TODAY.. WE ARE ADDING THE EQUIVALENT POWER (FEQ) OF THE LOW VISION DEVICE

Patient Visual Needs

1. History
2. Kestenbaum
3. Acuity Reserve: 2x Kestenbaum
4. Inverse Near Acuity
1. Inverse Critical Print Size

Prescribed Low Vision Device

1. Spectacles/adds
2. Loupes
3. Simple hand-held mags
4. Stand mags
5. Near telescopes
6. Video/electronic mag

Feq LVD must > Feq to allow 1M reading.

Feq LVD

Adapted from R. Flom, OSU, 2012
REVIEW FROM PREVIOUS LECTURE
METHODS TO DETERMINE FEQ REQUIRED FOR PATIENT TO READ 1M PRINT

1. Kestenbaum’s Rule
2. Near Acuity Method
3. Acuity Reserve Rule
4. **Ross’ Favorite**: Inverse of the Critical Print Size Method
INVERSE OF THE CRITICAL PRINT SIZE METHOD

To Determine Feq from MNRead note the following:

1. Note the spectacle correction the patient is wearing at near
2. Ask the patient to hold the card where it is in best focus and measure this distance
3. Ask the patient to read starting from large print levels
4. Note critical print size (can determine either with stop watch, or by listening... when do they start to slow down?)
5. Note the threshold
INVERSE OF THE CRITICAL PRINT SIZE METHOD

Example:
1. Patient wearing +3.00 over trial frame refraction
2. Holds card at 30 cm
3. Critical print size = 2.5M

\[ \text{Feq} = \frac{2.5\text{M}}{0.30\text{m}} = 8.33 \text{ D} \]

Next: decide on Spectacle, Hand or Stand magnifier.
**“STRONG” NEAR ONLY SPECTACLES**

**PRISM HALF EYES AND MICROSCOPE SUMMARY:**

<table>
<thead>
<tr>
<th>Advantages:</th>
<th>Disadvantages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>It’s “normal” to use spectacles as an approach</td>
<td>Close working distance</td>
</tr>
<tr>
<td>Wide Field of View</td>
<td>Limited depth of field</td>
</tr>
<tr>
<td>Custom rx’s can include cyl or ansio</td>
<td>Hard to get a light in, if needed</td>
</tr>
<tr>
<td>Ready-made versions also available</td>
<td>Training and reinforcement often needed</td>
</tr>
<tr>
<td>Binocularity possible if &lt; about +10</td>
<td>Binocularity impossible if &gt; about +10</td>
</tr>
</tbody>
</table>
## LOUPES SUMMARY:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from object to eye is greater than if it were an add in glasses</td>
<td>Still relatively close working distance</td>
</tr>
<tr>
<td>Relatively good Field of View</td>
<td>Limited depth of field</td>
</tr>
<tr>
<td>Amount of working distance gained is the distance between the loupe and</td>
<td>Fussy to align</td>
</tr>
<tr>
<td>the spectacle plane (about 2-3 cm for Optivisor)</td>
<td></td>
</tr>
<tr>
<td>Many low cost Ready-made versions available</td>
<td>Training and reinforcement often needed</td>
</tr>
<tr>
<td>Great for Hobbies</td>
<td>Poor cosmesis</td>
</tr>
</tbody>
</table>
The most common question concerning hand magnifiers is whether the hand magnifier should be used while looking through the distance Rx or through the bifocal add if one is worn.
EQUIVALENT POWER:

\[ \text{FEQ} = F_1 + F_2 - C (F_1)(F_2) \]

- Feq = total diopters needed by the patient
- F1 = power of the low vision device
- F2 = add or patient’s accommodation
- c = separation of the low vision device from the spectacle plane (in meters)
EQUIVALENT POWER OF NEAR ADDITION AND HAND MAGNIFIERS

• When $c = 0$, $F_{eq} = F_1 + F_2$ → Use add

• When $0 < c < f_1$, $F_{eq} > F_1$ → Use add

• When $c = f_1$, $F_{eq} = F_1$ → Power equal
  Use either distance lens or bifocal segment

• When $c > f_1$, $F_{eq} < F_1$ → Use distance portion of bifocal lens
Consider a +20 diopter hand held magnifier with a +4.00 diopter add

