Fun with Prisms!
Everything you ever wanted to know about the use of prisms

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Why do we love prisms?

- A prism has the ability to shift images.
- It is a very useful tool in optometry where we have a need to shift images so people no longer see double or can more easily be aware of objects in their peripheral vision.
Prisms

A **prism** is a transparent optical element with flat, polished surfaces that refract (bend) light.

It has a base and an apex.

The rays are bent toward the base of the prism.

Amount of bending depends on the angle of incidence and the refracting power of the prism.
Prisms deflect light towards the base of the prism.
Prism Diopter

- Prism power is defined by the amount of deviation produced as a light ray traverses the prism.

- The deviation is determined by centimeters of deflection 100 cm from the prism.

- Example: a $15^\circ$ held base down in front of a laser will displace the beam 15 cm down at a distance of 100 cm from the prism.

- The amount is expressed in prism diopters.

- Abbreviations: P.D. or $^\wedge$
FIG II-65—Definition of prism diopter.
How does the prism work?

- It works by displacing an image.
- Where the image is displaced depends on whether considering a real or virtual image.
- If a prism is introduced into the path of light rays that are converging to form an image (for instance, a slide projector or laser beam) all of the light rays are bent toward the base of the prism.
- The image is displaced toward the base of the prism.
- The image is a real image.
FIG II-67—Real images are displaced toward the base of a prism.
Virtual Image

- Turn the light around (making the image the object) and view the object through the prism (placing the prism in front of the eye).

- An image of the object is formed by the prism which is displaced toward the apex of the prism.

- **Image perceived by the eye is virtual.**

- **Virtual images are displaced toward the apex of the prism although the light rays themselves are bent toward the base of the prism.**

- Since we place prisms in front of the EYE, the image will always be displaced towards the APEX of the prism.
FIG II-68—Virtual images are displaced toward the apex of a prism.
Image Displacement with Prism
The prism displaces the image towards the base

When the prism is placed in front of the eye, the eye sees the image displaced towards the apex.
The stronger the prism, the thicker it makes the lens in the glasses.

Prisms greater than ~5° will start to cause some distortion.

In glasses, we will “split the prism” – put half in each lens. This makes the lenses equal in thickness and decreases the amount of distortion.

Horizontal prism, the base is the same in both lenses – either both BO or BI.

Vertical prism – one is BU and the other is BD.
Who discovered the prism?

- Albert Einstein
- Galileo
- Isaac Newton
- A leprechaun
Isaac Newton

- 1666 - discovered that prism refracts different colors at different angles
- 1670-1672 – lectured on optics
- Much of what we now know about prisms and light is from that early work
Cover/Uncover Test

- Assesses eye alignment
- **Tropia**: eye turns in, out, up or down
- Can be constant or intermittent
- Can always be the same eye or alternate between the eyes
- **Phoria**: a tendency for the eye to deviate
The displaced image from the eye that has strabismus is seen in the opposite direction of the eye turn.

A hypotropic eye sees the displaced image above the other image, a hypertropic eye sees the image below.

A right exotropic eye sees the displaced image to the left of the other image.

A right esotropic eye sees the image to the right of the other image.
Maddox Rod

- Best test to see the natural alignment of the eyes
- Will not determine if it is a tropia or phoria
Von Graefe Test (Dissociated Phoria Test)

- Create double vision using prism: vertical prism in one eye and horizontal prism in the other eye.

- Determine the horizontal phoria by moving the base in prism towards zero. “Tell me when the two images are aligned like buttons on a shirt:.

- Determine the vertical phoria by moving the base up prism towards zero. “Tell me when the two images are aligned like headlights on a car.”
Correcting Strabismus with Prism

- **Hypotropia:** The deviated eye is DOWN so you would use base UP prims to shift the eye UP to align the images.

- **Hypertropia:** The deviated eye is UP so you would use base DOWN prism to shift the eye DOWN to align the images.

- **Exotropia:** the deviated eye is turned OUT so you would use base IN prism to move the eye IN to align the images.

- **Esotropia:** the deviated eye is turned IN so you would use base OUT prism to move the eye OUT to align the images.
Examples

10^OD Exotropia

If we placed all of the prism in the right lens, the lens would be significantly thicker than the left and the distortion would be enough to cause a decrease in visual acuity. So we would Rx 5^ BI in both the right and left lens.

