Pearls for Examining and Prescribing for Preschool Children
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Refractive Decisions
Key Questions to Guide Us:

- What is “normal” refractive error during the critical period? (context of neuroplasticity)
- What is the normal emmetropization process?
  - Will optical correction alter it?
- How can we accurately measure RE in preschoolers?
- How much ametropia or anisometropia will disrupt normal development?
  - Acuity (Amblyopia risk)
  - Sensory fusion (Strabismus risk)
  - Perceptual/Cognitive/Behavioral

Neurophysiological Basis of Critical (Sensitive) Period
- The cerebral cortex contains ~100 billion neurons at birth, but synaptic connections are relatively sparse.
- Birth to 2 years, there’s an explosion of dendritic growth and synapse formation.
- Synapse density reaches its maximum at some point in early childhood (varies depending on area of CNS) after which selective pruning of unused pathways occurs.
  - Peak synapse formation for the primary visual cortex is around 8 months age

Use It or Lose It Model
- There is intense competition for synapses by growing
dendrites during the critical period.
• Pathways that are used more are reinforced.
• Pathways that are not used atrophy...those neurons are left out of the final wiring.

• The final “pruned” product is a much more efficient brain, tailored to utilize the best input from the sensory systems...

5 Early experience largely determines brain potential.

6 Cambridge Longitudinal Studies of Infant Hyperopia
• 2 population studies totaling over 8000 kids, screened starting at 9 months
• Hyperopes exceeding +3.50 D identified (5%)
• Spectacles prescribed at 9 months:
  – for all exceeding +6 D,
  –half in 4-6D range (treated group)
  –others in 4-6D range watched (untreated group)
• Low hyperopes (0 to +3.75D) served as controls
• Also collected data on cognitive, perceptual and motor development

7 Cambridge 1st Study
Acuity/Strabismus Outcomes at age 4
Controls:
1.6% Strabismus, 11.1% failed crowded symbols test

Moderate hyperopes left untreated (no glasses):
21% Strabismus, 68% failed acuity

*Treated hyperopes (glasses):
6.3% Strabismus, 28.6% failed acuity

*Provided with Rx 1.5D < the least hyperopic meridian
Not all “treated” hyperopes were compliant with spectacles

8 Emmetropization:
Refractive distribution change
Birth to 2 years (North America and Europe)

9 Emmetropization: Key Findings
• Most of emmetropization occurs between birth and 18 months.
  – Most children show little change (<1D) after 18 months (myopia is exception)
• Emmetropization is not for everyone
  – Children with high RE as infants often fail to emmetropize, may drift to higher ametropia
  – Retinal blur does not seem to drive these eyeballs toward emmetropia

10 Longitudinal Data: BIBS Study

11 BIBS Study: Probability of emmetropization

12 BIBS Study: Accommodative response and Refractive error in infants
• An accurate accommodative response has been observed over the range of 1 to 3D of hyperopic refractive errors in infants 3-18 months of age. These infants tend to emmetropize nicely
• Infants with hyperopia over 3- 4 D show less accurate accommodation and are less likely to emmetropize and more likely to develop strab/amblyopia

Chronic retinal blur interferes with normal development of acuity and places the infant at much higher risk for strabismus and amblyopia
Cambridge: 2nd Study Group
Hyperopic Visual Outcomes
784 children (9 months – 5 yrs)

- Significant hyperopes (>4D) with poor accommodative response at much greater risk for poor acuity and strabismus at age 4-5 than emmetropes, corrected hyperopes or significant hyperopes who showed good accommodative response

Take Home Clinical Message

- Borderline Hyperopia 3-5 D in infants/preschoolers may be a problem if the child is not coping.
- Habitual accommodative response is just as important as the absolute (cycloplegic) amount.
- Poor accommodative response leads to chronic retinal defocus, amblyopia and impaired sensory fusion.
- Accommodative ET arising at 1.5-3 years probably more due to a sensory deficit in this population than a simple AC/A ratio model suggests.

Will we mess up emmetropization by prescribing?