- $c=0 \text{ cm}$, $F_{eq}=F_1+F_2-c(F_1F_2)$
  \[F_{eq}=(20)+(4)-(0)(20)(4) = +24 \text{ D}\]

- $c=5\text{ cm}$, $F_{eq}=(20)+(4)-(0.05)(20)(4)= +20 \text{ D}$

- $c=10\text{ cm}$, $F_{eq}=(20)+(4)-(0.1)(20)(4)= +16 \text{ D}$
FIELD OF VIEW THROUGH HAND MAGNIFIERS

• As the power of the hand magnifier increases, the useable field of view decreases.

• As the distance of the hand magnifier from the spectacle plane is increased, the field of view of the hand magnifier is decreased.
DETERMINATION OF THE LINEAR FIELD OF VIEW IN HAND MAGNIFIERS

\[ W = \frac{(d)(f)}{h} \]

- \( W \) = linear width of visible field
- \( d \) = lens diameter
- \( h \) = distance of lens from the eye
- \( f \) = focal length of the lens power

**All terms must be in the same units**
Example: What is the linear field of view of a +8.00 hand magnifier with a 20 mm lens diameter held 6.25 cm from the eye?

\[ W = \frac{(d)(f)}{h} \]

\[ W = \frac{(2.0)(12.5)}{6.25} \]

\[ W = (2) \times 2 = 4.0 \text{ cm} \]

or 40 mm
What is the linear field of view of her +24.00 hand magnifier with a 35 mm lens diameter held 6.25 cm from the eye?

A. 2.35 mm
B. 6.25 cm
C. 2.35 cm
D. 6.25 mm
DETERMINATION OF THE LINEAR FIELD OF VIEW WITH HAND MAGNIFIERS

• If the magnifier is held one magnifier focal length from the eye, the field of view is equal to the diameter of the magnifier lens.

• If the magnifier is held two magnifier focal lengths from the eye, the field of view is equal to half the diameter of the magnifier lens.
**HAND HELD MAGNIFIERS SUMMARY:**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiar approach</td>
<td>Requires good “hand control”</td>
</tr>
<tr>
<td>Eye relief is flexible, but affects FOV and angular MAG</td>
<td>Not hands free</td>
</tr>
<tr>
<td>Small, portable</td>
<td>Smaller FOV than spectacles</td>
</tr>
<tr>
<td>Compatible with spectacle rx’s</td>
<td>Training and reinforcement often needed regarding:</td>
</tr>
<tr>
<td></td>
<td>- Use with bifocals</td>
</tr>
<tr>
<td></td>
<td>- Focal distance</td>
</tr>
<tr>
<td></td>
<td>- Field of view and distance from spec plane</td>
</tr>
<tr>
<td>LED lighted options available</td>
<td></td>
</tr>
</tbody>
</table>
STAND MAGNIFIERS

- High plus lens with a housing placed around it which sets the object distance less than the focal length of the lens. Available in powers from 2X up to 12.5X.

- The stand magnifier is placed directly upon the reading material. A virtual, erect, and divergent image is created.

Photo courtesy of Eschenbach Optik
STAND MAGNIFIERS

• May be non-illuminated or illuminated with an LED, incandescent, halogen, or fluorescent light source

• Location of magnifier image will determine how much accommodation or add is required to resolve the image

Photo courtesy of Eschenbach Optik
Formulas to know:

- $L' - L = F_1$ or $U' - U = F_1$
- $ER = (U' - F_1)/U'$ or $ER = (L' - F_1)/L'$
- $F_{eq} = ER \times F_2$
- $WD = 1/ADD = 1/F_2 = Z + l'$ = $Z + u'$

$F_{eq}$ = power of specific goal
$F_1$ = written on magnifier; physical power you can't change
$F_2$ = ADD
$ER$ = enlargement ratio

- $Z$ = distance b/w glasses & magnifier
  (= how far away to hold magnifier)

- STAND MAGNIFIER PLANE = POWER OF LENS = $F_1$

- $u = l$ = object distance

- $u' = l'$ = image distance

- ADD = $F_2$
  (glasses plane)

