in the first person singular and in chronological order. This should help the reader to see changes in the interactions of the symptoms and treatments from ocular surgeries in a complex medical example.

Results: This paper has documented malposition of an intraocular lens, ignoring patient's complaints of pain, lack of explanation of what the subject should expect after retinal detachment surgery (such as strabismus, diplopia, pain, wrinkled retina, and dynamic visual changes due to bubble changes), lack of explanation for the subject's potential visual acuity defects and color deficiencies, poor communication between patient care specialists about these defects, lack of knowledge of technicians using ophthalmological instruments, lack of documented processes for using these instruments (which means different technicians used the instruments differently), lack of proper medical care due to physician overload (i.e. scheduling more than 60 patients per day per physician), and ignoring the patient's complaints of pain. While reading this paper, the reader should accept or challenge each of these assertions.

Conclusions: Pain is hard to diagnose, measure, quantify and treat, making it frustrating for both the patient and the physician: in this case, there were many causes of the pain, which caused confusion. For the last six years, this patient complained about ten specific symptoms, which were treated individually: treating this case as a system of interacting problems led to a better understanding and resolution.

Keywords: cataract surgery; scleral buckle; communication; complications; retinal detachment; detaching retina; ocular pain; quality of life; retina surgery; lessons learned;

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19 **ACRONYMS**

20	<i>ILM</i>	<i>Inner Limiting Membrane</i>
21	<i>IOL</i>	<i>Intraocular Lens</i>
22	<i>MRI</i>	<i>Magnetic Resonance Imaging</i>
23	<i>OCT</i>	<i>Optical Coherence Tomography</i>
24	<i>OS</i>	<i>Left eye</i>
25	<i>OD</i>	<i>Right eye</i>
26	<i>RD</i>	<i>Retinal Detachment</i>
27	<i>RPE</i>	<i>Retinal Pigment Epithelium</i>
28		

29 **1. INTRODUCTION**

30 **1.1 Who Should Read This Paper And Why Should They Read It?**

31 **1.1.1 Ophthalmologists**

32 Ophthalmologists can read this paper and diagnose the patient's medical problems.
33 The patient's symptoms and the interactions of people have been laid out in chronological
34 order. These are the facts that were thought to be true at the time, but some of them might
35 prove to be wrong in the end. The appendix provides useful but possibly irrelevant statistics
36 that he or she might want to consider. Hopefully, the ophthalmologist can learn a little about
37 the patient's viewpoint of ocular surgeries. The ophthalmologist could learn about the types
38 of pain that can result from ocular surgeries. Then he or she could write brochures that
39 describe potential postoperative pain and explain treatments that could be used to resolve
40 those pains. Finally, the ophthalmologist can decide what he/she would have done differently
41 than these ophthalmologists did.

42 **1.1.2 Optometrists**

43 Optometrists can expand their horizons and find their place in ocular surgeries. In 1977, Larry
44 Stark et al. [1] described many nontraditional optometry tasks that professionals were
45 performing in his Neuro-optometry Clinic at Berkeley (UC) and San Francisco (UCSF). This
46 paper suggests another nontraditional task: assisting patients with detaching retinas.
47 Detached retinas seem to be in the purview of ophthalmologists. However, this paper
48 explains ways that an optometrist was involved in (1) diagnosing a detaching retina, (2)
49 tracking the specialties and equipment of local ophthalmologists, (3) acting as a primary
50 visual care provider, (4) understanding and explaining to the patient what lies in store for him
51 during and after the surgery, (5) diagnosing and perhaps solving postoperative complications
52 {such as (a) postoperative diplopia, which (in this case) was ameliorated with prism
53 spectacles, (b) the iris being trapped by the intraocular lens, which was solved by a lens
54 replacement, (c) inflammation, in this case due to the suture securing the scleral buckle and
55 (d) helping with pain diagnosis and remediation,} and (6) explaining the relationships
56 between fundus photos, visual field diagrams and ocular coherence tomography images. The
57 American Optometric Association also has an extensive set of recommendations for
58 optometrists dealing with retinal detachments [2].

59 **1.1.3 Students of Ophthalmology and Optometry**

60 Students of Ophthalmology and Optometry can augment their diagnostic skills by practicing on
61 this real-life case study. In addition, they can learn about a topic that does not get much
62 attention in the curriculum, namely pain.

63 1.1.4 Patient Advocates

64 Intelligent laymen, patient advocates and patient advisors can learn about complications and
65 interactions between cataract and retinal detachment surgeries, such as the following. Pain is
66 hard to diagnose, measure, quantify and treat, making it frustrating for both the patient and
67 the physician: in this case, there were many causes of the pain, which caused confusion.
68 There was no face-to-face communication between the dozen doctors that were involved in
69 this case: furthermore, many times the written communications were not received, read or
70 understood. In complicated procedures involving many physicians and many physical
71 systems, perhaps there should be a patient's advocate, who knows the system and is
72 interested only in the patients' best interests. A useful metric for choosing a doctor is the
73 amount of time that he or she schedules for each appointment or operation. A better
74 understanding and resolution for a medical problem may be treating the symptoms, the
75 doctors, the patients and the procedures as a whole system instead of a group of specific
76 entities to be treated individually.

77 1.1.5 Families and friends

78 Families and friends of patients who have or will undergo ocular surgeries can understand
79 what the patient is experiencing and what signs and symptoms should be reported to the
80 ophthalmologist. When a new clue surfaces, this group has to answer difficult questions such
81 as, Should we call the doctor? Should we go to the emergency room? Should we take more
82 narcotic pain pills? Reading this paper should help with these decisions.

83 2. HISTORY/METHODS/RESULTS

84 Andrew Terry Bahill (ATB) has had a dozen eye surgeries over the last half-dozen years. He
85 has been examined and treated by an optometrist and ten ophthalmologists. The following
86 report is his description of the interactions between these vision care specialists. This paper
87 describes (1) cataract and retinal detachment surgeries and their after effects (including
88 many images from the patient's viewpoint, which have never before been presented in the
89 literature), and (2) quality of life measures.

90 This section was written by ATB about his eye surgeries. Other patients will have different
91 numbers and details, but the overall processes should be about the same. This section is
92 written from the patient's point of view of the interactions between the patient, the
93 optometrist and the ophthalmologists during eye surgeries for cataracts and retinal
94 detachment. Therefore, this section is written in the first person singular. It was excerpted
95 from my notes, surgical reports, my letters to the doctors and their referral reports. Nothing
96 was retrospectively edited. So it is possible that at one time I wrote something in my journal
97 that was different from something that I had written at another time: I did not edit out these
98 contradictions. Oscillations in my health and mood may be apparent. This case is
99 multifaceted with many complications. The ten ophthalmologists are identified as
100 "Ophthalmologist-1" to "Ophthalmologist-10."

101 May 24, 2007, First Cataract Operation

102 It all started on a beautiful May morning in Tucson. Ophthalmologist-1, (assisted by his wife
103 (the anesthesiologist) and a surgical nurse) performed a cataract extraction and lens implant
104 on my left eye. It was a quiet relaxed atmosphere where they were describing to the nurse
105 their upcoming vacation to Italy. Ophthalmologist-1 was doing hydrodissection in the
106 membrane capsule, when he suddenly said, "Whoops. What was that?" He wrote in his
107 surgical report, "the posterior capsule had torn as a result of the hydrodissection... It was
108 elected to insert an [available] MA60AC lens rather than the [selected] one-piece acrylic
109 lens." Kenalog was not used to assist the partial anterior vitrectomy. That evening, the next
110 morning and the next afternoon, I told his staff that I was in pain.

111 May 25, 2007, Follow-up Exam

112 I told Ophthalmologist-1 that the eye hurt and that I was seeing many floaters. As he was
113 examining the operated eye, he said that in order to compensate for the ruptured posterior
114 capsule, he removed some of the vitreous(which pulled on the retina), placed the lens (a
115 square edged, 3-piece posterior chamber intraocular lens (IOL), Alcon model MA60AC)
116 more anterior than planned (in the ciliary sulcus), and put a suture in the cornea. Later he
117 said that rupture of the posterior membrane capsule was a rare event, happening to only one
118 of his other patients 17 years ago. See the appendix for statistics from the literature.

119 May 26, 2007, Pain in the Eye

120 My left eye hurt. It was tearing and bloodshot. Ophthalmologist-1 was on vacation in Italy. I
121 called a friend, Ophthalmologist-2, and told him that my eye hurt and I could not contact
122 Ophthalmologist-1 or his backup. He said that pain after a cataract operation most certainly
123 means infection. He advised me to go to the emergency room. Ophthalmologist-3 (who by
124 coincidence was the backup in Ophthalmologist-1's practice and also the ER
125 ophthalmologist on duty) gave me a prescription for Vicodin (hydrocodone). It did not relieve
126 the pain. I saw him another four times in the next two weeks. With his slit lamp, he never
127 saw inflammation within the eye (endophthalmitis): so he said that he did not know why there
128 was severe pain. In a four-month follow-up exam, ophthalmologist-1 used a Snellen chart to
129 assess my visual acuity. But he dismissed my complaints of pain and he never looked at the
130 placement of the IOL haplets: we do not know if he had instruments to do so. For the next
131 four years at every medical exam with my ten ophthalmologists, I complained about pain in
132 the front of the eye. Table 1 shows that nothing relived this pain.

133 **Table 1. Since 2008, at various times, ATB has taken the following anti-pain drugs.**
134 **None relieved the pain in the brain.**

Generic Name	Strength	Brand Name	Dosage
Ibuprofen	200 mg	Motrin®	16 pills per day
Hydrocodone/APAP	5/500 mg	Vicodin®	6 pills per day
Oxycodone/APAP	5/325 mg	Percocet®	6 pills per day
APAP is an abbreviation for acetaminophen.		Tylenol®	

135 May 8, 2008, One Year Later

136 I saw a static, 100-degree diameter¹, ¾ ring (two degrees thick) of bluish light for maybe a
137 half minute in left eye with the eye open. It looked like Figure 1 (top-left). The dark green (or
138 gray) disk represents the subject's field of view. That event was probably caused by the
139 vitreous (the jelly in the eyeball) detaching from the retina. Please note that this is the visual
140 experience of one subject. The literature more often describes the detaching vitreous with
141 spider webs and lightning bolts.

