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 College of Optometry, B&L, Bloe & Loom, Bolton College of Optometry, Boston College of Optometry, California State University, College of Optometry, College of Optometrists, Companhia, ESCD, Eliott, General Optical Council, Harvard College of Optometry, Institute of Optometry, International Myopia Institute, Johnson & Johnson, Johnson, Lehigh, MRC, NDS, Optica, Pearson, Harvard, University, Spectators, Thomas Puckett Trust.
  - Lecture content always my own.
  - I am not a myopia researcher, but a clinician with an interest in helping my myopic patients.

PLAN

Introduction
Myopia onset
Myopia progression
Myopia control
Conclusions

Myopia: the new view

Patient about to become myopic
- Image shall focused on retina at fovea
- Relative peripheral hyperopic defocus - RPHD

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. (2013)

Relative peripheral hyperopic does not predict development and progression of myopia in children.

Slowing of myopia progression with multifocal (MF) or myopia control (MC) soft contact lenses

Larger near segment gives greater treatment effect

(Bullimore, 2014, Sandalberg & Holden, 2014)
Historically, esophoria and increased accommodative lag have been associated with the onset & progression of myopia.

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.


BUT...

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 to 5y after onset.

In all ethnic groups; higher AC/A in Asian children.

Increased AC/A ratio is linked to development and progression of myopia.

Allen & O'Leary (2006)

Larger accommodative lags have been linked to development and progression of myopia.

Wildsoet et al (2019)

In all ethnic groups; higher AC/A in Asian children.

Increased AC/A ratio is linked to increased accommodative lag in myopia but is not associated with rate of myopia progression.


BUT: there is some evidence of a better treatment effect from multifocals when near esophoria or high lag.

Relative peripheral refraction only significant 2y before onset of myopia.

Increased AC/A appears to play a role in onset of myopia.

Argue compromised accommodation requires increased effort per dioptre of accommodative output.

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.


Elevated AC/A ratio is linked to increased accommodative lag in myopia but is not associated with rate of myopia progression.


BUT: there is some evidence of a better treatment effect from multifocals when near esophoria or high lag.
What effect do multifocal contact lenses have on binocular vision & accommodation?

- Kang et al (2016)
  - 24 myopes (18-39y) 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 eye direction. No significant differences in stereoacuity and fixation disparity
- Ruz-Pomeda et al (2019): assessed, before and with MiSight:
  - distance and near horizontal phoria, accommodative convergence/accommodation (ACA) ratio, stereoacuity, accommodative amplitude (AA), and accommodative response (AR) at 33, 25 and 20 cm
  - MiSight did not change the binocular and accommodative function in children
- Chang & 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 using the “add” to help near viewing

Impact of OrthoK on binocular function

Felipe-Marcuez 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

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

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

Impact of OrthoK on binocular vision & accommodation


- Methods:
  - 24 myopes (18-39y)
  - Baseline: spectacles
  - 1 month: OrthoK
- Results:
  - OrthoK associated with no change in:
    - distance and near phoria, fixation disparity, stereoacuity, ACA (subject), 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

Zone of clear binocular single vision in myopic OrthoK

Gifford et al. (2019)

- Methods:
  - 12 children (8-15y) 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 ACA, 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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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

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

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