FROM CORNEA TO OPTIC NERVE: HOW VISUAL FUNCTION IS AFFECTED WHEN THERE IS A FLAW IN THE SYSTEM

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ANATOMY OF THE EYE

Conjunctiva

Ora serrata

Ciliary body

Aqueous

Iris

Anterior chamber

Cornea

Pupil

Lens

Posterior chamber

Canal of Schlemm

Conjunctiva

Vitreous

Sclera

Choroid

Retina

Macula

Artery (central retinal)

Optic nerve

Vein (central retinal)

Rectus medialis
• When light strikes the cornea, it bends—or refracts—the incoming light onto the lens.
• The iris opens/closes to control the amount of light that enters the eye.
• The lens further refocuses that light onto the retina.
• The retina is a layer of light sensing cells lining the back of the eye that starts the translation of light into vision.
• For you to see clearly, light rays must be focused by the cornea and lens to fall precisely on the retina.
• The retina converts the light rays into impulses that are sent through the optic nerve to the brain, which interprets them as images.

NIH Facts about the Cornea
Emmetropic (Normal) eye
• In an emmetropic eye, the optical system of the eye (cornea, lens, axial length) is such that all reflected points of light from the object are focused on the retina to form a clear image.

• When the optical system of the eye is not “perfect” (ammetropia), we use lenses to change the vergence of the rays reflected off of the object so that the image formed is clear.
Hyperopic (Farsighted) eye
• When someone is hyperopic or farsighted, the focusing system of the eye is not strong enough.

• The cornea is flat or the eyeball is too short.

• Light rays do not focus on the retina but come to focal point behind the retina.

• Farsighted people see better at distance than they do at near.

• Until the age of 40, we can change the shape of the lens inside the eye to bend the light more so that it focuses on the retina (accommodation).

• Hyperopia is treated with converging lenses.
• Children can accommodate very well so this can be missed unless the child’s eyes are dilated.
• Dilation temporarily paralyzes the muscles that allow for accommodation so we can determine if a child has latent hyperopia.
• Uncorrected hyperopia makes reading and all near tasks difficult, so it is important that it is detected in children.
• Accommodation is affected in concussion/mild TBI so young patients may notice difficulty reading and even notice blurry distance vision if they have latent hyperopia.

• Latent hyperopia can cause headaches, visual fatigue, difficulty focusing and problems with concentration.

• A cycloplegic refraction should be performed in any young patient that is suspected to have latent hyperopia.
HYPEROPIA CORRECTED WITH CONVERGING LENS

Hyperopia

Hyperopia With Correction
Myopic (Nearsighted) eye
• People that are myopic or nearsighted have a focusing system that is too strong.
• The cornea is steep or the eyeball is too long.
• People that are nearsighted see better at near than at distance.
• Uncorrected myopia is not as great of a problem in children since most of their work is at near.
• It is usually discovered at a school screening or when the child makes mistakes copying from the board.
• Myopia is treated with diverging lenses.
MYOPIA CORRECTED WITH DIVERGING LENS
Astigmatic eye
• People with astigmatism have 2 focal points to the eye.
• We usually describe it as an eye that is not round but shaped like a football, thus creating two focal points.
• This irregularity in the curvature can occur in the cornea or the lens.
• In eye disease, it can also occur in the retina.
• Depending on the type of astigmatism, this can also be undetected in children.

• Uncorrected astigmatism in most cases affects near vision more than distance vision.

• Like hyperopia, it is often necessary to dilate a child’s eyes in order to detect the full amount of the astigmatism.

• Astigmatism is corrected with cylindrical lenses.
ASTIGMATISM IS CORRECTED WITH A CYLINDRICAL LENS
CORNEA

Diagram of the eye showing:
- Optic Nerve
- Conjunctiva
- Pupil
- Lens
- Iris
- Sclera
- Retina
- Cornea
• The cornea is the eye's outermost layer. It is the clear, dome-shaped surface that covers the front of the eye.

• It helps to shield the rest of the eye from germs, dust, and other harmful matter.

• The cornea acts as the eye's outermost lens. It functions like a window that controls and focuses the entry of light into the eye. The cornea contributes between 65-75 percent of the eye's total focusing power.