142 Note added in 2013:Both moving the lens forward and removing some of the vitreous gel
143 would move the vitreous forward, and pull on the retina. This sequence can lead to a retinal
144 tear and a detachment, especially during the first year after surgery. "if the cataract surgery
145 is complicated with a capsular rupture, the risk increase for RD [retinal detachment] is ten-
146 folded."It is a shame that I did not know that in 2008.

147 May 12, 2008, First Detached Retina Operation

¹In this paper, the size of the visual angle will be given in degrees of arc or angular size, because it is easy to estimate. For example, the clinical fovea(one degree in diameter) is the width of the fingernail on the little finger at arm's length and a fist is a little less than ten degrees wide. For comparison, the sun and the moon are ½ degree in diameter [3].

148 The optometrist saw a half-dozen retinal tears (like tears in a fabric, not like tears when a
149 person is crying) and referred me to a retina specialist, Ophthalmologist-4. He told me that
150 the operation had a 92% chance of success and if it did fail, there was a second operation
151 that he could do that had a 50% chance for success. For more statistics like these, the
152 reader should go to the appendix. He scheduled an operation for that evening. During that
153 operation, he put a scleral buckle around the eyeball, removed the vitreous humor
154 (vitrectomy), repaired the retinal tears with freezing (cryopexy) and with an endolaser, and
155 inserted a bubble of perfluoropropane (C_3F_8) gas (also called octafluoropropane), a
156 procedure known as pneumatic retinoplexy. My double vision (diplopia) started after this
157 surgery. The next day, and on other visits, I complained about inflammation, a blood shot
158 eye, foreign body sensation (like an eyelash trapped under the eyelid), pain in the front of
159 the eye and now pain behind the eye.

160 Explanations of Some Technical Terms

161 I had arhegmatogenous (rhegma = rent or rupture)retinal detachment, which means tears
162 (like tears in a fabric, not like tears when a person is crying) in my retina allowed fluid to leak
163 underneath the retina, thus detaching it from the choroid (the vascular layer of the eye lying
164 between the retina and the sclera). The tears were probably caused by the detaching
165 vitreous (the jelly in the eyeball). Ophthalmologist-4 decided to simultaneously use all
166 common retinal repair techniques: scleral buckling, vitrectomy, laser photocoagulation and
167 pneumatic retinoplexy. Simplistically, a scleral buckle is a band of silicone that is sutured
168 around the eyeball under the extra ocular muscles. It buckles the eyeball pushing certain
169 regions closer to the retina. In vitrectomy, the jelly-like vitreous humor is removed. Pars plana
170 vitrectomy describes a particular pathway (through the pars plana) that the surgeon uses to
171 remove the vitreous. In pneumatic retinoplexy the surgeon, inserts a bubble of about 15%
172 perfluoropropane (C_3F_8) gas (the other 85% is just air) into the vitreous chamber of the eye
173 (the big part of the eye between the lens in front and the retina in back). This bubble
174 prevents fluid in the eye from passing through the tear and under the retina. This allows the
175 choroid to pump the fluid out of the subretinal space allowing the retina to reattach to the
176 choroid. You cannot fly in an airplane (or do anything else that will rapidly change the
177 pressure around you) with a gas bubble in your eye.

178 Typically, an ophthalmic laser for retina photocoagulation uses a diode-pumped solid-state
179 green argon laser with a wavelength of 532 nm (a yellow 586 nm laser is another possibility),
180 a power of 50 to 2000 mW, a pulse duration of 0.01 to 4.0 seconds with a 635 nm red laser
181 aiming beam. The visual field comprises the images that the subject can see with the eye
182 looking straight-ahead (primary position): typically, this is 90° temporal, 60° nasal, 60° up
183 and 75° down.

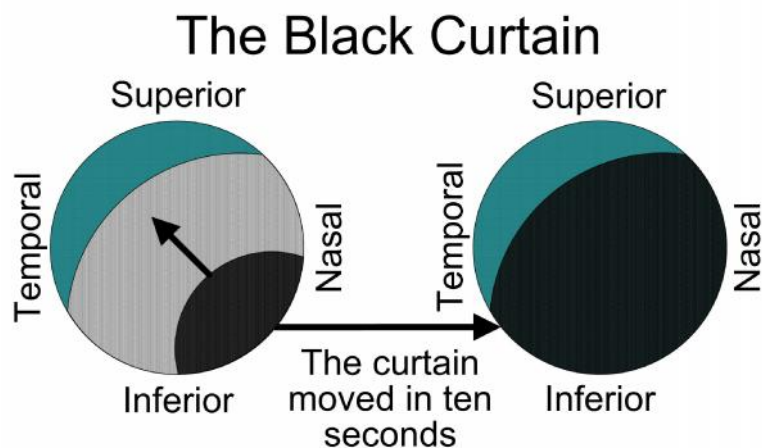
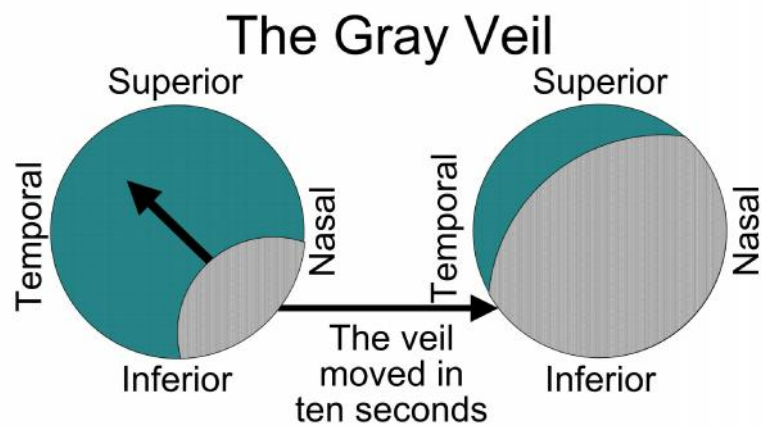
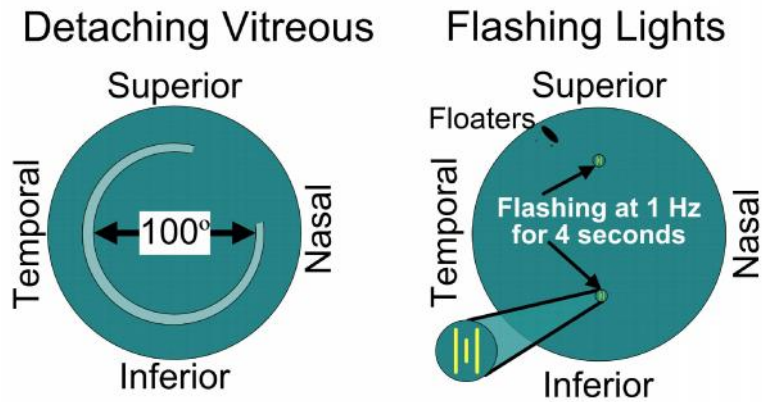
184 Concerning cataract operations, the human crystalline lens is enclosed in a capsule. This is
185 sometimes referred to as the membrane capsule, a capsular bag, or a lens *capsule*. The front
186 and backsides are referred to respectively as the anterior capsule and the posterior capsule.

187 Throughout May and June, my vision was improving. However, I was surprised by the tropia:
188 when at rest, my left-eye images were about ten degrees up and ten degrees to the right of
189 the right-eye images and I could not fuse the right and left eye images. This tropia was caused
190 by the scleral buckle. Ophthalmologist-4 did not prepare me for this.

191 June 29, 2008, Gas Bubble Disappears

192 Ophthalmologist-4 had told my wife and me to be patient for six weeks, or until the gas
193 bubble disappeared, then we would be out of the woods for further complications. Therefore,
194 on this Sunday, we were in high spirits, because this was six weeks after the operation and
195 the gas bubble was finally completely absorbed.

196 June 30, 2008, Retina Detaching



197

198 **FIG 1.**Temporal sequence from the patient's viewpoint of the left eye's retina
 199 **detaching.** Top-left: the vitreous detaching. The dark green (or gray) disk represents
 200 **the subject's field of view.** Top-right: floaters and flashing lights caused by the retina
 201 **detaching.** Middle: the gray veil started in the lower-right visual field and progressed
 202 **to the upper-left.** Bottom: the black curtain followed the same path as the gray veil.

203 **At 10:00 AM, Ophthalmologist-4 saw a small hole in the retina, as well as a scab on the**
 204 **retina. He scheduled an operation for 3 PM the next day. Four hours later, I saw vertical**

205 yellow lines about two degrees long and one degree apart: three on top of my field of view
206 and three on the bottom. See Figure 1 (top-right). They flashed at one hertz for about ten
207 seconds. Later I saw big black floaters². Then a convex gray veil (with a radius of curvature
208 of around 40°) moved from the lower-right to the upper-left across my field of vision as
209 shown in Figure 1 (middle row): this took around ten seconds. Then, a few minutes later, a
210 convex black curtain moved across my retina and eclipsed 80% of my field of vision, Figure
211 1 (bottom row). I called Ophthalmologist-4, told him my symptoms and he confirmed that the
212 macula of my retina had detached and we would do the operation the next day, as
213 scheduled. I was not a happy puppy: since the retinal detachment operation, they would not
214 let me drink beer, work on the computer for more than 15 minutes at a time, or go out of the
215 house for more than an hour a day. I had to lie on my side for most of the day. My primary
216 care physician had prescribed Sertraline for my depression.

217 Note: this is the visual experience of one subject. The literature most often describes the
218 detaching retina with spider webs or twig-like objects in the line of vision, flashing lights,
219 lightning bolts, sparkling dots, fireflies, fireworks or sparks. I did not take measurements of
220 the recovery from this first retinal detachment operation, because I had no idea of what to
221 expect. So I could not plan an experiment.

