

Binocular vision and accommodation in myopia progression

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DISCLOSURE

- I have received funding from the following bodies for lectures, key opinion leader/product feedback, and research:
 - Alcon, American Academy of Optometry (UK), Association of Optometrists, Birmingham Focus on Blindness, Black & Lizards, Central (LOC) Fund, Cerum Visual Technologies, College of Optometrists, Coopervision, ESRC, Essilor, General Optical Council, Hadassah College, Hoya, Institute of Optometry, Iris Fund for Prevention of Blindness, Johnson & Johnson, Leightons, MRC, NIOS, Noville, Optos, Paul Hamlyn Trust, Perceptive, Scrivens, Specsavers, Thomas Pocklington Trust.
- Lecture content always my own
- I am not a myopia researcher, but a clinician with an interest in helping my myopic patients

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PLAN

- Introduction
- Myopia onset
- Myopia progression
- Myopia control
- Conclusions

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Myopia: the new view

Patient about to become myopic
 - image shell focused on retina at fovea
 - image focused behind retina in periphery
 - **relative peripheral hyperopic defocus - RPHD**

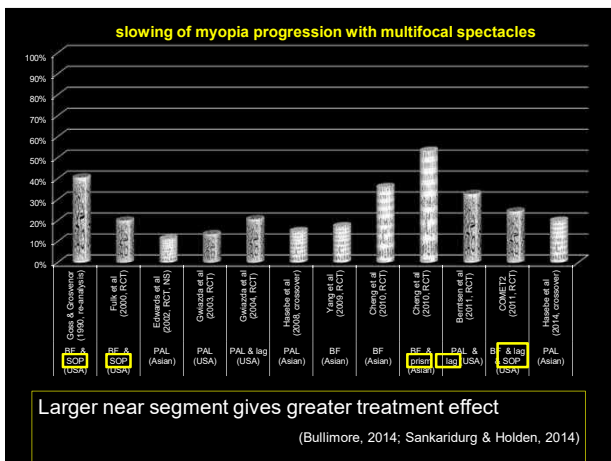
Reviews: Charman & Radhakrishnan (2010); Earl Smith (2011); Filtcroft (2012)

The eye grows so the peripheral image is in focus causing myopia at the fovea

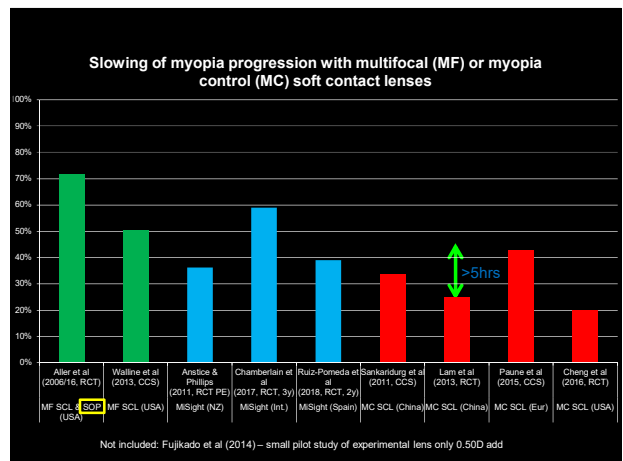
Spectacles or contact lenses correct the focus at the fovea, but not the RPHD so myopia progresses

BUT: see Atchison et al. (2015)
 Relative peripheral hyperopia does not predict development and progression of myopia in children

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Accommodative lag and esophoria

- Historically, esophoria and increased accommodative lag have been associated with the onset & progression of myopia
Goss & Rainey (1999)
- In myopes, esophoria is correlated with lower accommodative response
Wildsoet et al (2019)
- Hypothesis: Accommodative lag → hyperopic defocus → axial growth
Wildsoet et al (2019)
- Larger accommodative lags have been linked to development and progression of myopia
Allen & O'Leary (2006)
- CLEERE study: accommodative lag not predictive of onset of myopia
Zadnik et al (2015)

BUT...



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CLEERE study: AC/A ratio (Mutti et al., 2015)

- 698 children aged 6 to 14 years who became myopic and 430 emmetropic children
- Response AC/A ratio increases from 4y before onset of myopia → 5y after onset
- In all ethnic groups; higher AC/A in Asian
- Increased AC/A ratio is linked to increased accommodative lag
- Initially, linked to more near esophoria
- Esophoria may be driven more by the AC/A ratio than accommodative lag
- Relative peripheral refraction only significant 2y before onset of myopia
- Increasing AC/A appears to play a role in onset of myopia
- Argue compromised accommodation requires increased effort per dioptre of accommodative output

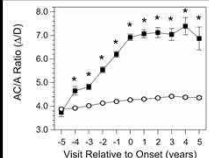
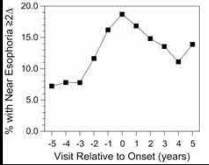


Figure 4. The response AC/A ratio as a function of annual rate relative to the onset of myopia (-5 years before to 5 years after onset), which is obtained as the difference between children who became myopic (●) and from nonmyopic control values (○). All error bars are ±SEM. Error bars for the nonmyopic control values are smaller than the symbols. Significant differences between groups (P < 0.05).