NIH Facts about the Cornea
Anything that affects the clarity of the cornea will affect vision.

- Eye infections that cause corneal scarring (bacterial, viral, fungal)
- Corneal dystrophies
- Keratoconus
- Severe dry eye
- Congenital anomalies
- Trauma
- Iridocorneal endothelial syndrome
- Pterygium
- Stevens-Johnsons syndrome
KERATITIS (CORNEAL INFEC TION)
CORNEAL DYSTROPHY
CORNEAL DYSTROPHY
BACTERIAL INFECTION
MICROCORNEA WITH IRIS COLOBOMA
PETER’S ANOMALY
KERATOCONUS
HERPES INFECTION
CORNEAL LACERATION
PTERYG IUM

Web Atlas of Ophthalmology
@ WebEyeMD.com
AFFECT ON VISION

• Damage to the cornea, whether it is disease or trauma, will cause vision to become blurry
• Disease will cause the cornea to become cloudy
• Trauma will cause scarring or even large amounts of astigmatism 2/2 corneal irregularity
• Corneal swelling from endothelial damage will also cause blurry vision and problems with glare and contrast sensitivity
CORNEAL TRANSPLANT
• Penetrating keratoplasty
  Full thickness of cornea removed—not performed as much

• Endothelial keratoplasty (EK)
  Removes tissue from the back corneal layers
  Descemet stripping endothelial keratoplasty (DSEK) - uses donor tissue to replace ~1/3 of cornea
  Descemet membrane endothelial keratoplasty (DMEK) – uses a much thinner layer of donor tissue

• Anterior Lamellar keratoplasty (ALK)
  Removes diseased tissue from the front corneal layers but leaves the back layer in place

• Advantage of EK and ALK: much less astigmatism post transplant! Better visual acuity.
ARTIFICIAL CORNEAL TRANSPLANT: KERATO PROSTHESIS (KPRO)
SCLERAL CONTACT LENSES
IRIS

- The colored part of the eye is called the iris.
- It controls light levels inside the eye similar to the aperture on a camera.
- The iris is embedded with tiny muscles that dilate (widen) and constrict (narrow) the pupil size.
- Most of the disorders in the iris are due to congenital anomalies, inflammation or trauma.
Fig. 1. View of the human eye
ANIRIDIA
TRAUMA
ICE SYNDROME
AFFECT ON VISION

• Since the iris regulates the amount of light in the eye, damage to the iris will cause light sensitivity, decreased vision due to light scatter and problems with glare
COSMETIC CONTACT LENSES
LENS

Lens

Zonules
• The crystalline lens is located just behind the iris.
• Its purpose is to focus light onto the retina.
• The nucleus, the innermost part of the lens, is surrounded by softer material called the cortex. The lens is encased in a capsular-like bag and suspended within the eye by tiny "guy wires" called zonules.
• In young people, the lens changes shape to adjust for close or distance vision (accommodation).
• With age, the lens gradually hardens, diminishing the ability to accommodate.

www.stlukeseye.com/Anatomy/Lens.asp
• The most common disorder to the lens is a cataract – a clouding of the lens.
• Like the cornea, anything that affects the transparency of the lens will cause vision loss.
• Cataracts can be congenital, toxic, traumatic, diabetic or “senile” (normal age related).
• The lens can also be dislocated in trauma or in systemic disease.
• In cataract surgery, the cloudy lens is removed and replaced by a thin, plastic lens.
SENILE Cataract
MARFAN’S SYNDROME WITH DISLOCATED LENS
CONGENITAL CATARACT
TRAUMATIC CATARACT
AFFECT ON VISION

- Similar to damage to the cornea
- Decreased visual acuity
- Myopic shift in refractive error
- Decreased color vision
- Decreased contrast sensitivity
- Poor night vision
- Effects on daily life: trouble with glare and contrast, reduced acuity.
INTRA OCULAR LENS
The Retina