222 July 1, 2008, Second Detached Retina Operation

223 Ophthalmologist-4 pushed the macula back into place, zapped the retina with his laser and
224 inserted another gas bubble. A gas bubble occludes the retinal tear, permitting the choroid to
225 remove subretinal fluid, and then the bubble presses the retina against the choroid,
226 sheltering the edge of the tear until a choroid-retinal scar is formed, sealing the break. A
227 bubble of perfluoropropane (C₃F₈) gas will gradually be absorbed into the blood stream and
228 will be replaced by aqueous fluid, which is continually produced by the ciliary body. This
229 process will take six to eight weeks, depending on how big the bubble is and other things.
230 The first objects that I saw as the gas was absorbed were stars in the sky as shown in
231 Figure 2. Obviously, I was outdoors looking straight ahead.

232

² Floaters are small clumps of cells, pigment or gel that "float" inside the vitreous. They have a wide variety of sizes and shapes. For me they are often black circles tenths of a degree in diameter. Sometimes they move, seemingly like a house fly. Floaters may appear as small specks, hair-like objects, clouds, strings, streaks, dots, dust or spider webs moving in front of a person's field of vision. They are especially apparent when looking at a plain white background or a blue sky.

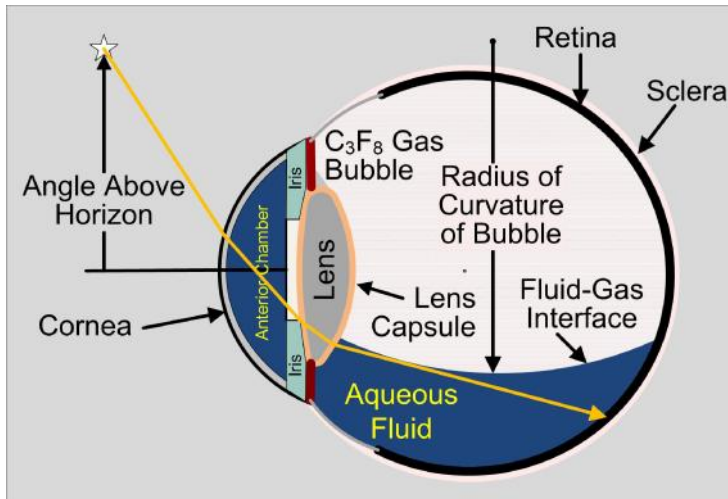
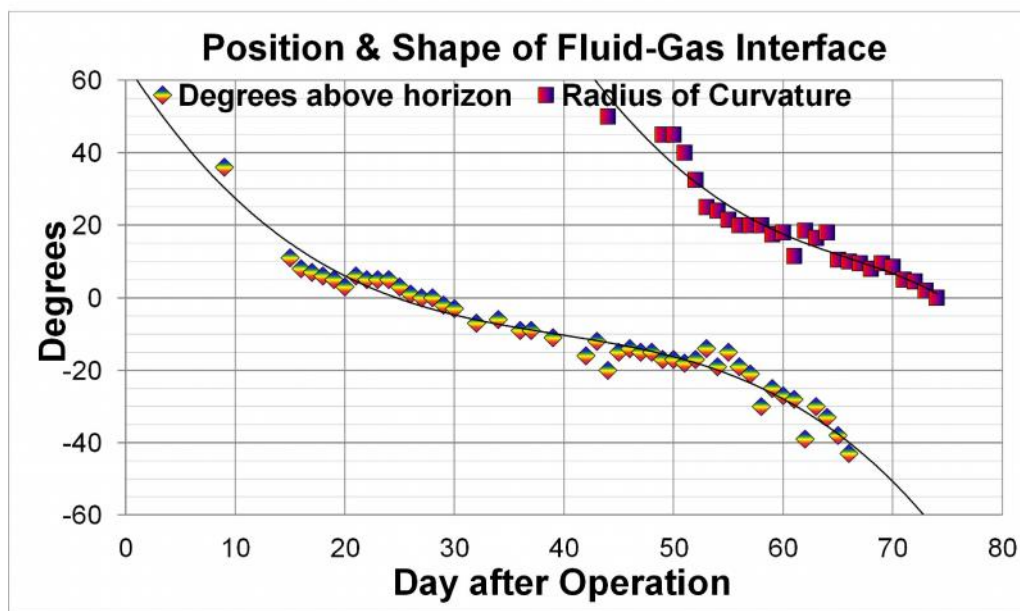
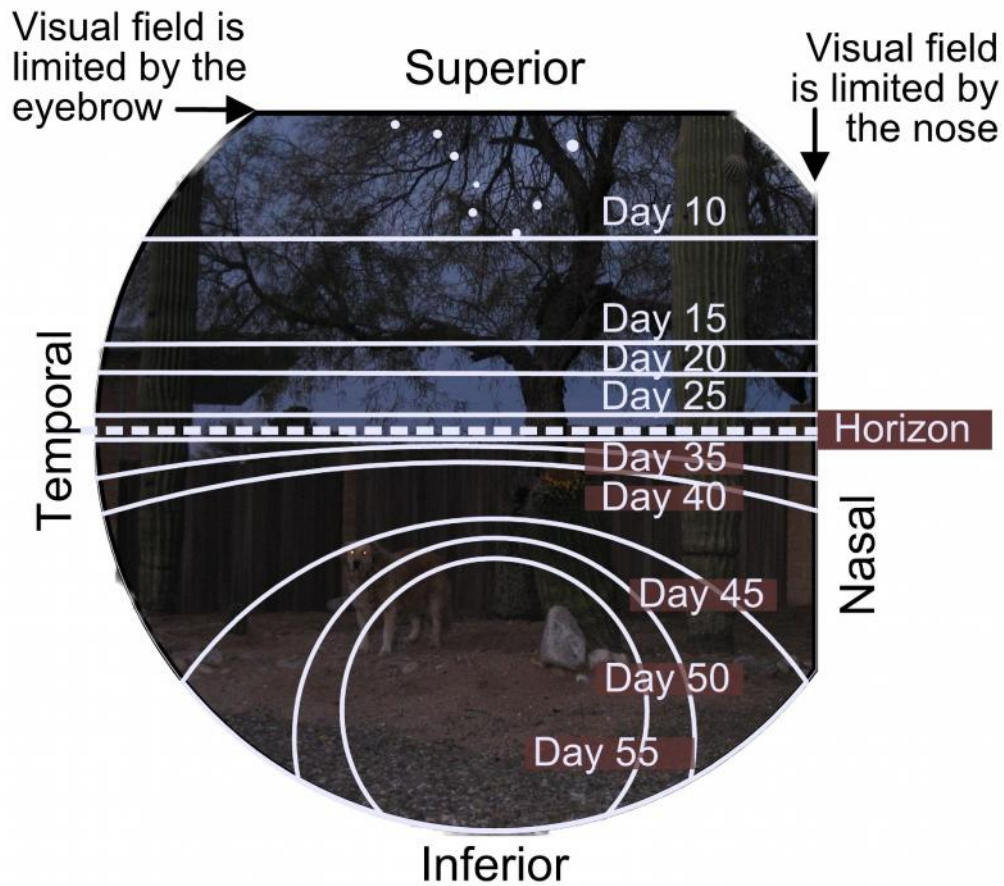


Fig. 2. Schematic drawing of the eye showing the path of the first light that the patient saw after the retinal detachment operations that used perfluoropropane gas.

Because of the difference in the index of refraction of liquid and gas, light rays that go through the gas bubble diffuse before they reach the retina. Only rays going through the aqueous fluid can reach the retina in focus, as shown in Figure 2. As a patient, this came as a surprise to me. Next, as the gas was being absorbed into the blood via the retina, choroid and aqueous fluid, the bubble changed its size and shape.



242

243

244

Fig. 3.The patient's viewpoint of the time sequence of the gas bubble being absorbed and replaced with aqueous fluid. The two curves are two views of the same event.

245 Figure 3, which is unique, shows my viewpoint of the time sequence of the gas bubble being
246 absorbed and replaced with aqueous fluid. I could only see what was above the white line for
247 that day. For, example, on day ten I could only see the stars. The surface of the bubble
248 looked like a straight line about 25 degrees above the horizon. When the fluid-gas interface
249 dropped below the horizon, it stopped being a straight line and seemed to have curvature,
250 eventually turning into a circle. For example on day 55 it looked like a circle with a radius of
251 curvature of 25 degrees, whose top was 20 degrees below the horizon. The bottom of Figure
252 3 shows quantitative data from my viewpoint of the temporal disappearance of the C_3F_8
253 bubble. It seemed to disappear from the top down starting about the 10th day after the
254 operation. On the 60th day, the bubble broke up into one big bubble and many little ones: the
255 numbers in this figure are for the big bubble.

256 In the first few days after an operation, the bubble increases in size, but I could not detect
257 this. I could only see white with shadows and bright objects like windows. Around day 10, I
258 was surprised to see the bottom of the gas bubble. It was in my upper field of view
259 (remember that the lens inverts the image before it is focused on the retina). In Figure 3, this
260 gas-fluid interface looked horizontal, so I measured how far it was above the horizon. I saw
261 many very strange reflections off this gas-fluid interface. Later at about day 40 the bubble
262 started to look more like a circle and less like a line. So I started measuring the radius of
263 curvature of the bubble. The ophthalmological literature emphasizes the volume of the
264 bubble [4], which may be scientifically more relevant. But as the patient, I did not care about
265 the volume. I only cared about what was happening in my visual field. Figure 3 is for one
266 patient only, with C_3F_8 gas only and in only one operation, although after the other two RD
267 operations the bubble behaved the same way.

268 Figure 3 might not be the first illustration of a patient's view of a disappearing C_3F_8 gas
269 bubble. A journal paper [16] may have an analogous description. However, it is in French
270 and I could not obtain a copy.