- OBJECT = TABLE

- VIRTUAL IMAGE

Courtesy of ASCO, LV Sig Meeting 2015
USING THE ENLARGEMENT RATION (ER) OR TRANSVERSE MAGNIFICATION (MT) TO DETERMINE THE EQUIVALENT POWER OF A STAND MAGNIFIER

- Enlargement Ratio = \( \frac{L'}{L'} - F_1 \)
- \( L' \) = image vergence
- \( F_1 \) = “equivalent power” of the plus lens
- Equivalent Power of combination stand magnifier and add or accommodation = \((ER) \times (add)\)
- If an add is used the image distance of the stand must be coincident with the focal point of the bifocal add \( (f_2) \)
USING THE ENLARGEMENT RATION (ER) OR TRANSVERSE MAGNIFICATION (MT) TO DETERMINE THE EQUIVALENT POWER OF A STAND MAGNIFIER

Let $F_1 = +15$ diopters, $F_2 = +3.00$ diopters and the object distance = -5cm

$$Er = \frac{L'}{-F_1} \quad (-5)+(+15) = 4X$$

$$L' = 5$$

$$Feq = (ER) \times (Add) = (4) \times (3) = 12 \ D$$
PROBLEM 2

Use the data below, and from the previous question, to calculate the resulting Feq with the patient’s +4.00 add at the appropriate distance.

Lens power = +16.00, Emerging vergence = -8.75 DS

A. \( \text{Feq} = +11.32 \)
B. \( \text{Feq} = +6.83 \)
C. \( \text{Feq} = +64.00 \)
D. \( \text{Feq} = +4.00 \)

\[
\text{ER} = \frac{-8.75 - 16}{-8.75} = 2.82X
\]

\[
\text{Feq} = \text{add(ER)} = (4 \text{ D})(2.8X) = +11.32D
\]
Use the data below to calculate the image distance.

Lens power = +16.00,
Emerging vergence = -8.75 DS

A. Image distance = -11.4 cm
B. Image distance = -6.25 cm
C. Image distance = -0.114 cm
Use the data below, and from the previous question, to calculate the maximum add that can be used.

Lens power = +16.00,
Emerging vergence = -8.75 DS

A. Maximum add = +8.75
B. Maximum add = +11.32
C. Maximum add = +4.00
You decide to select more appropriate stand magnifiers for Ms. Maggie. Indicate Yes or No as to whether each of the following magnifiers should allow her to read at least 1.0M print at her peak reading speed (CPS = 0.3/4M) using her +3.00 near addition.

Lens Power = +16.00 DS,  \( u' = 25 \text{ cm} \)

A. Yes
B. No
PROBLEM 5 ANSWER

You decide to select more appropriate stand magnifiers for Ms. Maggie. Indicate Yes or No as to whether each of the following magnifiers should allow her to read at least 1.0M print at her peak reading speed (CPS = 0.3/4M) using her +3.00 near addition.

Lens Power = +16.00 DS, u' = 25 cm

Patient NEEDS: Feq = 4M/0.3 = 13.3 D

Proposed Feq of Low Vision Device:
Feq = Fadd (ER)

ER = (-4)-16/ (-4) = 5X

Feq = (3)(5) = 15D

Feq LVD must > Feq to allow 1M reading.

Is this the case?

YES!!
PAPERWEIGHT/ DOME MAGNIFIERS

- Paperweight stand magnifiers have the following special properties
  - For most, the enlargement ratio produced is equal to the index of refraction
  - Have very short image distances
    - Thus, can be used with high adds or lots of accommodation!
      - *this is not the case for most stand magnifiers*. Which typically have an image distance of 20 to 25 cm
  - Image is almost in the plane of the object
# STAND MAGNIFIERS SUMMARY:

<table>
<thead>
<tr>
<th>Advantages:</th>
<th>Disadvantages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable hand position (SM is dragged along and maintains contact with the page)</td>
<td>Accommodation or near ADD power must be appropriate</td>
</tr>
<tr>
<td>Great LED Lighting available !!!</td>
<td>Bulky – not portable</td>
</tr>
<tr>
<td>Eye relief can be flexible – more so with NON-presbyopes</td>
<td>Writing and manipulation difficult to impossible</td>
</tr>
<tr>
<td>Can get additional mag in combination with near add</td>
<td>May need raised service or writing stand to bring device closer to spectacle plane</td>
</tr>
</tbody>
</table>
ELECTRONIC STAND MAGNIFIERS
DESKTOP CCTV