Macula
Optic Nerve Head
Retina
The retina is a multi-layered sensory tissue that lines the back of the eye. It contains millions of photoreceptors that capture light rays and convert them into electrical impulses. These impulses travel along the optic nerve to the brain where they are turned into images. Vision loss due to the retina can occur secondary to retinal dystrophies, vascular disorders, hereditary disease, detachment, trauma, inflammation and toxicity. Because the retina is sensory tissue (nerve cells), we have no cure for most retinal diseases.

www.stlukeseye.com/anatomy/Retina.asp
RETINITIS PIGMENTOSA

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CHLOROQUINE MACULOPATHY

Figure 108-7 Chloroquine bull's-eye parafoveal atrophy.
STARGARDT’S DISEASE
CONE DEGENERATION
CENTRAL RETINAL ARTERY OCCLUSION
DEGENERATIVE MYOPIA
RETINAL COLOBOMA
SHAKEN BABY SYNDROME
DIABETIC RETINOPATHY
AFFECT ON VISION

- The affect on vision will depend upon which photoreceptors are damaged.
- Disease that affects the cone photoreceptors will cause either metamorphopsia, a relative scotoma or a dense central scotoma.
- Damage to the cone photoreceptors will also cause reduced color vision, severe photosensitivity and difficulty with glare.
- Damage to the rod photoreceptors will cause constricted visual fields and poor night vision.
CONE PHOTORECEPTOR DYSFUNCTION
EFFECTS ON DAILY LIFE

- Difficulty reading and inability to recognize faces (leads to reluctance to participate in social activities).
- Difficulty with distance and depth cues (adversely affects safe mobility).
- Loss of color and contrast (interferes with a variety of leisure/household tasks).
Rod Photoreceptor Dysfunction

ROD AND CONE PHOTORECEPTOR DYSFUNCTION

Diabetic Retinopathy
EFFECTS ON DAILY LIFE

- Difficulty reading and recognizing faces.
- Increased sensitivity to glare.
- Difficulty with light/dark adaptation.
- Difficulty with distance and depth cues.
- Loss of color and contrast sensitivity.
- Fluctuating vision.
- Difficulty with diabetes self-care.
OPTIC NERVE
glossary term

**optic disc / optic nerve head**

The circular area (disc) where the optic nerve connects to the retina.

Illustration courtesy of [JirehDesign.com](http://JirehDesign.com)
• The optic nerve transmits electrical impulses from the retina to the brain.
• It connects to the back of the eye near the macula.
• The optic disc is the most anterior portion of the optic nerve and is the only part of the nerve that we can view in an eye exam.
• Vision loss secondary to optic nerve disease can be congenital; secondary to trauma, drugs or other toxic agents, inflammation, vascular disease, demyelination disease, compressive lesions in the brain; secondary to glaucoma.
• There is no cure for optic nerve disease and once the vision is lost, it cannot be regained.

www.stlukeseye.com/anatomy/OpticNerve.asp
OPTIC ATROPHY
OPTIC DISC EDEMA
OPTIC DISC COLOBO MA
AFFECT ON VISION

• Damage to the optic nerve causes decreased visual acuity and decreased visual field
• The pattern of visual field loss is dependent upon where the damage to the optic nerve is located
• Visual acuity can also be affected
• Color vision and contrast sensitivity or reduced
• Light sensitivity and glare are also a problem
• If the optic nerve is compressed due to a tumor or swelling, the visual acuity and visual field loss can return to baseline
• The longer the compression/swelling remains, the less likely there will be any improvement.
Normal Vision

Early Glaucoma

Advanced Glaucoma

Extreme Glaucoma

https://caeps.org/8426016

(Photo by CHONA M. DUROGA)
Visual Field

1. Left Eye
2. Right Eye
3. Optic Nerve
4. Optic Chiasm
5. Optic Tract
6. Lateral Geniculate Nucleus
7. Visual Cortex
8. Visual Cortex

Visual Field Diagram:

1. 1/2
2. 1/2
3. 1/2
4. 1/2
5. 1/2
Cranial Nerve Name

I - Olfactory
II - Optic
III - Oculomotor
IV - Trochlear
V - Trigeminal
VI - Abducens
VII - Facial
VIII - Vestibulocochlear
IX - Glossopharyngeal
X - Vagus
XI - Spinal Accessory
XII - Hypoglossal
VISION

• Most of what we think of concerning vision actually takes place in the brain.