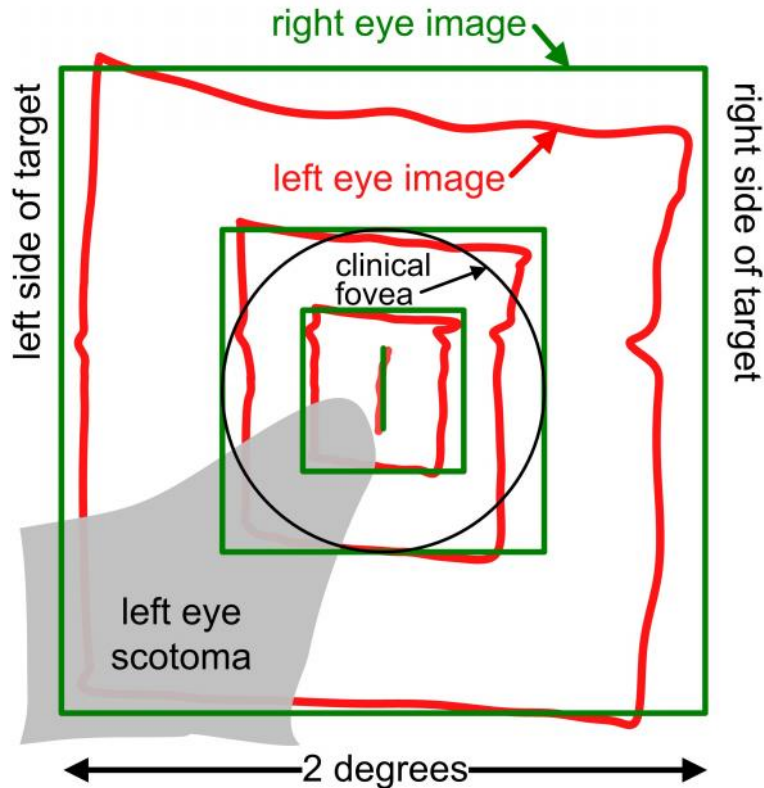
271 August 3, 2008

272 Since the implant of the scleral buckle, my eyes were misaligned (strabismus and diplopia)
273 by as much as twenty degrees. On this date I was finally able to align the left and right eye
274 images, albeit with difficulty and not for long.

275 September 11, 2008, Distorted Vision

276 The gas bubble from the second retinal detachment operation was gone after 10 weeks. The
277 left eye retinal image had become wrinkled, because of the macula-off detachment. The
278 width of the image of the left eye was around $\frac{3}{4}$ the size of the right eye. See Figure 4. With
279 the left eye, everyone looked like a pinhead, or a person in an El Greco painting. There was
280 some improvement in that the misalignment (tropia) of the left eye had become smaller and I
281 was able to roughly align the two eyes.

282 The ophthalmologists' have no instruments that could produce a figure showing as much
283 detail as in figure 4. Their closest tool would be an Amsler grid.



284

285 **Fig. 4. The patient's viewpoint of binocular viewing of a small black target comprised**
 286 **of concentric squares. The right eye's image (green) is the same as the visual target.**
 287 **The left eye's image (red) shows the distortion due to a wrinkled retina or macular**
 288 **pucker. (However, the left eye scotoma did not appear for another year, around**
 289 **October 20,2009.)**

290 September 12, 2008, Third Bubble

291 During a routine office visit, Ophthalmologist-4 found a new tear in my retina. He repaired it
 292 with 60 pulses of a head mounted laser. He inserted a cryopexy probe on top of the eyeball
 293 near the scleral buckle to freeze (cryopexy) the area of the retina above the tear. He
 294 removed some fluid from the eyeball and inserted a new bubble of C_3F_8 . But he was doing
 295 these procedures while he was seeing other regularly scheduled patients in his office. So he
 296 finally gave up and asked me to come back the next day.

297 September 13, 2008, Many Laser Pulses

298 Saturday morning we returned at 8 AM. Ophthalmologist-4 administered 567 laser pulses.
 299 He said, "I know you want to ask, why? The answer is bad luck." Over the next few months,
 300 there were varying degrees of vertical, horizontal and cyclorotational disparities between the
 301 two eyes due to the misdirection (phoria) of the left eye. The pain on the back of eye and the
 302 double vision (diplopia) started with the first surgery on May 12, 2008. But the phoria might
 303 have been exacerbated by the cryopexy freezing on September 12, 2008. At this time, with
 304 the left eye, everyone looked like Don Quixote, tall and skinny.

305 At this time, my symptoms were (1) inflammation and pain in the front of the left eye, (2) pain
 306 behind the left eye, (3) pain in the brain, (4) double vision, (5) lack of depth perception, (6)
 307 poor visual acuity in the left eye due to a wrinkled retina, and (7) poor vision in the *right* eye
 308 due to a cataract. Intraocular pressures were always normal.

309 October 29, 2008, Macular Edema was Noticed

310 Using a Heidelberg Engineering OCT instrument, Ophthalmologist-4 noted cystoid edema in
311 the macular area. He also noted that the retina was reattached.

312 March 9, 2009, Attempts to Eliminate Edema

313 The image of the left eye was about $\frac{3}{4}$ the size of the image of the right eye and the left
314 eye's image was wrinkled. Ophthalmologist-4 had been recommending use of cortical
315 steroids (drops and injections) for five months trying to flatten the macula. There was fluid
316 behind the retina. At various times he called it inflammation, swelling, fluid, a cyst and
317 cystoid macular edema: for the rest of this paper I will refer to this as macular edema.
318 Ophthalmologist-4 noted that the inner limiting membrane (ILM) was not thickened. He
319 injected corticosteroids (Kenalog®) directly into my eyeball. I probably had a reaction to the
320 carrier or the preservative (benzyl alcohol), because the Kenalog turned into white crystals
321 and I was blind in that eye for a week. The intraocular pressure increased to 30 mm Hg.
322 Thirty-six eye drops per day of three different types (spaced at least ten minutes apart)
323 brought things back to "normal."

324 June 1, 2009, TheRight Eye

325 A small inconvenience was caused by the cataract in my right eye. I had intended to have it
326 removed soon after the cataract in the left eye. But when the left retina started falling off, the
327 doctors suggested that nothing be done to the right eye until the left eye stabilized. For about
328 a year, I did not drive my car. Ophthalmologist-5 removed the cataract in the *right* eye and
329 replaced it with a 13 diopter artificial IOL. Although the right eye was *hiseye*, he spent a good
330 deal of time examining and tracking the progress of the left eye.

331 July 10, 2009, Additional Intra-ocular Injection

332 Ophthalmologist-4 injected *preservative-free* triamcinolone acetonide (generic Kenalog) into
333 the left eyeball. It did not react adversely and it did help with the fluid behind the retina.

334 September 4, 2009, Summary of Symptoms

335 The left eye's image was smaller than the right eye's image, it was wrinkled, it was about
336 eight degrees up, four degrees to the right and was rotated about three degrees clockwise. I
337 had a (possible) aniseikonia headache. I had no depth perception for near objects: therefore,
338 threading a needle, tying a hook on a fishing line or pounding in a nail was difficult, or near
339 impossible.

340 For about six months, I wore a black patch over my left eye when reading or working on the
341 computer and I wore the black patch on my right eye when I was teaching, riding in a car or
342 watching television. This reduced the pain in the brain. However, Ophthalmologist-4 asked
343 me to stop doing that, because he was afraid the brain would shut down the left eye if I
344 stopped using it.

345 October 16, 2009, Planning the Seventh Retinal Surgery

346 At a routine appointment, Ophthalmologist-4 worried about the macular edema and
347 scheduled surgery for October 20. He said that he would go in with his microscope, look, see
348 what is there and try to remove it. He said, "I *think* this will work."

349 October 20, 2009, Peeling the ILM

350 Ophthalmologist-4 peeled the inner limiting membrane (ILM) over the macula. The inner
351 limiting membrane is a diffusion barrier between the vitreous and the ganglion cells of the
352 retina. It is about two microns thick. He removed an area about one mm in diameter. He did
353 this manually, quite a feat! Then he injected Kenalog into the eyeball (fresh hospital Kenalog
354 is preservative free).

355 Note added in 2013: The purpose of peeling the ILM was to reduce the edema, not to
356 improve visual acuity [5], because visual acuity seldom improves after a macula-off
357 detachment. Peeling of the ILM is used to repair macular holes. However, it has side effects.
358 Tadayoni et al.,[6] wrote "ILM peeling may reduce retinal sensitivity, and significantly
359 increase the incidence of microscotomas.... We found that mean retinal sensitivity was
360 significantly lower ... in eyes that underwent peeling than in those that did not. Postoperative
361 microscotomas were also significantly more frequent in eyes that had undergone peeling...."
362 The scotoma that resulted from peeling my ILM is shown in Figure 4.

363 October 21, 2009, Follow-up Exam

364 The day after the surgery, he said, "That will be your last operation on that eye: that eye
365 can't take any more surgery: it was hard to get the membranes back together."
366 Ophthalmologist-4's practice schedules a patient every ten minutes. Well on that day he
367 said, "They're trying to kill me. Today they have scheduled 89 patients for me."

368 November 2, 2009, No Progress

369 I told Ophthalmologist-4 that peripheral vision in the left eye was good: but the left eye's
370 image was still smaller than the right eye's image. Since the operation, the left eye's image
371 had a two-degree diameter gray-brown cloud over the fovea. He looked and said that it was
372 a hemorrhage and that was not unusual: it will probably go away.

373 For the last year and a half I have reported to Ophthalmologist-4 that I have had the
374 following symptoms: (1) pain in the front of the left eye, (2) pain behind the left eye, (3) pain
375 in my brain, (4) double vision (diplopia) due to left eye phoria, (5) lack of depth perception
376 (no stereopsis), and (6) poor visual acuity in the left eye due to a wrinkled retina and, since
377 peeling the ILM, a scotoma (an area in the field of vision where the subject sees nothing) in
378 the inferior temporal macula as shown in Figure 4.