4^ OS Hypertropia

Although we could place 4^BD in the left lens (not much distortion and not really very thick), we would still split the prism and place 2^ BD in the left lens and 2^ BU in the right lens.
Fresnel Prism

- Press on prism
- A piece of plastic with diffraction rings that give it a prismatic effect.
- Has a base and an apex and works just like a “real” prism.
- Available in 1 – 10 diopters in 1 diopter increments, 12, 15, 20, 25, 30, 35 and 40 diopters.
- Costs ~ $30
- The greater the power, the more it blurs the vision.
- It is usually applied to the back surface of the lens in the glasses.
Fresnel Lenses

- Advantages: lightweight, easy to apply, can apply to only half of the lens, can try out prism before placing in lenses, can use for temporary strabismus (nerve palsies due to diabetes or TBI).

- Disadvantages: compromise acuity, especially with higher power prisms; glare and chromatic aberration, difficult to clean, fall off, cosmesis.
Advantages

- Allows us to trial prism before ordering glasses with prism ground in (costly).
- Can be used in very high powers when a conventional prism would be too thick.
- Can continue to change the power as the diplopia 2/2 CN palsies improves with time.
- The blurring effect is helpful when unable to neutralize the strabismus 100%.
- Can be used for diplopia as well as with visual field loss.
Diplopia – double vision

Double vision makes it difficult to read and comprehend.

- 4 basic categories of diplopia that we encounter are acquired strabismus, decompensated phoria, mechanical diplopia and monocular diplopia.

- Can use prism in the first 3.

- Most of the patients that we see will fall into the first 2 categories.
The cranial nerves most often affected are CNIII (oculomotor), CNIV (trochlear) and CNVI (abducens).

Cranial nerve palsies are very common in patients with vascular disease, in particular diabetes (the trifecta – diabetes, hypertension, high cholesterol) and in brain injury.

Sudden onset diplopia.

Will often improve with time, usually within 3-6 months.

In the past, would just patch but that is particularly not appropriate for a patient in a rehab setting where the goal is to get back to walking and performing activities of daily living.
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
Cranial Nerve Palsies

**CN III Palsy**

**CN VI Palsy**
We can use a Fresnel prism to eliminate the diplopia by determining the amount of prism that is necessary to achieve single vision.

A Fresnel prism is placed on the lens in front of the deviating eye.

If both a horizontal and vertical deviation (CN3 and 4), can use 2 prisms – highest power on the back of the lens, lower power in front.

Monitor monthly and can change the power as needed.

The prism blurs the vision slightly, which is helpful if we cannot eliminate the diplopia completely.

If the palsy remains after 6 months, can consider surgery or have the prism ground in the glasses at that time.
Decompensated Phoria

- A phoria is a tendency of the eye to turn, either in or out, usually out.
- More common at near.
- Many people do well until they require a bifocal – the additional plus power will relax the eyes even more so now it can be a problem.
- Can use a Fresnel prism just in the reading portion to see if helpful and if so, can get bifocals with prism in bottom only or get separate reading glasses.
Determining the amount of Prism

- Measure the amount of deviation in the phoropter by having the patient look at a letter (will see 2) and use rotary prisms until the image is single.

- Verify outside the phoropter using a prism bar – often will require less prism in free space.

- Use loose prism to ensure the patient sees single at all distances with the prism.

- Demonstrate a fresnel prism.

- May need to place the prism on the non-dominant eye if the blur is an issue.
Steps to Determining Prism Needed

**Phoropter**

**Prism Bar**
Final Steps

Loose Prism

Fresnel
Associated Phoria

- Fixation disparity is a small ocular misalignment of one eye or both eyes when the two eyes are fixating on an object during normal binocular vision.

- The amount of prism which is required to reduce the fixation disparity to zero has been called “the associated phoria”.

- Since you are measuring the misalignment binocularly, can prescribe the amount of prism exactly.

- Uses polarized filters
Near Phoria tests
Case #1

- 37 YO male admitted to the PRC on 10/21/2016 s/p unhelmeted motorcycle collision – hit a mailbox at high rate of speed.
- Injuries: left non-displaced frontotemporal skull fractures, left temporal and occipital SAH and IVH, left femoral neck fracture, multiple facial fractures and other fractures.
- First eye exam on 11/13/2016
Case #1

- Constant large left hypotropia with exotropia – left eye was down and out – CNIII palsy.
- Lagophthalmos – left eye did not close all the way 2/2 significant facial trauma – usually have a ptosis with CIII palsy.
- He had a right head tilt but he was wearing a C-collar
- Since the left eye didn’t close, he had a lot of ointment in that eye so the visual acuity was affected
- DVA uncorrected

  OD: 20/20

  OS: 20/60-2
Case #1

- He was not complaining of double vision – the deviation of the eye was so great that the deviated diplopic image was very far from the primary image so he didn’t notice it and the blur from the ointment helped.