• The eyeball (globe) itself is only the image capturing mechanism.

• If you think of the eye as a camera, the retina is like the film that captures the image.

• The developing (processing) of the image takes place in the brain.
Figure 2. The dynamics of closed-head injury. The coup or acceleration injury occurs when the head hits the fixed surface. The contrecoup or deceleration injury occurs as the head bounces back. Reprinted from Zost, MG. Diagnosis and management of visual dysfunction in cerebral injury. In Maino: DM, ed. Diagnosis and Management of Special Populations. Santa Ana, CA: Optometric Extension Program Foundation, 2001. (Originally published by Mosby.)
VISUAL SEQUELAE OF ABI

- Decreased visual acuity.
- Visual field losses - central, congruous and incongruous homonymous hemianopias, altitudinal defects.
- Eye movement dysfunctions - fixation, pursuit, saccade, nystagmus.
- Ocular muscle dysfunctions - strabismus, anisocoria, laophthalmos, ptosis.
- Accommodative dysfunctions - amplitude, flexibility, sustainability
- Binocular dysfunctions - exophoria, convergence insufficiency, vertical phorias, fusional instabilities
- Perceptual dysfunctions - contrast sensitivity, color vision, body image, left-right discrimination, spatial relationships, agnosias, "subjective visual disturbances"
- Visually-involved vestibular dysfunctions - vertigo, loss of balance
• The natural recovery from an ABI can be up to 1 year post injury and incomplete.
• Many patients are left with multiple residual deficits, *including reading and visual scanning dysfunctions* relating to the ocular motor dysfunctions.
• These residual deficits may adversely affect their rehabilitation as well as other avocational and vocational goals.


WHAT IS “LOW VISION”?
VISUAL IMPAIRMENT

- Any chronic visual deficit that impairs everyday function and is not correctable by eyeglasses, contact lenses or surgical/medical intervention.
- Any damage to the visual system that impedes the ability to re-learn or perform usual tasks of daily life, given their pre-morbid level of activity.
- Damage to the ocular structures and damage to the brain that can cause visual impairment or low vision.
VISUAL IMPAIRMENT IN CHILDREN

- Approximately 3% of persons under the age of 18 have visual impairment.
- Leading causes of legal blindness in children: in developed countries: cerebral vision impairment, optic nerve hypoplasia, inherited disorders.
- Blindness occurs mainly among children with very low birth weight (<1,000 grams).
- The number of children with vision impairment is expected to rise with the increase in multiple births as well as the improved survival of low-birth-weight babies.
- One study found that 63% of very low birth weight children had reduced visual function.
• Another study found that the rate of vision impairment for babies less than 1500 grams was 26% higher than for higher birth weight babies.
• In this study, very low birth weight babies accounted for 17.5% of all severely impaired children.
• The CDC found that from $\frac{1}{2}$ to $\frac{2}{3}$ of children with vision impairment also had one or more other developmental disabilities.
• Crofts et al concluded “Although the contribution made by babies with very low birth weight to overall severe vision loss in the community is small, many of these children have additional impairments and probably place considerable demand on health and educational services and families”.


www.cdc.gov/ncbddd/dd/vision3.htm
• Since 80% of learning in the first 12 years is visual, children with vision impairment require low vision services throughout their schooling.

• Determining the child’s functional vision as early as possible provides valuable information to the teacher.

• Low vision devices can be beneficial at an early age and will change as the child’s school needs change.
VISION LOSS FROM EYE DISEASES WILL INCREASE AS AMERICANS AGE

- As of 2012, 4.2 million Americans age of 40 and over have visual impairment
- This figure is projected to reach 8.96 million by the year 2050 due to the increasing epidemic of diabetes and other chronic diseases and our rapidly aging population
- People 80+ make up 8% of the population but account for 69% of blindness.

https://www.cdc.gov/visionhealth/basics/ced/fastfacts.htm

WHAT IS REHABILITATION?

• According to Webster, “rehabilitate” means to restore or bring to a condition of health or useful and constructive activity.
• It is the process used to train someone to be able to perform tasks in spite of a loss of physical function.
• It is goal driven.
• It requires a multidisciplinary approach.
• In low vision rehabilitation, the physical function that has been lost or compromised is vision.