Pediatric Refraction Methods

Screening vs Prescriptive

1. Dry auto-refraction
   - Photo-screening
   - Direct O-Scope
   - Mohindra Retinoscopy
   - Distance (Dry) Retinoscopy

2. Distance (Dry) Retinoscopy
   - Wet Retinoscopy
   - Wet Autorefraction

Pediatric Friendly Autorefractors

- Welch-Allen Sure-Sight
Not as accurate as Retinomax
(Vision in Preschoolers Study)

• Nikon Retinomax

18 Autorefraction with Children
• Autorefraction is not reliable/accurate with children unless cycloplegic is used
  – does not control accommodative response
• Very young children may not cooperate for AR (fixation errors)
• AR is accurate and quite helpful for astigmatism power and axis (with or without cycloplegia)
• Auto-Ks are helpful too!

19 Photorefraction
• Uses off-axis photography of retinal reflex
• MTI Photoscreener was the first available instrument and has been widely used and studied

20 Digital Photoscreeners
• Digital camera and computerized system eliminates need for “expert” interpretation
• Studies show highly effective for detecting strabismus, anisometropia and significant refractive errors
• Accuracy for measuring hyperopia is questionable (accommodation control)

21 Results

22 The Direct Ophthalmoscope can be used to screen for binocular and refractive conditions very quickly and
easily...using the same optical principals as photoscreeners

23 **Procedural Set-Up**

- Dim or dark room illumination
  - Encourage larger pupil size, discourage accommodation
- Test distance 75 cm to 1 meter
- Kid must fixate ophthalmoscope light

24 **Both retinal and corneal reflexes can be evaluated simultaneously:**

- Binocularity
  - Bruckner Test
  - Hirschberg Test
- Ocular media/retina
  - Cataracts
  - Retinoblastoma
- Refractive status

25 **Bruckner Test: What’s the likely diagnosis?**

26 **Anisometropia**

27 **Type of refractive error in each meridian is determined by position of crescents**

- Hyperopic crescents will be oriented toward the head of your O-Scope.

- Myopic crescents toward the handle

28 **Turn your O-scope horizontal, to observe crescents in the 180 meridian**
29 Significant Hyperopia

30 Astigmatism

31 Mohindra Near Retinoscopy
   • Infant looks at retinoscope light at 60-70 cm in dark room
   • Neutralize reflex
   • Correction factor of -0.75D
      –instead of full 1.5 D for working distance
   • Pros: Can detect astigmatism, significant myopia, and aniso
   • Cons: assumes a certain amount of accommodation, not accurate for hyperopia (unless cyclopeed)

32

33 Prescriptive Methods: Distance Retinoscopy (Dry and Wet)
   • Loose lenses, skiascopy lens bar
      –+2.00 working distance glasses when possible
      –Can also fog by holding (+) lens bar horizontal
      –Need good distance fixation target (video or assistant can keep attention or cycloped)
   • Common error is not measuring on axis (stay within 10 degrees)

34 Drop Time…

35 Atropine
   • 1% Atropine is the strongest of the cycloplegics commonly used
   • Onset of action (3-6 hrs) and duration of action (7-14 days) make it impractical for clinical measurement of refractive error
      –Although some clinicians still use it…parents given drops or ointment to apply 1-2 days prior to exam
   • Primary use now is for amblyopia therapy
   • Myopia treatment (in Asia)

36 1% Cyclopentolate
• Good cycloplegia in 20-40 minutes
• Recommended dosage is 1 drop of 1%, 0.5% for infants under 6 months
• Side-effects not severe but common
  • Irritability, flushed skin, central nervous system disturbances, acute psychosis, weakness, dizziness, loss of consciousness or hyperactivity
  • more common with fair-skinned kids
  • More likely with multiple drops of 1% (or 2% soln)
  – Punctal occlusion decreases systemic absorption and keeps the child from wiping away the drops immediately

37 Optimal Dosage of 1% Cyclopentolate for Complete Cycloplegia: A randomized clinical trial
• Compared 1 drop to 2 drops or 3 drops
• Found no significant difference in cycloplegia between the 3 regimens
• More drops increased side effects

Conclusion: 1 drop of 1% cyclopentolate is optimal dosage

38 1% Tropicamide
• Not as strong as Cyclopentolate but adequate for children with myopia, mixed astigmatism and low hyperopia with no other concerns
• Studies comparing distance retinoscopy or AR results between 1% Tropicamide and 1% Cyclopentolate show minimal difference (0.25-0.75D range) between the two agents in infants and young children
• Better dilator than Cyclopentolate
• Far less side effects (very safe, use with special needs children, young infants)
*Short window of maximal cycloplegia...you have to get your wet findings from 20-35 minutes post-instillation.