379 June 23, 2010, Motrin

380 I visited Ophthalmologist-4. Vision in the left eye has been about 20/60 to 20/70 for the last
381 half year. I could obtain this only by scanning across the letters and recognizing them with
382 peripheral vision. There was tremendous variability in this measure. Peeling the inner limiting
383 membrane (ILM) over the macula has made the vision worse. Ophthalmologist-4 wrote,
384 "Andrew's main problem now is buckle associated discomfort. I am going to put him on a trial
385 of high dose Motrin [sixteen 200 mg pills per day] and consider biofeedback therapy prior to
386 the removal of the scleral buckle," At this time, we lost confidence in Ophthalmologist-4 and
387 switched to Ophthalmologist-6.

388 July 27, 2010, New Ophthalmologist

389 I asked if it would help if we removed the scleral buckle. Ophthalmologist-6 suggested *not*
390 removing the scleral buckle. His optical coherence tomography (OCT) confirmed fluid behind
391 the retina.

392 At this point my symptoms (and possible known causes) were (1) pain in the front of the left
393 eye and light sensitivity (perhaps caused by the haptics of the artificial lens interfering with
394 the iris), (2) inflammation and intermittent pain behind the left eye (perhaps caused by the
395 scleral buckle or damage to the superior rectus and superior obliquemuscles), (3) pain in the
396 brain {Surely, this had many causes. It could be a continual retinally induced aniseikonia
397 headache (asthenopia). The MRI's did not reveal a cause. A neurologist found no reason for
398 them. They are not migraine or cluster headaches.}, (4) left eye phoria {When looking
399 straight ahead, the left eye's image was rotated about three degrees right, two degrees up
400 and five degrees clockwise. (This may have been caused by the scleral buckle, damage to
401 superior oblique muscle or interference with the inferior rectus muscle.)}, (5) diplopia and

402 lack of stereopsis (caused by the phoria and the wrinkled retina) and (6) poor visual acuity
403 (caused by a wrinkled retina and a scotoma in the inferior temporal macula).

404 At this time, Optical Coherence Tomography (OCT) images were the cat's meow of
405 ophthalmology. The OCT instrument scans the retina with a laser beam. It stores this
406 information in a computer as a three dimensional model of the eye. The OCT images of my
407 eye showed fluid under the retina, so the doctors tried to get rid of that fluid. That fluid
408 caused an elevated thickness at two places in the retina. They were about five degrees left
409 and right of the fovea. Visual field analysis does not have the resolution to show such
410 defects. In fact, when I looked for evidence of such defects I could not find any. So the OCT
411 images showed a new type of pathology and my ophthalmological treatments over the last
412 two years were directed to reduce these fluids and those potential defects.

413 At most of my eye exams since May 2007, before dilation, a technician would measure the
414 pupillary reflexes. The right eye was normal; the left eye was irregular and non-reactive
415 (tonic). I presumed that these test results were entered into my records and read by the
416 doctor: but no ophthalmologist ever commented on this anisocoria.

417 November 5, 2010, Letter to Ophthalmologist-6

418 Visual acuity in the left eye is about 20/70. However, viewing a Snellen chart is a primitive
419 indicator of vision. For example, it did not disclose the important additional information that
420 the brain has shut down vision of the left eye by about 1.5 log units. That is, if I want to see a
421 target equally with both eyes in the same illumination, then I must put a 1.5 log unit neutral
422 density filter in front of the right eye to equalize the perceptual disparity between the eyes. It
423 also failed to disclose retina wrinkles and scotomas as shown in Figure 4. It did not reveal
424 lack of stereopsis or color vision deficiencies. If I were given enough time and
425 encouragement, I would saccade across the letters of the Snellen chart and recognize the
426 proper letter with off-foveal vision.

427 December 3 and 8, 2010, MRIs

428 Magnetic Resonance Imaging (MRI) of the brain and left eye orbit showed no cause for the
429 pain in the brain. This pain seems to be localized in a cylinder two inches in diameter
430 stretching between the temples.

431 December 10, 2010, Diagnosis of Phoria

432 The optometrist measured the misalignment of the eyes. This was the first time that anyone
433 had measured it. He suggested that the pain in the back of the eye and the vertical,
434 horizontal and cyclorotational disparities between the two eyes were due to the scleral
435 buckle and the effects of the surgery on the superior rectus and perhaps the superior oblique
436 muscles. He prescribed new spectacles with horizontal and vertical prisms for both eyes.
437 These spectacles got rid of some of the pain in the back of the eye and attenuated the pain
438 in the brain. Since the first retina operation, when looking straight ahead (eyes in primary
439 position), my left-eye image was $5.7^\circ \pm 1.5^\circ$ right, $3.6^\circ \pm 2.3^\circ$ up and $4.5^\circ \pm 1^\circ$ clockwise. The
440 optometrist recommended spectacles with horizontal prisms of one Δ base-in for both eyes,
441 and two Δ base-down for the OD and two Δ base-up for the OS. A prism diopter, Δ , is about
442 0.57° . Although it is only the left eye that is misaligned, half of the needed prism correction is
443 put into each spectacle lens.

444 Note added in 2013: alternative words that describe my eye position at rest are that the left
445 eye was abducted 5.7° , depressed 3.6° and excyclorotated 4.5° .

446 December 29, 2010, Diagnosis of Tonic Pupil

447 The optometrist told me that the right eye pupillary response was normal, but the left pupil
448 was dilated, oblong shaped, with the pulling point at 11 o'clock, and was nonresponsive
449 (tonic). The optometrist wanted to run an experiment to see if the origin of the tonic pupil was

450 mechanical or neural. One possible neural cause of the tonic pupil was an injury (during the
451 surgeries) to the axons in the short ciliary nerve between the ciliary ganglion and the ciliary
452 muscles. So he called a retina specialistdistantly involved with my case, Ophthalmologist-8.
453 Together they decided that pilocarpine (a pupil constrictor) might help and would not hurt.
454 The pilocarpine did not cause the pupil to constrict; therefore, the tonic pupil was due to
455 mechanical not neural restraints. The pilocarpine was then discontinued. This experiment led
456 us to think that perhaps the haptics were hooked into the iris. However, we did not have an
457 instrument that could image the haptics.

458 Note added in 2013: This situation led to the lens replacement surgery of July 21, 2011.

459 January 24, 2011, Confirmation of Tonic Pupil

460 Ophthalmologist-7 noted that the left pupil was an oblique oval with a diameter of five mm.
461 Prism cover testing showed five prism diopters.

462 January 31, 2011, Summary of Symptoms

463 I gave the optometrist the following summary of my symptoms: (1) inflammation and pain in
464 the front of the eyeball. I described it as a scratchy, blood-shot irritation of the eyeball. This
465 pain was intermittent. It came on a half-dozen times a day and lasted 10 or 20 minutes. The
466 left eye was light sensitive. After walking the dog in the sun for a half-hour, the eyelid was
467 almost closed and the eye hurt. (2) Pain in the back of the eyeball: an intermittent localized
468 pain, sometimes sharp, sometimes dull. It felt like a foreign body was trapped in the orbit. I
469 attributed it to the scleral buckle or to inflammation around the buckle. This pain had been
470 there for two years. (3) Pain in the brain, a continual periphery-induced aniseikonia
471 headache (asthenopia). My brain hurt when I got up in the morning: it got worse as the day
472 went on. I had put a black patch on the left eye for close vision like reading on a computer
473 screen and on the right eye for distance vision like when watching TV or being outside. That
474 helped, but Ophthalmologist-4 and the Optometrist asked me to stop doing that, because
475 they were afraid that the brain would shut down that eye. So I put a small (one degree) dot in
476 the center of the left lens. This blocked the distorted left eye image and caused the left eye
477 to use peripheral not foveal vision. I had hoped that this would ameliorate the static
478 aniseikonia. The optometrist's prism spectacles did help with the pain. Roughly, the pain
479 seemed to be localized to a region between the temples. If I rubbed the temples hard, it
480 helped to alleviate the pain. This pain got worse five or ten times a day. These episodes
481 lasted a half hour. However, the MRIs found nothing wrong and my neurologist also found
482 nothing wrong. (4) If I bent over to pick up something from the floor, the left eye hurt. About
483 once a day, I would lose my balance and almost fall.

484 My notes state that Ophthalmologist-7wrote in his report that all four of these pains were
485 consistent with the eight operations that were done on that eye. He also offered nothing to
486 relieve the pains.

487 Spring 2011, Finding a Specialist

488 Now the biggest difficulty was finding an ophthalmologist who had the experience and
489 instruments to handle this one-in-a-million problem. Finally, Ophthalmologist-5
490 recommended Ophthalmologist-9, with whom he had done a fellowship, at the UCLA
491 Medical School. Ophthalmologist-9 was a professor of ophthalmology specializing in the
492 anterior chamber (cataracts and refractory surgery).

493 May 6, 2011, First visit to Ophthalmologist-9

494 Ophthalmologist-9 and two of his Fellows spent over an hour examining me. He wrote in his
495 report, "Ocular Motility... With Distance Fixation cc: 6 prism diopter left exotropia and 4 prism
496 diopter left hypertropia, Left incycloclotortion persists after horizontal and vertical deviations are
497 neutralized.... The left pupil was 3×4 mm, oval, and peaked at the 11 o'clock position...

498 posterior synechiae [meaning places where the iris adheres to lens] at the superonasal
499 optic-haptic junction... A single posterior synechia is noted at the 11 o'clock position. The iris
500 is stuck to the optic-haptic junction at this location... The quality of the central vision in his
501 left eye is poor. He must scan over letters to read them, and even when he does, his acuity
502 is not very good."

503 June 17, 2011, Preoperative Visit

504 Ophthalmologist-9 noted, "2 permanent sutures that are attached to the scleral buckle tent
505 up, but do not pierce the conjunctiva."

506 July 21, 2011, Lens Exchange Operation

507 Ophthalmologist-9 noted significant posterior synechia superonasally, an eccentric pupil and
508 a chafe between the iris and the square edge of the IOL. He performed refractive cataract
509 surgery with peripheral corneal relaxing incisions. He removed the IOL in the left eye and
510 replaced it with a type of lens that was designed to be placed in the ciliary sulcus (Starr
511 Surgical AQ20110V). In two months the pain in the iris was gone, but the pupil was still
512 noncircular and nonresponsive (tonic).

