Retinal Imaging

“The eyes are the window to the soul”
16th century proverb

The retina gives an unobstructed view of the human vascular. Also, retinal imaging is important for diagnosing retina diseases.

Retinal Physiology
Rods and Cones

Rod and Cone Density

Adapted after Österberg, 1935
Rod and Cone Mosaic

Direct Ophthalmoscopy
Observer adjusts power of lens wheel so that the patient’s far point is imaged to the Observer’s far point.
**Indirect Ophthalmoscopy**

The Observer holds a high power lens in front of the Patient and views the intermediate image formed by the lens. The system is binocular, so a 3-D feel for structures with the eye is obtained.

![Diagram of Indirect Ophthalmoscopy]

**Fundus Camera**

A fundus camera is a device for photographing the retina. It is based on the indirect ophthalmoscopy principle, where the Observer’s eye is replaced with a camera.
Red-Free Images

Fundus images are sometimes taken with a green filter to enhance the contrast of the blood vessels.

Fluorescein Angiography

Sodium Fluorescein dye is injected into a vein in the patient. As the dye circulates, it passes through the vessels of the retina. Blue light is used to illuminate the retina and fundus photographs are taken to capture the green fluorescence of the dye. This technique aids in visualizing the vessels of the retina.
Indocyanine Green (ICG)

Angiography

Indocyanine Green dye is injected into a vein in the patient. As the dye circulates, it passes through the vessels of the retina. Digital fundus photographs are taken to capture the infrared fluorescence of the dye. This technique aids in visualizing the vessels of the choroid.

Retinal Mosaic
Stereo Pairs

• Two images of the retina can be taken from slightly different angles to form a stereo pair.
• Useful for visualize cupping of the optic nerve head in glaucoma and edema (swelling) that occurs from some pathologies.

Red/Blue Anaglyphs

Take the red channel from the left hand image and the blue and green channels from the right hand image.
Red/Blue Anaglyphs
Merge images to create an anaglyph

Cup to Disk Ratio

- Diameter of the cupped region of the optic nerve head divided by the diameter of the optic nerve head.
- Normal is ~0.3-0.5.
- Abnormal values are higher and are associated with glaucoma

C/D = 0.6
Portable Fundus Camera

Portable Fundus Camera
Normal Retina

Shaken Baby Syndrome

- Severe head injury of baby from being shaken.
- Cause is usually child abuse.
- Poor prognosis, typically severe disabilities in survivors.
- Injuries and symptoms may include:
  - Bruising, swelling and bleeding in the brain.
  - Lethargy, loss of consciousness, convulsions.
  - Hemorrhages in the retina.
  - Possible broken or dislocated bones.
Shaken Baby Syndrome

• SBS and Retinal Hemorrhages
  – 50-80% of SBS have retinal hemorrhages
  – 60-90% are bilateral
  – Retinal Hemorrhages is strong confirmatory evidence of abuse.

• Victims are usually in a pediatric intensive care unit and cannot be easily moved to ophthalmology departments for conventional fundus photographs.
• Victims usually cannot sit upright, so conventional fundus cameras cannot be used.
• Emergency room and intensive care personnel may not be well versed in traditional retinal examination, so an easy to use camera may aid in identifying retinal hemorrhages.
• Inexpensive cameras can be placed in multiple hospitals.
• Digital photographs can easily be transmitted for consultation by off-site ophthalmologists.
• Child Protective Services and the Police can use the photographs as evidence against abusers, instead of solely relying on the expert verbal testimony of an ophthalmologist.
Shaken Baby Syndrome

Child Abuse
Veterinary Use

Scanning Laser Ophthalmoscopy

Scanning confocal microscope
Adaptive Optics

Nerve Fibers  Blood Vessels  Photoreceptors

Adaptive Optics
Retinal Densitometry

Scanning Laser Polarimeter
Optical Coherence Tomography

A low coherence light source is used

Macular Degeneration

- An age-related degenerative disease of the retina that causes loss of the rods and cones.
- Vision is lost in the center of the visual field, which makes reading especially difficult.
- Peripheral vision is spared.
- 30% of People over 80 years of age suffer from this disease.
Macular Degeneration

Normal Macula (Cross-Section)

- Retina
- Choroid
- Macula
- Blood vessels
- Capillaries
- Rods and cones
- Bruch's membrane
- Retinal pigmented epithelium (RPE)
Macular Degeneration

Dry Macular Degeneration (Cross-Section)

- Retina
- Choroid
- Blood vessels
- Drusen
- Capillaries
- Rods and cones
- Bruch’s membrane
- Retinal pigmented epithelium (RPE)

Macular Degeneration

Wet Macular Degeneration (Cross-Section)

- Retina
- Choroid
- Blood vessels
- Blood
- Capillaries
- Rods and cones
- Bruch’s membrane
- Retinal pigmented epithelium (RPE)
Retinitis Pigmentosa

- Hereditary Disease
- Slowly destroys photoreceptors
- Usually progresses earlier in life
- Starts in mid-periphery and works towards central and peripheral vision.
Background

- In 1967 GS Brindley applied an electrical stimulation to the retina of a completely blind nurse.
- The nurse reported seeing some very distorted images and light.
- This means the wiring is ok, but the sensors are bad.

Subretinal Implant
FDA Trials

- Implant surgery was performed in the first three recipients in June 2000, and three others received the implant in July 2001.
- The patients range in age from 46 to 76 years and baseline vision ranged from count fingers to almost no light perception.
- Surgery was performed unilaterally with the fellow eye serving as a control.
FDA Trials

• All patients have noted varying degrees of improvement in their vision, with some gaining perception of light and shapes.
• Two patients showed dramatic improvements in visual acuity following treatment: one from none at baseline to 20 to 25 letters and another from 20 at baseline to 40 letters.

Epiretinal Implant
Hurdles For Retinal Implants

- Materials – Body must not reject the sensor – Silicone, Platinum & Iridium
- Lifetime – Sensor must function for years or decades
- Power – Energy must be indirectly supplied to the implant – Solar powered batteries.