• The goal of low vision rehabilitation is to teach the individual with vision loss how to perform daily tasks with reduced visual function.
ADAPTATION THROUGH VISION
VISUOCOGNITION
VISUAL MEMORY
PATTERN RECOGNITION
SCANNING
ATTENTION = ALERT AND ATTENDING
OCULO MOTOR CONTROL VISUAL FIELDS
VISUAL ACUITY
GOAL OF REHABILITATION

• “The ultimate goal of most people is to enjoy a high quality of life through mutually satisfying interpersonal relationships and meaningful contributions in a manner that allows them to value themselves and to be valued by others – family members, friends and neighbors, and society as a whole”. (Corn and Koenig, 2000)

• **Utilizing a team approach to low vision rehabilitation allows the person with vision loss to achieve this goal!**
LOW VISION EVALUATION

• The low vision evaluation is the necessary first step in the low vision rehabilitation process.

• The purpose of the low vision evaluation is to determine the level of functioning vision – what vision is available for the individual to use to perform daily tasks.

• This is critical information for the entire rehab team.
• How do you know if someone has “low vision”?
• What visual acuity constitutes “low vision”? 
Most agencies use 20/70 vision as the reference acuity for providing services. So, 20/70 acuity has become the defining acuity for “low vision”.

ANY level of acuity that interferes with an individual’s activities of daily living can be an impairment.
EXAMPLE

• Individual with 20/50 visual acuity that does not drive. Main hobby is watching television. This level of acuity is not adversely affecting quality of life.

• Individual with 20/50 visual acuity that is a salesman with South Texas as his territory. Enjoys reading the stock pages. The same acuity level will drastically alter quality of life.
A person who has difficulty accomplishing visual tasks, even with prescribed corrective lenses, but who can enhance his or her ability to accomplish these tasks with the use of compensatory visual strategies, low vision and other devices, and environmental modifications.
THE ROLE OF THE LOW VISION OPTOMETRIST

• Assess the clinical visual functioning
• Match treatment options to the stated goals
• Prescribe optical and non-optical devices
• Ensure that visual skills are successfully integrated
• Usually serve as the coordinator of the low vision team
• The low vision evaluation is different from a conventional eye exam in that our focus is on what vision is left, not what vision has been lost!

• More time is needed
  - Requires an extensive history including goals
  - Additional functional tests need to be performed
  - Initial device demonstration
  - Discuss the rehab plan
COMPONENTS OF THE LOW VISION EVALUATION
VISUAL ACUITY

• Always inquire about a previous RX! Glasses are often lost or broken, especially in TBI patients.
• Numbers or Lea symbols may be easier for the patient to identify than letters.
• If the patient has aphasia, utilizing a matching technique with the Lea symbols is quite effective.
• Near visual acuities should always be performed since accommodative dysfunctions are also common after ABI.
Can't quite make it out, Mrs. Garlock? And we drove here all by ourselves, did we?
DISTANCE AND NEAR ACUITIES
• Visual acuities are necessary since they are used to qualify patients for eligibility for services as well as to qualify for disability.

• We use large targets and allow the patient to hold their head and/or eyes in whatever position allows them to see better.

• We use numbers, letters or symbols – whichever is most appropriate.

• We always measure single letter and test acuity since patients may have the ability to read single letters but be unable to read continuous text (mild aphasia, paracentral scotomas).
DISTANCE ACUITY CHARTS

[Image of an eye chart with letters and numbers for testing visual acuity]

[Image of a number chart for testing visual acuity]

[Image of various shapes for testing visual acuity]
GRATING ACUITY
• Crowding is more of a factor in the patient with ABI - isolating a line or even each letter may help.

• If the patient reads letters, we use a child’s text near card. Less severe aphasia will be more evident.