513 Ophthalmologist-9's reports were excellent: they were clear, specific and detailed and he
514 made sure that copies were sent to all seven of my previous principal doctors. Evidentially
515 the optometrist and the eight ophthalmologists that had examined me before had never seen
516 this particular cluster of symptoms. So, I was a rare patient. I think that doctors in medical
517 schools are more experienced in dealing with rare cases. So, in retrospect, when I realized
518 that my case was so rare and I found Ophthalmologist-9 at a medical school that solved my
519 major problem, perhaps I should have stayed with him, even though it would have meant
520 frequent trips between Tucson and Los Angeles and a more expensive medical insurance
521 plan.

522 January 25, 2012, Revisiting the Pain Behind the Eye

523 The optometrist noted inflammation of the sclera and of the anterior chamber. He prescribed
524 Bromday and Pred Forte. This prompted Ophthalmologist-6 to inspect the suture securing
525 the scleral buckle.

526 May 8, 2012, Ophthalmologist-6 is Optimistic

527 In his consultation report Ophthalmologist-6 wrote, "Bahill was in again with his remarkable
528 scientific knowledge and his scientific analysis of what is happening in his left eye. ...
529 Summary: The only treatable condition here is the macula edema."

530 June 4, 2012, Old Suture Removed

531 For four years, my sclera was inflamed, blood-shot and it hurt. Bromday seemed to be
532 helping. But on June 4, in an in-office operation, Ophthalmologist-6 removed an exposed
533 Dacron suture in the sclera from the original scleral buckle operation of May 12, 2008. The
534 pain dropped by 40%. But then he noted a 2 mm fistula in theconjunctiva over the scleral
535 buckle. He consulted with his associate, Ophthalmologist-10, and then suggested an
536 operation in the hospital.

537 July 18, 2012, Fistula Sutured

538 Ophthalmologist-6 sutured a conjunctiva fistula in the sclera over the scleral buckle. The
539 operation went well, except that the area became infected. Ophthalmologist-6 and
540 Ophthalmologist-10 treated the infection with Ofloxacin and Neo/Poly/Gram.

541 November 6, 2012, Large Macular Edema

542 The optometrist noted that his OCT instrument showed an overall retinal thickening with a
543 maximum thickness near 500 microns in the area centered five degrees temporal of the

macula. The optometrist recommended that I accelerate my next visit with Ophthalmologist-6 and sent a consultation letter to him.

November 26, 2012, Treatment of Macular Edema

Ophthalmologist-6's OCT instrument replicated this macular edema with a thickness of 427 microns in the area centered five degrees temporal of the macula. He recommended reapplication of cortical steroids (Durezol) four times a day. Table 2 summarizes the eye drops that I have taken.

Table 2. Over the last six years, ATB has used the following eye drops.

Category, Purpose	Generic Name	Brand Name
Corticosteroid, Anti-inflammatory	Difluprednate 0.05%	Durezol® emulsion
	Prednisolone acetate 1%	Omnipred®
	Prednisolone acetate 1%	Pred Forte®
	Triamcinolone acetonide	Kenalog® (by injection)
NSAID, Anti-inflammatory	Bromfenac 0.08%	Xibrom™
	Bromfenac 0.09%	Bromday™
	Ketorolac 0.4%	Acular®
Vasoconstrictor, Antihistamine, Anti-inflammatory	Naphazoline HCl, Pheiramine Maleate	Naphcon A®
Intra-ocular pressure reduction		
alpha agonist	Brimonidine tartrate 0.15%	Alphagan®
beta-adrenergic blocker	Levobunolol HCl 0.5%	Betagan®
cholinergic agonist	Pilocarpine HCl 1.0%	
Antibiotic	Gatifloxacin 0.3%	Zymar®
	Gatifloxacin 0.5%	Zymaxid™
	Moxifloxacin HCl 0.5%	Vigamox® Solution
	Neo/Poly/Gram	Neosporin®
	Ofloxacin 0.3%	Ocuflox®
Artificial Tears and Lubricants	Propylene glycol	Systane®
HCl means hydrochloride		

December 27, 2012, Macular Edema

The macular edema had started in 2008. It was detected and measured with OCT scans. It was treated with corticosteroid eye drops Omnipred® and Pred Forte®, injections of Kenalog®, peeling of the inner limiting membrane (ILM) over the macula, and eye drops of Xibrom™, Bromday™, Acular® and finally Durezol® four times a day. Note added in 2014: In Zeiss Cirrus OCT scans performed from 2008 to 2012, in the ILM-RPE Thickness diagram, the thickness of my left eye's retina in a region five degrees temporal of the fovea was ($\bar{x} = 358 \mu\text{m}$, $\sigma = 86$, $n = 23$). After using Durezol four times a day, in scans performed in 2013, the thickness of my retina in this same region was ($\bar{x} = 278 \mu\text{m}$, $\sigma = 15$, $n = 5$). For comparison, the thickness of my right eye in this region is ($\bar{x} = 297.7 \mu\text{m}$, $\sigma = 1.3$, $n = 9$). Unfortunately, eliminating the edema did not cure the visual acuity deficit.

December 29, 2012, More Mysteries

If there were only one object in my visual field and it was a small green dot of light, then it appeared green to my right eye and white to my left eye. This was repeatable in intraocular

pressure tests (glaucoma air-puff test, Reichert AT555 non-contact tonometer). Several times, a white dot in a Humphrey visual fields test appeared green. I had mentioned these peculiarities for two years, but I did not have experiments to explain them, nor did anyone else.

March 27, 2013, Color Blindness

The fovea of the left eye is colorblind. When a small visual target is placed on the fovea, the left eye misperceives its color. A bright white dot on a white background appears green to the left eye. Conversely, a green laser dot on a white background appears white or bluish-white. These effects would be consistent with the destruction of ganglion cells [7] during the ILM peeling of the left eye.

Note added in January 2014 from [8]. The fovea of the left eye is color vision deficient. When a small (0.07 degree diameter) green dot of laser light was positioned on my fovea, it appeared green to the right eye and white to the left eye. This was repeatable in intraocular pressure tests and with lasers in my laboratory.

For the Ishihara color blindness test [9], distance from the screen was adjusted so that each of the test plates was two degrees in diameter. Viewing was monocular. With my right eye, I perceived all 22 of the Ishihara test plates correctly. With my left eye, I perceived none of these test plates correctly.

<http://www.colour-blindness.com/colour-blindness-tests/ishihara-colour-test-plates/>.

For the Hardy-Rand-Rittler (HRR) pseudoisochromatic test, distance from the screen was adjusted so that each of the test plates was two degrees square. Viewing was monocular. With my right eye, I perceived the first seven HRR test plates correctly. With my left eye, I perceived none of these test plates correctly.

For the X-Rite color IQ test (a simplified on-line version of a Farnsworth-Munsell 100 Hue Test), distance from the screen was adjusted so that each of the squares was one degree. Viewing was monocular. My right eye scored 16, which is low and therefore good: my left eye scored $\bar{x} = 200$ $\sigma = 52$ $n = 5$, which is poor and in the 99th percentile.

http://xritephoto.com/ph_toolframe.aspx?action=coloriq.

The results of all three of these tests were size dependent. If the targets were five or ten degrees in visual angle, then I could pick up hints and fragments and then occasionally guess correctly. These tests suggested that I am deuteranomalous and tritananomalous!

October 17, 2013

My intraocular pressures (IOP) were 13 mm Hg, as they have been for the last year. With the exception of the incidence with the preservative in Kenalog in March 2009, my IOPs seldom went above 20 mm Hg.

3. DISCUSSION

Table 3. Summary of ATB's ocular status October 2013

Description	Determined to be	Primary treatment	Present condition 100% is best
OS = the left eye, OD = the right eye, IOL = the intraocular lens, ILM = inner limiting membrane			
Poor vision in the <i>right</i> eye (OD)	Cataract	Replaced natural lens with IOL	100%
Pain on front of OS and light sensitivity	The iris was stuck to the square edge of IOL or to	Replaced IOL	90%, the pupil is

	the haptics, thereby immobilizing the iris		still tonic
Pain behind OS	Scleral buckle, its sutures and damage to or obstruction of the superior rectus and superior oblique muscles	Removed exposed suture & sutured conjunctiva fistula over the scleral buckle	80%, the muscles are still obstructed
Poor visual acuity in OS macula	Wrinkled retina, macular edema	Durezol twice a day is keeping the macular edema down	70%
Different size and shape of eye images and one or two log difference in the luminance threshold of OS and OD	Macula-off detached retina, peeling the ILM, subretinal edema and disruption of retinal pigment epithelium	Corticosteroid anti-inflammatory eye drops	10%
At rest, OS image drifts up and to the right of OD image causing double vision.	Obstruction of or interference with the superior rectus and superior oblique extra ocular muscles	Prisms in spectacles	60%
Lack of depth perception for objects within ten feet (lack of stereopsis)	Different size and shape of eye images and misalignment of the left eye particularly cyclorotation	None	0%
Color deficiency in OS fovea	Peeling the ILM	Ishihara test for color blindness, and Farnsworth-Munsell 100 Hue Test	0%
Poor visual acuity in OS fovea	Macular scotoma due to peeling the ILM	Maybe a macular 10-2 threshold visual fields test could quantify it.	0%
General pain in OS	Inflammation of the sclera	OS is blood shot and it hurts for about 15 minutes a few times a day, a drop of Systane or Refresh helps	60%
Pain in the brain	Different images from the two eyes particularly due to cyclorotation	Headaches, five times a day, 30 minute duration	40%

603 3.1 Quality of Life

604 Because the images in my two eyes are of different sizes and shapes, it is difficult, error
605 prone and time consuming to read. My ability to read lips is diminished, so my hearing
606 impediment is exacerbated. The lack of stereopsis (depth perception for objects within 10
607 feet due to the difference in the images of the two eyes) makes it dangerous to climb stairs
608 or even walk on a sidewalk. I lose my balance daily, but fortunately, I have only fallen few
609 times, once I broke my fibula. This lack of depth perception makes it difficult to tighten a
610 small screw, zip up a jacket, pound in a nail, put a nut on a bolt or twist a wire around a
611 receptacle screw terminal.