- Our main concern at this time was the corneal integrity.

- We saw him several times and as the nerve palsy improved and the deviation lessened, he began to experience diplopia.

- 12/2/2016 – Finally able to perform a prism evaluation
Case #1

- Phoropter – saw single with $11^\circ$BD OD and $12^\circ$ BI OS.
- Loose prism – saw single with the same amount of prism.
- $11^\circ$ is not available and we did not have a $12^\circ$ so we trialed $10^\circ$BU OS and $10^\circ$ BI OS.
- The vertical prism was placed on the back surface of the lens and the horizontal prism was placed on the front surface.
- He noticed a significant improvement in the diplopia; however, it also blurred the vision somewhat so that is helpful.
Case #1

12/14/2016 – ran in to him at therapy – he said he didn’t think he needed the prism anymore and his left eye no longer appeared down and out.

In the exam room, at distance the eyes were now aligned.

At near, he was still exhibiting an intermittent left exotropia of 18^.

Since he could still fuse, we opted to go with vision therapy rather than prism.

1/25/2017 – final eye exam – no diplopia at distance or near, still high exophoria at near. He will continue with his home exercise vision therapy program.
Case #2

- 71 yo male with history of right Bell’s Palsy X2, left CNVI palsy (microvascular) and subdural hematoma s/p left sided craniotomy after a fall. Also has glaucoma followed in the glaucoma clinic on latanaprost. Complaining of photophobia and diplopia

- Referred to us to manage the diplopia.
Case #2

He presented to us stating that he no longer experiences diplopia in primary gaze – only when he looks to the left which is a challenge while driving. He has to turn his head. He currently uses Rx reading glasses only.
Case #2

- Unaided distance visual acuity:
  - OD: 20/25-1
  - OS: 20/25-2
  - OU: 20/20-2 (-) Diplopia

- Unaided near visual acuity:
  - OD: 20/50
  - OS: 20/32
  - OU: 20/40 (-) Diplopia

- EOMs: Diplopia in left gaze. OS Abduction deficit

- Slight head tilt to right
Case #2

- Cover Test: Primary Gaze
  - Distance: Ortho
  - Near: XP
- Cover Test Left Gaze:
  - Distance: OD hyperT
  - Near: XP
- Maddox Rod: Primary Gaze
  - Vertical: ortho
  - Horiz: ortho
- Maddox Rod: Left Gaze
  - Vertical: OD HyperT
  - Horiz: XP
Case #2

- **Refraction:**
  - OD: -0.25+1.25X030  20/25-2
  - OS: -0.75+1.00X002  20/25
  - OU: 20/25
  - Add: +2.25

- OD: 20/30-
- OS: 20/20-
- OU: 20/20-

- **Von Graefe Distance:**
  - Vertical: 2^BU OS
  - Horizontal: ortho

- **Von Graefe Near:**
  - Vertical: ortho
  - Horizontal: 2XO

- **Dynamic visual acuity:** affected in left gaze only
Case #2

Prism evaluation in left gaze

**Prism Bar:** $10^\text{BU}$ OS neutralized vertical phoria but still horizontal diplopia

**Loose prism:** $10^\text{BU}$ OS neutralized vertical phoria but still horizontal diplopia

**Loose prism:** saw single with $10^\text{BU}$ OS and $1^\text{BO}$ OS

- **Plan:**

  Rx'd Manifest Refraction with +2.25 add

  RTC – after receives glasses for Fresnel trial
Case #2

- Second visit 5 months later– received PALs, happy with vision. Still diplopia in left gaze.

- Visual acuities are good at distance and near

- All other testing results are similar EXCEPT:

- Prism evaluation in left gaze

  Prism bar: no vertical component, single with 1^BO OS

  Loose prism: no vertical component, single with 1^ BO OS

- Wife states that he has always had ahead tilt, even in is baby pictures.
Case #2

- Applied $1^\circ$ Fresnel prism to temporal aspect of OS lens
- Rx for sunglasses given
- Follow-up in one month
- Returned in 1 month – (-) diplopia in left gaze, blurry when looks through prism, difficulty with glare
- Acuities are good at distance and near.
- EOMS: (-) diplopia in left gaze with prism, (+) diplopia in left gaze without prism

Plan

Consult placed to Chadwick for clear glasses with $1^\circ$ BO sector prism lateral aspect of OS lens.