• Mild aphasia that interferes with reading may never have been diagnosed or addressed!
CROWDED VS. NON-CROWDED ACUITY
NEAR TEXT CARDS

My bird sings.
Helen has a pet hen.
Dogs make good friends.
Jack can make a good cake.
RETINOSCOPY
The first step in the low vision evaluation is to determine if the visual acuity can be improved with lenses. Most ophthalmologists do not have the staff that can refract patients with low vision. The refraction is time consuming, so it is often simply not performed. Retinoscopy and autorefraction are ways to get an objective measure of the refractive error.
REFRACTION
• The refraction is the “which is better, one or two” component of the eye examination.

• We tend to use a trial frame rather than a phoropter because it allows us to use larger increments of change, making it easier for the patient.

• It also allows the patient to hold their head and/or eye in any position necessary.

• We check near vision as well, often using near lens powers that are much stronger than most doctors are comfortable prescribing.

• The refraction is important since what we want to know is the “best corrected” visual acuity.
PERIPHERAL FIELD TESTING
• I use the tangent screen since it is quick and easy to perform.

• It gives me a better idea as to the functional visual field.

• It is helpful for family members to understand the scope of the visual field loss.

• However, for disability purposes, the automated visual fields are needed.

• Automated visual fields are acuity dependent so people with reduced acuity will usually appear to have much worse visual fields.
CENTRAL VISUAL FIELDS

- For patients with macular disease, it is important to measure the central field.
- I use the Fletcher Central Tangent test.
- Quick, easy, inexpensive and also a good tool to show the patient and family members for education.
COLOR VISION AND CONTRAST SENSITIVITY TESTING
• **Color vision is important for activities of daily living and in particular, impacts hobbies (sewing, painting).**

• **We can’t do anything to improve color vision but often it is not really the color vision that is the problem but poor contrast.**

• **Poor contrast is very common with people that have vision loss and it can be helped with the proper lighting and with tinted shades (filters).**
INTERNAL AND EXTERNAL OCULAR HEALTH
Undilated pupil

Dilated pupil

Optic nerve

Light beam

Pupil

Retina

Portion of retina that can be seen through undilated pupil.

Portion of retina that can be seen through dilated pupil.
TONOMETRY
NEAR AND DISTANCE TESTING OF VISION ENHANCING DEVICES, INCLUDING OPTICAL, ELECTRONIC, AND NON-OPTICAL DEVICES.
• This is the goal driven portion of the evaluation.
• I know what tasks the patient wants to perform (reading, sewing, woodwork, driving).
• I know the patient’s functional vision – visual acuity, peripheral and central visual fields, color vision and contrast.
• We now look at optical and non-optical devices that will allow the patient to perform the tasks.
• I then discuss the findings and address each goal, stressing what goals we will be able to meet (reading) and which ones we may not be able to meet (driving).
DECREASED VISUAL ACUITY

- Magnification is the main principle used in low vision devices.
- If the visual acuity is reduced, the objects need to be larger for the patient to identify them.
- Magnifiers simply make the print bigger BUT bigger is not necessarily better.
- The stronger the magnifier, the smaller the field of view.
MAGNIFICATION FOR NEAR
MAGNIFICATION FOR DISTANCE
TALKING DEVICES

- Talking device for reading newspapers
- Talking device for reading text
- Talking device for medication reminders
- Talking device for time and date information

Images show various talking devices for different purposes, such as reading aloud, reminders, and time information.
• A low vision evaluation is an important first step in the low vision rehabilitative process.

• The low vision evaluation is NOT the same as a regular ophthalmic evaluation.

• The purpose is to determine the functional or usable vision and how the vision loss is affecting quality of life.

• Instead of focusing on how much vision has been lost, the focus is on how much vision is left!
TRAINING IN THE USE OF LOW VISION DEVICES

• The role of the optometrist is to determine the functional vision and make device recommendations
• That is only the first step in the process
• A low vision therapist/occupational therapist will work with the patient performing activities of daily living utilizing the devices preferably in the home
• They will also make recommendations for environmental changes and other strategies to make the home safer and more organized
• A TEAM APPROACH IS NECESSARY FOR SUCCESS!
ADAPTATION THROUGH VISION

VISUOCOGNITION

VISUAL MEMORY

PATTERN RECOGNITION

SCANNING

ATTENTION = ALERT AND ATTENDING

OCULOMOTOR CONTROL VISUAL FIELDS

VISUAL ACUITY
THANK YOU!