612 The pain in my brain varies (on a scale of 0 to 10) from one to four. It spikes about a dozen
613 times a day and these episodes last about 15 minutes, but sometimes they last for hours.
614 This pain prevents me from working on a computer for extended periods. Sharp occurrences
615 of pain make it impossible to maintain a continuous long chain of thought. Therefore, writing
616 papers or proposals is difficult.

617 **3.2The Systems Thinking Approach**

618 The next sentence should be read rapidly. For the last six years I have complained that my
619 left eye had pain, floaters, pain on front of the eye, light sensitivity, poor visual acuity,
620 inflammation, blood shotness, foreign body sensation (like an eyelash trapped under the
621 eyelid), pain behind the eye, no vision due to the C_3F_8 bubble, no vision due to the Kenalog
622 injection, strange visual effects due to absorption of C_3F_8 bubble, phoria or double vision,
623 headaches, pain on front of the eye, pain behind the eye, poor visual acuity in the macula,
624 poor visual acuity in the fovea, color deficiency in the fovea, general pain, different
625 luminance thresholds for the two eyes, different primary positions of the two eyes (the left eye
626 image drifted up and to the right causing double vision), lack of depth perception, lack of
627 stereopsis, pain in the brain, lack of explanation of expectations, ophthalmological
628 instruments used differently by different technicians, and physician overload.

629 I have abridged these complaints into the following symptoms (1) inflammation and pain on
630 the front of OS, (2) pain behind OS, (3) pain in the brain, (4) OS misalignment (phoria), (5)
631 double vision (diplopia), (6) lack of depth perception (no stereopsis), (7) poor visual acuity in
632 OS, (8) OS foveal color blindness, (9) OS light sensitivity and (10) OS non-circular and non-
633 responsive pupil. This sounds like many disassociated symptoms. I am sure that the
634 ophthalmologists felt overwhelmed as they treated one symptom at a time.

635 These ten symptoms seemed like ten different problems. This is like the story of seven blind
636 men describing an elephant: each saw a different aspect. But now we can see the
637 relationships between these problems. We can understand this medical history as a system,
638 instead of ten isolated events. As shown in figure 5, it can be seen how treating one
639 symptom affected other symptoms.

656 (among other reasons) the algorithms for transforming three-dimensional (3D) shapes into
657 two-dimensional (2D) images are nonlinear and are different for different techniques.

658 **4. LESSONS LEARNED**

659 **4.1 Pain**

660 Medical doctors have difficulty successfully treating pain, even if it is in their realm of study
661 and experience. Pain is hard to diagnose, measure, quantify and treat. However, and most
662 importantly, pain is often an important clue as to what is wrong. If the cause is not visually
663 obvious (either to the naked eye, in photos, CAT scans or MRIs), then many times it is not
664 successfully treated. In this particular case, for the last six years most ophthalmologists
665 failed to resolve my complaints about pain.

666 In fact, Ophthalmologist-6 wrote in his May 8, 2012 consultation report, "Bahill was in again
667 with his remarkable scientific knowledge and his scientific analysis of what is happening in
668 his left eye. He still complains of bi-temporal headaches, which I do not believe are related to
669 his eye disease. If there is any connection, it is purely stress or depression related as a
670 result of his concern for his left eye. ... Summary: The only treatable condition here is the
671 macula edema. Hopefully successful treatment will improve the acuity and bring him back to
672 where he was." However, on June 4, in an in-office operation, Ophthalmologist-6 removed
673 an exposed Dacron suture in the sclera from the original scleral buckle operation. The pain
674 that had bedeviled me for six years dropped by 40%. On July 18, in an in-hospital operation,
675 he sutured a conjunctiva fistula in the sclera over the scleral buckle. The pain dropped by
676 20%. In summary, in May he said that the only improvement that could be made was
677 reducing the macular edema: but in June and July, he performed operations that
678 substantially reduced the pain. It is hard to predict pain resolution.

679 Before each of my operations, the ophthalmologist discussed likely outcomes and some
680 risks of the operation. However, none of them mentioned the risk of potential postoperative
681 pain. We believe that the ophthalmologist should know about the types of pain that could
682 result from each type of ocular surgery. Perhaps they could describe in a brochure what the
683 pain could be like. They could tell the patient what to do if such pain occurs. And then
684 they could explain what they would do to alleviate the pain and correct the operation.
685 However, this would require uncompensated time.

686 **4.2 Communications**

687 From this case, we have learned a little bit about the medical profession. I was not simply
688 jumping around trying to find a doctor that could cure my problems. Instead, most of these
689 doctors were working together to help me. Certainly, they exchanged referral reports. One
690 pair talked on the telephone, and another pair talked in person about this case. Perhaps it
691 would have been better if there were more face-to-face communications, but that would have
692 required extra time, money and resources.

693 Most of their communications were implemented by FAX. Their referral reports varied in
694 quality: some were incomprehensible because the doctor used a canned report generation
695 program, some were superficial, some were merely boilerplate, but the reports of one doctor
696 were truly excellent. This means that we have examples of excellence. It is important that the
697 patient and the doctors ensure that all relevant parties (including the patient, when
698 appropriate) get copies of the reports. In my experiences, most of the time this link failed.

699 Often referral reports were written by inclusion of standard common phrases. Sometimes
700 they started with partially filled out forms with default values checked. Two of my doctors
701 wrote in their reports that they had administered the Ishihara color blindness test, but they
702 actually had not. However, abandoning such forms and short cuts would cost time.

703 **4.3 Selecting a Doctor**

704 I have found that searching the Internet and asking friends for recommendations about good
705 ophthalmologists was not useful. People tend to make recommendations based on only a
706 few data points. Searching the Internet to find specific procedures that I wanted the doctors
707 to use was futile. My best results came from asking doctors that I trusted for referrals and
708 then trusting the judgments of these doctors [although this process was also fallible]. In the
709 future, I will ask what the ophthalmologist's patient load is. I will not recommend
710 ophthalmologists who schedule more than six patients per hour nor the cataract surgeons
711 who schedule more than four operations per hour. The average ophthalmologist can perform
712 a cataract surgery in less than ten minutes. However, scheduling patients at this rate would
713 not allow for bathroom breaks or time to fix minor complications.

714 An anonymous reviewer of this paper wrote, "a retina surgeon seeing 6 patients per hour is
715 the norm and most in private practice see up to 10 per hour. That's the reality of being a
716 small businessman.... Likewise face-to-face communication for each patient is impossible
717 with physicians seeing 500+ patients per week and none in the same location."

718 In the last six years, I have had 12 eye operations and 150 doctor's visits. I estimate that, on
719 average, (a) the ophthalmologists scheduled a patient every 20 minutes with a standard
720 deviation (SD) of 10 and a range of 10 to 60, (b) on each visit, the ophthalmologists or their
721 staff spent 30 minutes with me with a SD of 15 and a range of 10 to 90, (c) Each operation
722 lasted 65 minutes with a SD of 15 and a range of 30 to 90.

723 4.4 Invisible Gorilla

724 When people focus on a task that demands their attention, they usually fail to notice
725 unexpected objects and events that occur in full view. This phenomenon is known as
726 *inattention blindness*, because people typically do not consciously perceive aspects of their
727 world that fall outside of the focus of their attention[10]. Medical doctors are just like the rest
728 of us: they suffer from *inattention blindness*; they only see what they expect to see.

729 From the very first surgery until today, I have complained about pain in the eye. In
730 retrospect, it seems that initially the pain was caused by the iris being trapped by the edge of
731 the original IOL: but it was difficult to figure this out, because people do not see what they do
732 not expect to see.

733 On December 29, 2010, the optometrist gave me a through exam lasting 1.5 hours. He
734 looked for unusual things. Finally, he told me that the right-eye pupillary response was
735 normal, but the left pupil was dilated, oblong-shaped with the pulling point at 11 o'clock, and
736 was nonresponsive (tonic). This was the needed breakthrough. He had looked at the iris,
737 which no one else had done.

738 Ophthalmologist-1 was looking for evidence of the success of his surgery; therefore, he only
739 looked at visual acuity: he did not look at the iris. Ophthalmologist-3 was using his slit lamp to
740 look for inflammation; therefore, he did not look at the iris. Ophthalmologist-4 was trained to
741 look at the retina; so he did not look at the iris. Ophthalmologist-5 was trained to look at the
742 lens; so he did not look at the iris. Ophthalmologist-6 was trained to look at the retina; so he
743 did not look at the iris. Ophthalmologist-7 was a neuro-ophthalmologist trained to look for
744 neurological problems: he noted the tonic pupil, but said nothing about it.

745 At the beginning of each exam, a technician measured intraocular pressures, Snellen acuity
746 and pupillary reflexes. The ophthalmologists often commented about the pressures and the
747 acuity, but none mentioned the abnormal pupil.

748 It would be prohibitively expensive for each ophthalmologist to look at all measurements that
749 were taken, read all of the information presented by the patient, and examine all aspects of
750 the eye. Each ophthalmologist focuses on his or her specialty and leaves tangents for others
751 to deal with.

752 4.5 Process

753 In complicated procedures involving many physicians and many physical systems, it can be
754 unclear who is in charge of the overall system. Some hospital rules force them to “work on
755 only one body part at a time.” In addition, there is usually no patient’s advocate, who knows
756 the system and is particularly interested in only the patients’ best interests. Perhaps both of
757 these roles are played by the patient or a member of the patient’s family.

758 For every visit, the patient should have a written letter listing symptoms and questions to ask
759 the doctor. It is the patient’s responsibility to make sure that the doctor reads the letter. Often
760 he/she does not. Also, I guess that it is the patient’s responsibility to make sure that tests
761 and measurements (such as intraocular pressure, visual acuity and pupil reflexes) made by
762 technicians are read by the doctor, because the process does not.