If does well, will consider getting similar in tints or consider fitovers
Case #2

- Loves the new ground in prism
- Doesn’t like to drive without the prism but has problems with glare and photophobia
- Tint evaluation was performed – did well with NoIR 11
- Consult placed to Chadwick for same lenses/frame in NoIR 11 tint
What causes a rainbow?
A rainbow is caused by reflection, refraction and dispersion of light in water droplets resulting in a spectrum of light appearing in the sky. The droplets of water act like prisms.

Rainbows caused by sunlight always appear in the section of sky directly opposite the sun.
Visual Field Loss

- Homonymous hemianopsia is the most common visual field loss after ABI.
Visual Field Loss

- Homonymous hemianopia is the most common.
- Can also have neglect, either by itself or in combination with hemianopsia.
- Several types of prism placement can be utilized to help the patient navigate more safely.
- The type of prism selected is dependent upon whether neglect is present and the cognitive abilities of the patient.
Visual Field Loss without Neglect

There are two major prism options for visual field loss without neglect:

- Sector prism
- Peli Prism

The first requires the patient to actively scan into the prism.

The Peli prism requires a level of cognition to understand how it works.
Sector prism

- Applied to half of the lens on the affected side, BO.
- Can apply to temp and nasal side or temp only on affected side.
- Does require that the patient scan into the prism.
- This shifts the image so that they are aware something is there.
- Very helpful for mobility.
- Start with Fresnel and then can have them ground in.
- 10° to 20°
Sector Prisms for Hemianopia
Training to Use the Sector Prism

- THE PRISM WILL NOT BE SUCCESSFUL WITHOUT ADEQUATE TRAINING!
- Training is done in our clinic by the BROS.
- Scanning training is augmented with the Dynavision/Bioness Integrated Therapy System (BITS)
Scanning Training

Dynavision

BITS
Peli Prism

- Uses the concept of physiological diplopia.
- $40^\circ$ strip of prism placed BO in the superior and inferior portion of the lens on the affected side.
- Shifts the image to the seeing side of the opposite eye so the patient sees a shadow.
- Serves as an early warning system to alert the patient that something is there.
- Since scanning is not required, theoretically could be used for neglect but really disconcerting so need to be able to understand the concept.
Peli Prism
Standard Peli
Oblique Peli
Case #3

- 44 y/o male
- 1999 – aneurism: left inferior rectus palsy and right homonymous hemianopsia
- He has worn glasses with vertical prism (12^ split between the right and left lens) but he wanted contact lenses and was fit with contact lenses.
- He now exhibits a significant right head tilt because that is the only way he can see single.
- Referred to our clinic to consider prism for his visual field deficit.
Case #3

- Best Corrected distance acuity with CLs
  - OD: 20/20
  - OS: 20/20-1
  - OU: 20/20 with right head tilt

Near Visual Acuity
- OD: 20/40
- OS: 20/50
- OU: 20/32 with right head tilt

Text Acuity with +1.50 add over CLs
- OD: 20/20
- OS: 20/20
- OU: Diplopia
Case #3

Cover Test

Distance: Large left hypertropia
Near: Large left hypertropia

Maddox Rod

Vertical: ~25^ left hyper
Horizontal: Exophoria, increased with add

EOMs: Restricted right inferior gaze OS

Confrontation Visual fields:

OD: Complete right hemifield defect
OS: Complete right hemifield defect
Case #3

Prism Evaluation for Hypertropia

**Distance** – unable to perform behind phoropter 2/2 suppresses OS

Prism Bar: 5^ BD OS for single

Loose prism: 6BD OS for single

No horizontal prism required

**Near**

Unable to appreciate single with any prism 2/2 cyclo component at near

Can read 20/20 with OS occluded – hasn’t been able to read since the aneurism
Case #3

Tangent Screen:

OD: Complete right hemifield defect
OS: Complete right hemifield defect

Applied 15^ OD Fresnel sector prism to lateral aspect of right lens

He appreciated how much more of his right field he was able to determine by simply moving his eye instead of his head.
Case #3

Plan:

1. He was given +1.50 half eyes to wear over his contact lenses. We applied a 20/400 blur patch on the left lens.

2. We applied the 15° Fresnel sector prism to the right lens of Plano glasses for him to wear until his prism glasses arrive

3. Plano glasses with 3° BU OD and 3° BD OS were ordered. He will bring them in as soon as they arrive so we can place the sector prism on the right lens.