- Digital camera
- Flat panel monitor
- XY table
- Auto focus or focusing mechanism
- Zoom magnification
- Color (to view photos)
- Contrast Reversal
- Allow for contrast enhancement
  - Black on white
  - Or. White on black
PORTABLE ELECTRONIC MAGNIFIERS

• Great option when contrast enhancement needed (CS < 1.00 log)
• Allow for contrast enhancement
  – Black on white
  – Or.. White on black
• Some also have speech output!!
DISTANCE OPTICAL AIDS AND TELESCOPES

Photo courtesy of Eschenbach Optik
INDICATIONS FOR TELESCOPE USE

Distance Viewing Indications

• Viewing Signage
  – Mobility: Eg. Traffic, street signs, aisle signs in store, building or business names, building directories
• Other remote viewing needs
  – Chalkboard
  – Special of the day menu
  – Museum exhibits
  – Slide presentations

Near/Intermediate Viewing Indications

• When the task is not easy to complete at very close working distance
• When hands-free is important
  – Eg. Knitting, model building, music, surgery, computer work
• Occasionally using for continuous reading
TYPES OF TELESCOPES USED IN LVR

1. Hand held monocular and binocular telescopes
2. Spectacle mounted telescopes
   - Full diameter
   - Bioptic position
   - Reading/ surgical position
REVIEW: OPTICS OF A TELESCOPE

• Afocal telescopes (used for distant viewing)
  – Parallel rays in, parallel rays out
  – Zero dioptric power
  – Create angular magnification
  – (note: do not confuse lack of dioptric power with Mag)
  – Composed of two lens elements at minimum
    • Objective lens
    • Ocular lens, aka eye piece
OBJECTIVE LENS

• The lens furthest from the eye
• Always a converging element (aka a plus or convex lens, or a concave mirror)
• Must have a longer focal length compared to the ocular lens
OCULAR LENS

• The lens closest to the eye
• Can be:
  – Positive lens (Keplerian telescope)
  – Negative lens (Galilean telescope)
• Must be positioned so image is formed by objective lens at the primary focal point of the ocular
• Due to the above, must have shorter focal length compared to the objective lens
KEPLERIAN TELESCOPE: 2 PLUS LENSES

- All rays from a point focus to a point and then diverge to become parallel again
- The two focal points are INSIDE the telescope
- Image in inverted
- Prisms or mirror are used to re-invert the image in LVR
- Magnification = ratio of the resulting angles

From Bullimore et al. Geometric Optics
GALILEAN TELESCOPE: 1 PLUS, 1 MINUS LENS

- All rays from a point converge, then diverge at the eye piece to become parallel
- The two focal points are OUTSIDE the telescope
- Image in erect
- Magnification = ratio of the resulting angles

From Bullimore et al. Geometric Optics
WHERE IS THE EXIT PUPIL?
GALILEAN VS. KEPLERIAN TELESCOPE

As a result of the above optical principles, one can differentiate a Keplerian and Galilean telescope by the appearance of its exit pupil. A Galilean telescope will have an exit pupil within the telescope, where are a Keplerian telescope has an observed “floating” exit pupil outside the telescope system.

From Bullimore et al. Geometric
TELESCOPE FORMULAS

Telescope Length (t)

\[ t = \text{sum of focal lengths} \]

\[ t = f_{\text{objective}} + f_{\text{ocular}} \]

\[ t = \frac{1}{F_{\text{objective}}} + \frac{1}{F_{\text{ocular}}} \]

Telescope Magnification (M)

\[ M = \text{ratio of the focal lengths} \]

\[ M = -\frac{f_{\text{ob}}}{f_{\text{oc}}} \]

\[ M = -\frac{F_{\text{oc}}}{F_{\text{ob}}} \]
TELESCOPE FORMULAS

We know that Telescope Magnification (M)

\[ M = \frac{\text{ratio of entrance pupil (objective diameter)}}{\text{exit pupil diameter}} \]

\[ M = \frac{-F_{oc}}{F_{ob}} \]

\[ M = \frac{-f_{ob}}{f_{oc}} \]
Most patients which to use monocular telescopes and like systems without their habitual distance spectacles