39 When you really need to cycloplege...
- I use 1% cyclopentolate followed by 1% Tropicamide 5 minutes later.
  – Combo yields very effective cycloplegia and dilation, even with dark irides.

40 Most common reason for poor dilation/cycloplegia is inadequate instillation
- Cooperation is key to success
- If a child is fearful they will not be cooperative
- There is no need to “warn” a child about stinging
- If really fearful, scaffold: put drop on your hand, on child’s hand, drop on a doll or other “friend”, use closed eye technique
- Punctal occlusion
- Proparacaine for school age kids: “bubble gum drops”

41 Cycloplegic Spray
- Compounding pharmacist can mix up soln to yield concentrations of 1% cyclopentolate, 2.5% phenylephrine and 0.5% Tropicamide
- Spray on closed eyelids, easier administration for kids uncooperative with drops

42 Prescribing Guidelines

43 Anisometropic Amblyopia
- 1.5 D of anisometropia is the low end of the amblyogenic
range
• Hyperopic aniso creates greater deficit than myopic aniso
• As little as .5 D aniso impairs stereoacuity
• Aniso can change significantly during emmetropization (up to 2 years)

### Aniso Case 1

- 6 month old baby in for Infantsee Exam
  - No concerns, healthy baby, (-)FMHx of early vision problems
  - Good ocular alignment with Hirschberg/Bruckner
- Dry Ret:  
  - OD +4.50 -1.00 x 180
  - OS +2.00 sph

What should we do?

### Aniso Case 2

- 5 yr old boy presents with red, itchy eyes x 1 week
  - Crusts in AM, no apparent pain, appears better today, cornea clear
  - DX: Allergic Conjunctivitis, Rx or OTC: Antihistamine/mast cell stabilizer
  - VA's 20/25 OD, 20/100 OS with iso HOTV
  - Screening Ret:  
    - OD +1.25 sph
    - OS +4.50 sph
  - Wet Ret (and AR) on FU:  
    - OD +2.00 sph
    - OS +6.00 -1.00 x 175

### Prescribing for Anisometropia

- Always prescribe the FULL Aniso you find based on cycloplegic measures
  - Leave equal residual error
- Consider contact lenses in high anisometropia
  - Aniseikonia will limit ultimate binocular fusion in spectacles
if more than 3 D of aniso

Amblyopia Treatment?

47 Glasses for Anisometropic Amblyopia
   • (84) 3-6 yr old kids with untreated refractive amblyopia, provided FT specs and measured VA every 5 weeks for 30 weeks
   • Mean Improvement = 2.9 lines
   • 27% resolved completely (IOD less than 1 line)
   • Most reached plateau by 4 months but some continued to show improvement over 9 months

48 Optical Correction Strabismic or Combined Strabismic/Anisometropic Amblyopia
   • (146) 3-6 yr old kids, 52 with previously untreated strabismic and 94 with combined etiology amblyopia (1 D or more aniso)
   • Mean improvement of 2.6 lines
   • 32% resolved completely (IOD less than 1 line)
   • Strabismic amblyopes improved more than combined etiology amblyopes
     –mean 3.3 lines

49 Optical Correction Strabismic or Combined Strab/Refractive Amblyopia
   • About 1/3 of patients became orthotropic at distance and/or near and many more showed reduced angle
   • 25% of the kids showed modest gains in stereopsis
   • Improvement in acuity was independent of angle of deviation at baseline or after treatment.

50 The “Magic” of Glasses
   • Most patients with strabismus have some significant refractive error, mostly hyperopia and astigmatism.
   • We now have proof that we should let the glasses work for a few months before we initiate further therapy
• Patching or atropine therapy often unnecessary in mild refractive amblyopia cases
  – Consider risk of child rejecting glasses due to association with patching/atropine
  – Child will likely be more compliant with penalization if amblyopia is already partly resolved

51 **Astigmatism and Amblyopia**

• Depends on magnitude and type
  – ATR/Oblique much more amblyogenic
  – Almost all astigmatism in pediatric population is WTR... thankfully

• 2 - 4 D of WTR astigmatism is likely to cause mild amblyopia but it resolves well with correction even at age 4-7
• >4 D may not achieve 20/20 ever unless corrected by age 2

52 **Astigmatism Case**

• 8 mo. old girl presents for routine first eye exam
  – Good alignment, motility, convergence
  – Bruckner indicates equal WTR astigmatism
  – MEM: 1-2 D lag at 180

Dry Ret:  
OD +2.00 -3.50 x 180
OS +1.50-3.50 x 180

Wet Ret:  
OD +2.50 – 3.50 x 180
OS +2.50 – 4.00 x 180

What’s the game plan?