763 The medical profession does not seem to have a strong culture of using feedback
764 from patients and other physicians: often they do not even checkup on their own work. For
765 example, ophthalmologist-1 never looked for possible complications of his cataract surgery
766 such as a trapped iris, cystoid macular edema, intraocular infection or signs of potential
767 retinal detachment. He never viewed the haplets of the IOL that he implanted: we do not
768 know if he even had instruments for doing so. Ophthalmologist-4 did not look for possible
769 complications of retina surgery such as strabismus and diplopia and he did not look for
770 possible complications of peeling the inner limiting membrane such as central scotomas.

771 It seems that the purpose of the present process is to deliver the most cost-effective medical
772 treatment, requiring the least amount of physician time, to the largest number of patients.
773 Other goals must be the responsibility of the patient.

774 4.6 Miscellaneous

775 Be sure to shake eye drops before use, because some are suspensions, not solutions or
776 emulsions. In suspensions, the solids will eventually fall to the bottom. Try to use
777 preservative free eye drops.

778 Professors in medical schools are probably more experienced in dealing with rare cases.
779 When I realized that my case was rare and I found an ophthalmologist at a medical school
780 that solved my major problem, maybe I should have stayed with him, even though it would
781 have meant frequent trips between Los Angeles and Tucson.

782 My final advice is, do not accept an appointment for surgery right before the surgeon is
783 scheduled for vacation! The surgeon may be distracted and you will miss follow-up care.

784 5. CONCLUSION

785 (1) Pain is hard to diagnose, measure, quantify and treat, making it frustrating for both the
786 patient and the physician: in my case, there were many causes of pain and this produced
787 confusion. (2) There was no face-to-face communication between the dozen doctors that
788 were involved in this case: furthermore, many times the written communications were not
789 received, read or understood. (3) In complicated procedures involving many physicians and
790 many physical systems, perhaps there should be a patient’s advocate, who knows the
791 system and is interested only in the patients’ best interests. (4) I found the best metric for
792 choosing a doctor was the amount of time that he or she scheduled for each appointment or
793 operation. (5) For the last six years, I complained about ten specific symptoms, which were
794 treated individually: treating this case as a system of interacting problems led to a better
795 understanding and resolution.

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804 **AUTHORS' CONTRIBUTIONS**

805 Bahill designed the study, performed the statistical analysis, wrote the protocol and wrote the
806 first draft of the manuscript. Barry provided the medical instruments, measurements, clinical
807 images and medical expertise.

808 **CONSENT**

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

810 **REFERENCES**

- 811 1. Stark L, Bahill AT, Ciuffreda KJ, Kenyon RV, Phillips S. Neuro-optometry: an
812 evolving specialty clinic, *American Journal of Optometry and Physiological Optics*,
813 1977;**54**:85-96.
- 814 2. Jones WL (editor), *Optometric clinical practice guideline care of the patient with*
815 *retinal detachment and related peripheral vitreoretinal disease reference guide for*
816 *clinicians*, American Optometric Association, St. Louis, MO,2004.
- 817 3. Bahill AT, Barry PJ. Multimodal Views of the Human Retina, *Ophthalmology*
818 *Research: An International Journal*, 2014;**1**(2): in press.Editor: This paper is first
819 referenced in footnote 1.
- 820 4. Woon WH, Greig D, Savage MD, Spokes D, Skorski S. Thompson GL, Murphy B,
821 Taylor S. Evidence for the aqueous absorption of gas from the eye following
822 vitreoretinal surgery, *Phys. Med. Biol.* 2008;**53**:3309–3316 doi:10.1088/0031-
823 9155/53/12/016
- 824 5. Nadal J, Verdaguer P, Canut MI. Treatment of Retinal Detachment Secondary to
825 Macular Hole in High Myopia: Vitrectomy with Dissection of the Inner Limiting
826 Membrane to the Edge of the Staphyloma and Long-term Tamponade. *Retina*.
827 2012;**32**(8):1525-1530.
- 828 6. Tadayoni R, Svorenova I, Erginay A, Gaudric A, Massin P. Decreased retinal
829 sensitivity after internal limiting membrane peeling for macular hole surgery, *British J*
830 *Ophthalmology* 2012;0:1–4. doi:10.1136/bjophthalmol-2012-302035.
- 831 7. Kolb H, Nelson R, Fernandez E, Jones BW (editors). Webvision: The Organization
832 of the Retina and Visual System, <http://webvision.med.utah.edu/book/> accessed
833 November 2, 2013.
- 834 8. Bahill AT, Acquired Color Blindness Caused by Ocular Surgeries, submitted to
835 *Digital Ophthalmology*, 2014.
- 836 9. Flück D. Colblindor, <http://www.colblindor.com/color-arrangement-test/> , accessed
837 November 2, 2013.

10. Chabris C, Simons D. *The Invisible Gorilla: and Other Ways our Intuitions Deceive us*, New York, Crown Publishers, 2010. Available at: <http://www.theinvisiblegorilla.com/videos.html> Accessed November 2, 2013.
11. Lee RM, Foot B, Eke T. Posterior capsule rupture rate with akinetic and kinetic block anesthetic techniques, *J Cataract Refract Surg*. 2013 Jan;**39**(1):128-31. doi: 10.1016/j.jcrs.2012.11.002.
12. Haug S, Bhisitkul RB. Risk factors for retinal detachment following cataract surgery. *Current Opinion in Ophthalmology* 2012;**23**(1):7–11.
13. Clark A, Morlet N, Ng JQ, Preen DB, Semmens JB. Risk for retinal detachment after phacoemulsification: a whole-population study of cataract surgery outcomes, *Arch Ophthalmology* 2012;**130**(7):882-888.
14. Benson SE, Schlottmann PG, Bunce C, Xing W, Charteris DG. Optical Coherence Tomography Analysis of the Macula after Scleral Buckle Surgery for Retinal Detachment, *Ophthalmology* 2007;**114**:108–112
15. Beutel J, Dahmen G, Ziegler A, Hoerauf H. Internal limiting membrane peeling with indocyanine green or trypan blue in macular hole surgery a randomized trial, *Arch Ophthalmology* 2007;**125**(3):326-332. Doi:10.1001/archophth.125.3.326.
16. Bertin S, Chauvaud D. Simple retinal detachment: computer reconstruction of visual perception during the first month after surgery. *J Fr Ophtalmology*; 2000 Dec;**23**(10):1026-1028.

APPENDIX: SUCCESS RATE

What is the likelihood of success for a medical procedure? That is a hard question to answer, because it depends on the type of operation, the patient, the surgeon, the staff, the year, the operating equipment and the definition of success. This appendix will examine published success rate examples for cataract and retinal detachment operations. The percentages do not total to 100% because the studies had different definitions for the outcomes, which were not mutually exclusive. There is a lot of variability in these numbers as is demonstrated by the large standard deviations.

A.1 Cataract Surgery Success Rate

For simplicity, let us define cataract surgery success as an operation where the biological lens was removed and an artificial IOL was inserted without serious complications. With this definition, papers published in the last decade have documented that 97% of cataract operations are successful ($\bar{x} = 96.7$, $\sigma = 3.6$, $n = 11$) the numbers in parenthesis are (average, standard deviation, number of reports), while 0.8% had posterior capsule rupture [11], 1.4% caused cystoid macular edema that produced visual acuity less than 20/40 ($\bar{x} = 1.4$, $\sigma = 0.6$, $n = 8$), 0.7% caused intraocular infection ($\bar{x} = 0.7$, $\sigma = 0.4$, $n = 11$), which is called endophthalmitis, and 1% were followed by retinal detachment within a year [12] and [13]. The percentages do not total to 100% because the outcomes are not mutually exclusive.

A.2 Retinal Detachment Surgery Success Rate

Of retinal detachment surgeries, about 90% are successfully repaired with a single operation. In the remaining cases, the retina detaches again and needs another operation that has a 50% success rate, which yields an overall success rate of 95% http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Retinal_detachment.

882 If the retina is successfully reattached, another possible failure is ocular misalignment after
883 surgery. Among 821 patients who underwent scleral buckle surgery 1.5% of the patients
884 developed strabismus and diplopia
885 <http://www.ncbi.nlm.nih.gov/pubmed/17978674>. Another study reported that among of 1030
886 patients who underwent scleral buckle surgery 3.8% developed strabismus and diplopia
887 <http://www.ncbi.nlm.nih.gov/pubmed/22466475>. A third study reported that among of 750
888 patients who underwent scleral buckle surgery 3.3% developed strabismus and diplopia
889 [http://80.36.73.149/almacen/medicina/oftalmologia/enciclopedias/duane/pages/v6/v6c059.ht](http://80.36.73.149/almacen/medicina/oftalmologia/enciclopedias/duane/pages/v6/v6c059.html)
890 [ml](http://80.36.73.149/almacen/medicina/oftalmologia/enciclopedias/duane/pages/v6/v6c059.html)
891 The average misalignment percentage for these three reviews is ($\bar{x} = 2.9, \sigma = 1.2, n = 3$).
892 Another possible failure mode is macular edema. A recent paper [14] stated that 55% of their
893 patients who had scleral buckles implanted had cystoid macular edema a. k. a. subretinal
894 fluid ($\bar{x} = 42, \sigma = 37, n = 9$). Less than 1% of retinal detachment operations produced
895 intraocular infection ($\bar{x} = 0.7, \sigma = 0.4, n = 11$).

896 **A.3 Interlimiting Membrane Peeling Success Rate**

897 Macular holes in the retina are commonly treated by peeling off the inner limiting membrane.
898 This operation is effective in closing macular holes. However, ILM peeling has
899 complications: 39% caused central scotomas [15 et al.] ($\bar{x} = 39, \sigma = 15, n = 5$), 0.1%
900 resulted with infection, 1% produced retinal detachment and 75% created a need for cataract
901 removal within one year.