- Why?
  - Keep close eye to lens distance to improve field of view
- How do we prescribe and account for this?
  - Add lens to ocular
  - Add lens to objective
  - Adjust telescope lengths
- Does this alter the magnification produced
  - YES!
FOCUSABLE TELESCOPES AND HYPEROPIA

Keplerian System

*adjusting t*

Think of this as the patient contributing some of the plus to the ocular lens

Example:

- 8X Keplerian Telescope
- +3.00 D Hyperopia
- Let: $F_{oc} = +40$ D, $F_{ob} = +5.00$D

Does this hyperopic patient make the tube length longer or shorter compared to a emmetrope?

Does Magnification Remain 8X?
## SUMMARY OF REFRACTIVE ERROR AND TELESCOPES

<table>
<thead>
<tr>
<th>Telescope Type</th>
<th>Myopic Refractive Error</th>
<th>Hyperopic Refractive Error</th>
</tr>
</thead>
</table>
| Keplerian      | • Makes tube length shorter  
                • Increases mag        | • Makes tube length longer 
                • Decrease mag          |
| Galilean       | • Makes tube length shorter 
                • Decrease magnification | • Makes tube length longer 
                • More magnification     |
Prescription of telescopic systems of various designs depend on three key considerations:

1. **Binocular or Monocular?**
   - If possible, and the visual acuity is similar between the two eyes then binocular viewing is likely to be beneficial. In cases of visual field loss (e.g. central scotoma visual field loss), the extent of the binocular scotoma may be smaller than the smaller monocular scotoma.

2. **What is the required task?**
   - When a telescope is first evaluated and then prescribed, a particular task or goal must be identified.
   - Specifically, it is important to identify whether the task requires the patient to be hands-free, or whether multiple demands are involved.
   - This is particularly important when deciding if a spectacle based telescope or hand held telescope is most appropriate.
## Prescribing Telescopes: Hand-Held Versus Spectacle Based

<table>
<thead>
<tr>
<th>Spectacle Mounted Examples</th>
<th>Hand Held Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labeled by Mag</td>
<td>Labeled as Mag X objective diameter</td>
</tr>
</tbody>
</table>

- Spectacle Mounted Examples:
  - Images of spectacle-mounted telescopes labeled by Mag.

- Hand Held Examples:
  - Image of a hand-held telescope labeled as Mag X objective diameter.
3. What is the required amount of magnification?
   - Once the task is identified, the clinician must determine the acuity level necessary to achieve the goal and then calculate the necessary magnification that will provide it.
   - For example, if a patient’s goal is to spot a distant aisle sign in the grocery store which has an acuity demand of approximately 20/60, and the patient’s best corrected acuity is 20/200.
     
     Here,
     
     \[= 3.33 \times\]

   • Because telescopes are often have a limited selection of powers available, selection of the nearest appropriate power is often required.
WHEN DECIDING ON HAND HELD VS. SPECTACLE …

<table>
<thead>
<tr>
<th>Spectacle mounted (permanent placement)</th>
<th>Hand- held</th>
</tr>
</thead>
<tbody>
<tr>
<td>• For spotting or continuous use (depends on position)</td>
<td>• Good for spotting</td>
</tr>
<tr>
<td>• Hands free</td>
<td>• Can fit easily in pocket or on a cord that hangs around the neck</td>
</tr>
<tr>
<td>• Good for patient’s with poor dexterity</td>
<td>• More inconspicuous</td>
</tr>
<tr>
<td>• More obvious</td>
<td>• Consider tremor/stability</td>
</tr>
<tr>
<td>• Can incorporate RX in ocular lens</td>
<td>• Can be heavy (sturdy frame with adjustable nose pads, may need retaining strap)</td>
</tr>
</tbody>
</table>
PRESCRIBING TELESCOPES:

As such the diagnostic test sequence for prescribing telescopes must provide a systematic approach including:

• Determining best corrected distance vision
• Determining the goal acuity for the required task
• Determining and calculating the magnification needed
• Evaluating appropriate telescope systems with the patient
• Training with the appropriate systems
• Final prescription
CUSTOMIZED PRESCRIPTION IN TELESCOPE

• Can only do this in spectacle mounted telescopes, $$
• RX put into ocular lens (i.e. eye piece lens correction)
• Doesn’t change the magnification of the system (patient is now corrected...)