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Accommodation & binocular vision

- Historically, esophoria and increased accommodative lag have been associated with the onset & progression of myopia
Goss & Rainey (1999)
- Hypothesis: Accommodative lag → hyperopic defocus → axial growth
Wildsoet et al (2019)
- Larger accommodative lags have been linked to development and progression of myopia
Allen & O'Leary (2006)
- No significant correlation between myopia progression and magnitude of accommodative lag
Weizhong et al (2008)
- Elevated AC/A ratio is linked to increased accommodative lag in myopia but is not associated with rate of myopia progression regardless of amount of near vision
Mutti et al (2015)
- BUT: there is some evidence of a better treatment effect from multifocals when near esophoria or high lag

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What effect do multifocal contact lenses have on binocular vision & accommodation?

- Kang et al (2016)
 - 24 myopes (18-28y) in centre-distance multifocal soft contact lenses; c.f., single vision soft contact lenses; 2-week interval
 - Multifocals had minimal effect on accommodative lag, shifted phorias in exo direction. No significant differences in stereopsis and fixation disparity
- Ruiz-Pomeda et al (2019): assessed, before and with MiSight:
 - distance and near horizontal phoria, accommodative convergence/accommodation (AC/A) ratio, stereopsis, accommodative amplitude (AA), and accommodative response (AR) at 33, 25 and 20 cm.
 - MiSight do not change the binocular and accommodative function in children
- Cheng & Brennan (2019)
 - NB, this design of lens only slowed myopia progression by 20%
 - A soft contact lens with positive spherical aberration for controlling myopia progression results in an apparent decrease in accommodation
 - The reduced accommodative response correlated with greater myopia progression
 - Conclude some participants were use the "add" to help near viewing

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Impact of OrthoK on binocular function

Felipe-Marquez et al. (2017)

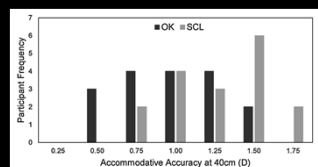
- **Methods:**
 - Longitudinal study of young adults: 21 controls, 26 OrthoK, 25 different OrthoK
 - Some tested at 3 months, some at 3y
- **Results:**
 - OrthoK associated with minimal changes
 - Near exophoria increased

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Binocular vision & accommodation in young adult myopic OrthoK

Gifford et al. (2017)

- **Methods:**
 - Retrospective analysis of 17 OrthoK & 17 soft contact lens wearers, 18-30y
 - Matched for age, Rx, duration of contact lens wear
- **Results:** OrthoK associated with:
 - Decreased accommodative lag
 - Near exophoric shift
- **Concludes:**
 - OrthoK associated with more accurate near accommodative-vergence profile



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Impact of OrthoK & Medcall lens on accommodation

Han et al. (2018)

- **Methods:**
 - Children: 90 spectacles, 90 OrthoK, 90 Medcall myopia control spectacles
 - Baseline: single vision spectacles
 - 1 month: OrthoK
- **Results:**
 - OrthoK and Medcall reduce accommodative lag and improve accommodative facility

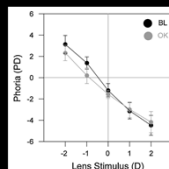


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Impact of OrthoK on binocular vision & accommodation

Kang, Watt, Chau, Zhu, Evans, Swarbrick (2018)

- **Methods:**
 - 24 myopes (18-38y)
 - Baseline: spectacles
 - 1 month: OrthoK
- **Results:**
 - OrthoK associated with no change in: distance and near phoria, fixation disparity, stereoacuity, AC/A gradient; but phoria became less variable
 - Phorias close to ortho changed little, larger exophoria and esophoria reduced closer to normal
 - Accommodative facility improved (p=0.053)
- **Concludes:**
 - Normalisation of phoria may be an indication of improved accommodative accuracy

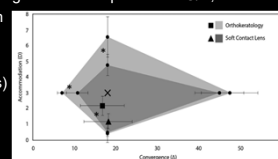


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Zone of clear binocular single vision in myopic OrthoK

Gifford et al. (2019)

- **Methods:**
 - 12 children (8-16y) and 8 adults (18-29y)
 - Baseline: single vision soft contact lenses
 - OrthoK effect evaluated after 1 month & 12 months
- **Results:**
 - Orthokeratology associated with no change in distance phoria or AC/A, but:
 - Increased amplitude of accommodation
 - Decreased accommodative lag
 - Increased divergent reserves
 - Near exophoric shift (only at 12 months)
 - Expansion in zone of binocular single vision
- **Concludes:**
 - Shift towards state reflecting emmetropia, maybe via increase in spherical aberration
 - Speculate could be a mechanism for the effect of OrthoK on myopia control



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Conclusions

- Myopia is sometimes associated with esophoria, increased accommodative lag, increased AC/A ratio
 - These cases benefit most from multifocal myopia control interventions
- Dual focus (multifocal) contact lenses have minimal effect on binocular vision and accommodation (less lag, more exo)
- OrthoK slightly shifts phoria to exo & decreases accommodative lag
 - Mild effect at normalising/improving binocular vision
- This may be one factor influencing myopia control, but causal evidence is not strong



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Clinical implications: myopic child

- Is there a near esophoria, high lag, high AC/A?
 - Assess: near vision asthenopia, cover test, fixation disparity, MEM retinoscopy
- If yes, myopia control contact lenses are likely to alleviate symptoms & reduce myopia progression
- Large segment bifocal spectacles are likely to reduce symptoms & may have mild effect at myopia control



Mille grazie a Giancarlo Montani e agli eccellenti traduttori

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