Basic Optics of Near Low Vision Devices

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Examination sequence
- Case Hx
- VA’s distance, near, continuous text
- Low Contrast acuity (Bailey-Lovie)
- Refraction
- Central field test (scotomas)
- Magnification response

Sequencing of optical prescribing
- Magnification response (high add or cctv)
- Does the patient require EV training?
  - Steady PRL?
- IF yes, Explain need for EV training
- Explore response to magnification on a couple devices to demonstrate concept and no magic glasses

WAIT
- Don’t prescribe devices at this point in time
- Determine most successful strategy to incorporate devices at a later stage when EV training makes progress
- Discussion

Determining Necessary Magnification for Near
- Magnification Needed
- Convert to De (M times 2.5 D)
- Consider near treatment options
- ALL THEORETICAL

Categories of Optical Aids at Near
- Spectacle plane lenses (microscopes, high adds, SV near)
- Hand held magnifiers (2 ways to use)
- Stand magnifiers
- CCTV/Video Magnifiers
- Telemicroscope (near telescope)
Example

- Mrs. Smith wants to be able to read a book. Her best corrected visual acuity is 10/80.
  
  \[ 160/40 = 4 \times 2.50 \text{D} = +10.00 \text{D} \]

  Reading distance?

Equivalent Power

- power of add predicted
- any lens or combination of lenses used to produce the power of add predicted
- whole optical system can be replaced by a single lens positioned such that the object is located at its primary focal point

Equivalent Power

\[ D_e = D_1 + D_2 - tD_1D_2 \]

where

- \( D_e \) = equivalent power
- \( D_1 \) = power of lens in LV aid
- \( D_2 \) = add or accommodation
- \( t \) = separation between LVA and spectacle plane

Microscopes/High Adds

- Lens at spectacle plane
- Object at focal length of lens: working distance = object distance
- Image at infinity; one magnification created \( M_{RD} \)
- \( D_e = D_1 + D_2 - tD_1D_2 \)
- \( D_e = D_1 \) (because \( D_2 = 0 \))

Microscopes/High adds

- 90 yof with BVA 10/200 wants to read great-granddaughters letters (RS80). She is a 4.00D myope.
- ROV?
- Add?
- \( M_{RD} \)?
- Final prescription of reading glasses?
Another example

- 74 yof, BVA 10/120 with +1.00DS, wants to read 0.8M print and have her hands free.
- Single vision near glasses RX?
- Rated Mag = 16/4 = 4x (what magnifier is usually marked with from manufacturer)

HAND/STAND MAGNIFIERS

Virtual Image Magnified Print, RO Magnifier Reading add

Distance = focal pt of add

Hand Magnifier: Object at focal point of lens (no add, fully corrected)

Real object at focal point
Hand magnifier
Image at infinity

print = at focal point

Eye

Easiest way to use Hand magnifiers

- Hold reading material at focal point of lens (1/D)
  - De = D_{add}
  - image at infinity
  - magnification equation simplifies to M_{RD}
  - i.e. magnification is constant for any distance of the magnifier to eye - WOW!
  - Field of view changes with distance. How?

Example

- 82 yom wants to read the newspaper. His BVA is 10/80
2nd way to use Hand Magnifiers

- Object is held inside the focal length of the lens
- Image is then virtual and at a finite distance from the lens
- Image is enlarged (lateral magnification is induced)
- User must use add (or use accommodation or is myopic) to see finite image clearly
- Image must be located at the focal length of the add to be seen clearly

\[ \frac{1}{D_e} = \frac{1}{D_{HM}} + \frac{1}{D_{add}} - tD_1D_2 \]

\[ D_1 = D_{HM} ; \ D_2 = D_{add} \]

\[ \text{Starts to get ugly} \]

\[ \text{Still ugly but slightly easier} \]

Clinical Rule

- One add’s worth of power is lost from the maximum combined power for every focal distance of the magnifier that it is held away from the spectacle plane

Stand Magnifiers

- Same optics as case 2 with hand magnifiers
- Manufactured so that objects are inside the focal length of the lens (height of stand is object distance)
- Must use an add or accommodation
Stand or hand magnifiers

\[ \frac{1}{D_{\text{add}}} \]

\[ \text{amount of add or accommodation required depends upon the position of the virtual image} \]

Stand Magnifiers

\[ X' \]

\[ \text{image created by the stand magnifier is at the focal point of the add/accommodation used} \]
\[ \text{the distance of the virtual image behind the lens will also determine the maximum add that can be used} \]

So how do I prescribe a stand magnifier?