Jamara-Ross general rules to add a patient’s prescription:
1) For any type of telescope, the patient’s astigmatism is >1.5D
2) For a fixed focus telescope, the patient has >2.5D of sphere power
3) Can always consider a focusable telescope to compensate.
NOW MANY TELESCOPE CLIP OPTIONS AVAILABLE

• Allow patient to have their refractive correction without much more added expense

Eschenbach 2.1X MaxTV Clip

Ocutech 2.2X Sightscope Clip
EVALUATE THE PATIENT WITH THE DEVICE

1. Demonstrate to the patient how to use and focus for them
2. Allow them to do it on their own
3. Give them a real life target to view (not just the acuity chart) i.e. sign down the hallway, television, out a window, the face of their loved one
4. Will modify device according to their success and response
Patient Visual Needs

1. History
2. Kestenbaum
3. Acuity Reserve: 2x Kestenbaum
4. Inverse Near Acuity

1. Inverse Critical Print Size

Feq or EVD for 1M

Feq LVD must > Feq for 1M to meet allow 1M reading.

Prescribed Low Vision Device

1. Spectacles/adds
2. Loupes
3. Simple hand-held mags
4. Stand mags
5. Near telescopes
6. Video/electronic mag
PRESCRIBING NEAR TELESCOPES

• Remember for afocal telescopes
  \[ \text{Feq} = \text{Mag of telescope} \times F_{\text{cap}} \]

  \[ f_{\text{cap}} = \text{working distance patient needs} \]

• Special considerations:
  – Near work with a telescope requires lots of accommodation, a reading cap, or a focusable telescope!
RECENT CASE FROM CLINIC

• Patient with macular degeneration
• BCVA: OD 20/60, OS 20/80
• Goal: Needs solution to play bridge. Needs to see cards in hand at 25 cm, and cards on table (estimated to be 68 cm from rehab therapist)
• Determined $F_{eq}$ to see cards: $=+3.50 \text{ D}$
Goal: Needs solution to play bridge. Needs to see cards in hand at ~29 cm, and cards on table (estimated ~68 cm from rehab therapist visit)

- Determined $F_{eq}$ to see cards: $=+3.50 \, \text{D}$

- $F_{eq} = (\text{Mag}_{ts})(F_{\text{cap}})$, $F_{\text{cap}} = 1/0.68 \approx 1.50 \, \text{D}$

- $3.50 = (\text{Mag}_{ts})(1.50)$, $\text{Mag}_{ts} = 3.50/1.50 = 2.3X$
NEAR TELESCOPE FOR BRIDGE PLAYING

- 2.2X telescope with +1.50 Cap for cards on table
- For cards in hand: +3.50 bifocal
- Added Bonus: takes reading cap off of telescope to watch the Patriots game
- Patient also uses system for computer work (answers telemarketing company), papers on desk stand 30 cm, computer at 65 cm viewing distance
OTHER CONSIDERATIONS FOR PRESCRIBING TELESCOPES

• Alignment is critical
  – Exit pupil of telescope has to match up with entrance pupil of the eye
  – Hand-held systems require good coordination
  – Spectacle mounted systems must be precisely positioned and angled
• Speed of motion is multiplied!
• Weight
• Cosmesis
Ready to Start a Low Vision Rehabilitation Clinic?
We Recommend Starting With....

Basic LV Aid Diagnostics

• Lighted Hand Held Magnifiers:
  – +6D, +8D, +10D, +12D, +20D

• Lighted Stand Magnifiers:
  – +10D, +12D

• Prism Half Eyes:
  – +4 w/ 6Δ BI, +6 w/ 8Δ BI, +8 w/ 10Δ BI

• Telescope: 2X Binocular System, 4X and 6 X Monocular System

• Electronic Magnification: Portable or desktop unit
THANK YOU !