4. Referral to BROS to begin training in the use of the sector prism as soon as the glasses with the vertical prism arrive.
Case #3

- 53 yo male with severe TBI 2002 while active duty. Helicopter crash. Medically retired from military 2/2 vision loss. Referred to us by the Polytrauma Network Site clinic.

- He had tried Peli Prism for visual field loss previously (several years prior) and was unsuccessful.

- Drove for 12 years successfully, few minor accidents and he was found to not be at fault.

- Saw an ophthalmologist a few years ago that said he should no longer drive. Had his license revoked. He lost his job because of it. Has been depressed since he lost his license.
Case #4

- Has been seen by BROS for a tint evaluation and for a Dynavision evaluation
- He exhibited below passing scores especially inferior left but did demonstrate consistent scanning techniques
Case #4

- Distance visual acuity:
  - OD: 20/25-2
  - OS: 20/20
  - OU: 20/20

- Near visual acuity:
  - OD: 20/32
  - OS: 20/20
  - OU: 20/26

- Refraction:
  - OD: -0.25+0.75X005  20/20-2
  - OS: -0.25+0.50X093   20/20
  - OU: 20/20
  - Add: +1.75  OD: 20/20- OS:20/20

- Confrontation Visual Fields:
  - OD: Inf nasal constriction
  - OS: Inf temporal constriction
Case #4
Case #4

- Rx given for Bifocals with MRx and +1.75 add.
- RTC- when he gets new glasses to apply Fresnel sector prism
- He has already spoken with the kinesiotherapist about a driving evaluation, but she prefers to wait until after he has shown success with the prism
- Visual acuities at distance and near were 20/20 OD, OS and OU
Case #4

- Applied 15° sector prism to back of lateral aspect of OS lens, following the field loss found upon tangent screen testing
- Referred to BROS for Dynavision testing/therapy with the sector prism
- RTC – 2 months
Case #4

- Returned in 2 months
- Wearing sector prism at all times
- Finds it very helpful but it is blurry when scans in to the fresnel
- Would like to pursue ground in prism and drivers training with the kinesiotherapist
- Consult placed to Chadwick for ground in sector prism
Case #4
Neglect

- Since patients that have neglect are simply unaware that the world exists on the affected side, they will NOT scan towards the affected side in the early stages.

- They will veer towards the remaining field when walking, only eat food on half the plate and read only half the page.

- Teaching them to scan towards the affected side is the main focus of therapy.

- Yoked prism can be a useful tool until they are able to scan.
Yoked Prism Goggles
Yoked Prisms

- In yoked prisms, both lenses have prism with the base toward the affected side.
- This shifts everything several degrees towards the non-affected side so scanning is not required.
- The BROS works with the prism goggles during occupational and physical therapy to see if the patient functions better with them.
- Our rotatable goggles are $8^\circ$ and $10^\circ$.
- If they do function better, we will order glasses with $\sim 4^\circ$.
- Once they begin to scan, we will switch to a sector prism.
Visual Field Constriction 
RP/Glaucoma

- Can use the same concept as the sector prism but the prism is applied BO to the temporal aspect of both lenses.

- Can also apply a sector prism BD in the inferior portion of the lens.

- As in the sector prism, if the patient does well, the lenses can be ground in
Channel lenses
RP Patient Glasses
Other Uses

Altitudinal defects AION
- Bilateral base down sector prism to the inferior portion of the lenses can help with mobility
- Base down yoked prism may be helpful for reading

Midline Shift
- Common after TBI
- Can have vertical or horizontal shift
- Use small amounts (4^) of yoked prism with the base towards the affected side.
Case #5

- 31 yo active-duty male s/p burn trauma with bilateral optic atrophy and visual field deficit from aviation fire. NLP OD and visual field defect OS. PRK OU

- Distance visual acuity OS: 20/20-2

- Refraction OS: -0.25+0.25X070 20/20-2

- Preferred +1.25 add – 20/20-

- Tangent screen OS: Superior altitudinal defect
Case #5

- When questioned, he did admit hitting his head on objects that he cannot see, challenges watching television.

- Trialed $10^\circ$ and $7^\circ$ BU Loose prism OS

- He found the $7^\circ$ BU Prism helpful to shift images more in his field of view.

- He wasn’t wearing any glasses so we recommended glasses for safety.

- Rxd 2 pair – one without prism and one with $7^\circ$ BU Prism OS for television viewing.
Physical/Postural limitations

- Bedridden patients can use prism glasses to make it easier to watch TV.
- Patients with a severe head droop can also benefit with prism to shift images down so that they can see them.
Questions?
Thank You!