\[ \text{calculate ROV and necessary add} \]
\[ \text{this is the equivalent power you need} \]
\[ \text{do a lot of measurements and calculations} \]
\[ \text{or} \]
\[ \text{look at the prepared charts!} \]
\[ \text{Rule of thumb:} \]

Telescopes Adapted For Near Viewing

Two Methods:

- Reading Cap: Plus lens over objective
- Extending the length of the telescope

Reading Cap

\[ M_{\text{cap}} = D_{\text{cap}}/2.5 \ D \quad (40 \text{ cm reference}) \]
\[ D_{e}=D_{\text{cap}}*M_{\text{ts}} \]

- **Advantage:** Longer working distance than high add of same dioptic power
- **Disadvantage:** Smaller FOV than high add
Consider Prescribing Over the Implantable Telescope

**Extended length for near**
- Extra length in telescope often called optical tube length
- Hard to calculate actual magnification created
- Spiral telescope has ability to be lengthened for near viewing at about 25-30 cm depending on telescope

**CCTV**
- Electronic Magnification
  \[ D_e = M_{screen} \times D_{add} \]
  Where \( D_{add} = 1/\text{distance of pt from screen} \)
- \( M_{screen} = \text{actual letter height (mm)/magnified letter height} \)
Prescribing for Near Viewing

Test for best add
- Equivalent Power

Microscopes or High Adds
- Aspheric monocural or single lens design
- Doublet – monocural
- Prism glasses
  - Full frame
  - Half eye

Microscopes and High Adds: Terms
- Working distance = distance from spec plane to reading material
- Full diameter = lens fills frame or usable lens space

Microscopes/ Doublets
- +8.00 D to +48.00D
- Special doublets above +12D can improve optical performance
  - Clear Image = Great quality
- No mobility with full diameter design

Binocularity
- Binocularity practical to +12.00D according to textbooks
- Clinically practical upper limit – some docs think +8 is max
- BI prism to aid in convergence
- Good for sustained near tasks
**Binocularity**

- Prentice Rule
  \[ P = dD \]
  \[ \text{prism} = d \, \text{(cm)} \times \text{Power of lens} \]

  Clinical Rule:
  Amount of BI in each lens
  = add power +2

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**Finding the Near PD**

(For rx’s<+9D)

- Several ways exist
- Ian Bailey recommends: decentering the lens 1.5mm for each diopter of add. If the distance PD is > than 65mm, decenter 1mm further.

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**Example**

- Patient with distance PD of 62mm requires the use of a +6.00 D monocular add to read a textbook. What is the patient’s near PD:

  \[ 6(1.5) = 9 \text{mm} \]

  \[ 62 - 9 = 53 \text{ mm} \]

  So near PD should be set at 53mm

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**Example**

- Answer: \[ 6(1.5) = 9 \text{mm} \]

  \[ 62 - 9 = 53 \text{ mm} \]

  So near PD should be set at 53mm

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**example**

This method only determines the NPD. To create BI prism, more decenteration would be necessary or prism can be ground in.

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**Prescribing On Center**

- If prescribing monocular above +8 consider prescribing On-Center (at distance pd)
- Teach patient to view straight ahead
- Must move paper to read – not head!
Custom Microscopes and High Adds

- Prism Spectacles: Full Field or half eyes (+8 practical maximum)
- High plus aspheric (monocular)
- Microscopes (monocular) (typically over +8D)
  - Aspheric doublet (Clear Image)
  - Marked at Rated Mag (4D X Mag printed on side)

Microscopes and High Adds

Types of Delivery

- Regular bifocals from local lab
  - (FT28 or FT35) can get to +8.00D add in CR39
  - (FT28 or FT35) can get to +4.00D add in POLY (correction on handout)
  - Round seg can get to +40D
  - Executive to +20D

Types of Delivery – low vision custom companies

- Multifocals (2X to 10X)
  - Frame should have adjustable nosepads
  - Segment should be set higher than a conventional bifocal (as high as lower pupil margin)
  - A monocular bifocal should never be decentered

Other Considerations

- What if patient doesn’t respond to the theoretical ideal magnification?
- Have you considered the scotoma?
- Have you considered contrast sensitivity?
- Have you considered cognitive deficits
- Prior to ever introducing magnification, I like to try to predict how they will respond

Summary

- Know the general optics of your devices
- Know the optics of the eye – refraction
- Combine knowledge with clinical relevance and practicality
- = Confidence in prescribing
- Don’t forget complexities of scotomas and consider entire rehabilitation plan