53 **Hyperopia: THE risk factor**

• High isoametropic hyperopia (over 5-6D) will cause bilateral amblyopia if the infant fails to accommodate....most do fail at
this level.
• Moderate hyperopia (3-5D):
  – Risk of accommodative ET
  – Are there other developmental issues associated with hyperopia?
• Low amounts of hyperopia by school age may cause near point difficulties.

Hyperopia Case 1
• 6 yr old girl presents due to failed school screening
  – 20/200 VA OD, OS, inaccurate eye movements, receded NPC, no stereo
  – Good alignment on Bruckner, Hirschberg but dull retinal reflex, CT shows ortho at distance, XP at near, no accommodative response on MEM
  – Dry Retinoscopy: +10.00 - 4.00 x 180 OU
  – Wet Retinoscopy: the same

What’s the plan?

Hyperopia Case 2
• 2.5 yr old boy presents with intermittent esotropia x 3-4 months
  – Eye turn OD observed 2-3 x /day, short duration, more at night
  – VA’s OD 20/32, OS 20/32 (Pacific Acuity Test)
  – Bruckner/Hirschberg equal, 400” Randot stereo
  – CT: approx. 10-15 EP, E(T) at near, MEM: +0.50 OU
Dry Ret:  OD +2.50 sph
  OS +3.00 sph
Wet:  OD +4.50 sph
  OS +5.00 sph

What’s the Plan?
Hyperopia Case 3

- 3 yr old female presents due to failed screening at pediatrician office
- No other concerns, (-) FMHx
- VA's 20/30 OD, OS with Lea Symbols
- Hirschberg/Bruckner show good alignment, symmetric hyperopic reflexes, +Lang Stereo
- Difficult to get fixation time for CT

Dry Ret:
- OD +3.50 - 0.75 x 180
- OS +3.00 - 0.50 x 175

Wet Ret:
- OD +4.00 - 0.75 x 180
- OS +3.75 – 0.75 x 180

What else would be helpful to guide us?

Other risks associated with hyperopia?

- We know hyperopia is a risk factor for learning difficulties in school-age kids
  - Eames 1930s
  - Rosner, Rosner 1980s

- What about preschoolers?
  - Intuition and experience tells us these kids are at risk for visual perceptual delays. Poor visual attention.
  - Use it or lose it….may not be using their vision like the little emmetrope or myope.
- What is the evidence?

Cambridge Longitudinal Study of Hyperopia

- Compared psychomotor and language development of uncorrected hyperopes to controls at several ages from 2-6 years
- Hyperopes performed significantly worse than controls on
tests involving visual perception and visual-motor integration
• No difference between groups on other cognitive and language tests

59 **Ametropia, Preschoolers’ Cognitive Abilities, and Effects of Spectacle Correction**

• Hyperopic astigmats (> +4.00-2.00) compared to emmetropes (<+2.00-1.00) had significantly lower scores on Beery VMI and Wechsler Preschool Performance Scale but no difference on Verbal Scale
• After spectacle correction for 6 weeks, there was no significant difference on the same tests between groups

60 **Down Syndrome or Cerebral Palsy**
• Accommodative insufficiency is common
• Any hyperopia may be significant
• Consider bifocals (BIDS Study)

61 **Correcting the refractive error holds greater benefit for a young patient’s overall function than just decreasing risk for or treating amblyopia/strabismus.**

62 **Billing and Coding Refractive Amblyopia**
• If a child has enough refractive error to potentially cause amblyopia, you should code amblyopia until proven otherwise on follow-up
• It is difficult to judge from initial VA at the first visit (uncorrected or trial frame) whether there is amblyopia.
• Second visit after 1 month of glasses wear provides a better baseline acuity.

63 **Dispensary**
• Good selection of children’s eye wear including flexible nylon infant/toddler goggles
  –Solobambini
• Myth: Comfort cables are appropriate for most children.
  – They are NOT! They stretch out, get chewed on, etc. and the frame cannot be adjusted.