Contact Lens Treatments for Myopia Control: Emerging Evidence Based Practices
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Abstract: There is growing evidence to support the use of multifocal and orthokeratology contact lenses for myopia control. Research on the safety of these devices in the pediatric population supports expansion of their use, but there is still much to be learned regarding their efficacy and safety. This lecture will review the translational and clinical evidence showing how multifocals and orthokeratology may work to slow myopia progression. The instructors will identify some of the concerns and questions surrounding the use of contact lenses and orthokeratology in children, and discuss the current options for clinical care of the young myope.

Objectives:

1) Review prevalence, progression and ocular risks associated with myopia.
2) Understand the role of retinal defocus and the potential significance of eye shape and peripheral refractive state on emmetropization and myopia progression.
3) Review research on optical treatments for myopia with an emphasis on recent clinical studies of multifocal soft contact lens and orthokeratology.
4) Examine evidence surrounding CL safety in the pediatric population.
5) Discuss current options for care of the pediatric myope.
6) Appreciate the challenges in adopting new treatment technologies.

Outline:

I. Introduction
   a. Myopia as a public health problem
      i. Prevalence
         1. Increase in US prevalence of myopia from about 20-30% in 1970s to 35-45% in early 2000s (Vitale, Arch Ophthalmol, 2009)
         2. Incidence exceeds 80% in Asian countries (e.g. Morgan, Prog Ret Eye Res, 2005)
      ii. Associated ocular disease risk
         1. Increased risk of maculopathy, retinal degeneration and other conditions. Risk increased with increasing levels of myopia. (Flitcroft, Prog Ret Eye Res, 2012)
      iii. Progression
         1. Expect about 0.25 to 0.50 D/year, with younger patients progressing faster. (Kennedy, Trans Am Ophthal Soc, 1995)
   b. Overview of theories of myopia control
      i. Genetics
ii. Accommodation/Near work
iii. Visual regulation using retinal defocus

II. Experimental evidence for the visual regulation of eye growth
a. Animal models and local control of eye growth
   i. Visual deprivation causes axial elongation (e.g. Wallman, Science, 1987)
   ii. Positive and negative defocus effect ocular growth (e.g. Troilo, OVS, 2009; Benavente-Perez, IOVS, 2012)
   iii. Local control of eye growth (e.g. Troilo, Curr Eye Res, 1987; Diether, Vis Res, 1997)

b. Eye shape and peripheral refraction
   i. Retinal processing
      1. 90% of retinal ganglion cells found outside the fovea (Azzopardi and Cowey, Neuroscience, 1996)
   ii. Off-axis refraction may be more or less hyperopic or myopic in the periphery.
      1. Myopes have more relative peripheral hyperopia (Mutti, IOVS, 2000; Millodot, OPO, 1981)
   iii. Ocular dimensions in myopia, emmetropia and hyperopia
      1. Myopes have more oblate eyes (Atchison, IOVS, 2005)
   iv. Peripheral regulation of eye growth in animal models
      1. Laser lesions to the macula do not prevent lens-induced refractive error changes (Smith, IOVS, 2005)

III. Spectacle treatment for myopia
a. Undercorrection
   i. Theory similar to lens induced changes, but lack of support from clinical studies (Adler, Clin Exp Optom, 2006; Chung, Vis Res, 2002)
   ii. May not provide enough positive power (especially in the periphery), may change visual behavior

b. Bifocal/PAL glasses
   i. Originally based on accommodative theories of myopia development
   ii. COMET / COMET 2 studies show some statistically significant decreases in myopia progression, but only in kids with higher lags and near esophoria (Gwiazda, IOVS, 2009)
   iii. Peripheral aberrometry suggests bifocal glasses may have limited efficacy since primarily effect superior retina (Berntsen, IOVS, 2013)

IV. Contact lens treatments for myopia
a. Multifocal lenses
   i. Theory: add plus to distance correction – across whole retina or in periphery
   ii. Animal studies
      1. Dual focus lenses with simultaneous plus and minus
         a. Response favors plus (Benavente-Perez, IOVS, 2012)
      2. Spatial and temporal integration
         a. Spatial - Greater effect seen with increasing plus in the periphery (Benavente-Perez, under review).
         b. Temporal – short amounts of plus may be effective (Zhu, Exp Eye Res, 2013; Benavente-Perez, in preparation)
iii. Human studies
1. Case reports suggest slowing of myopia progression with soft multifocal lenses for presbyopia (Aller, Clin Exp Optom, 2008)
2. DIMENZ study: Within-subject crossover study with dual focus design soft contact lens showed slowed refractive error and axial length progression compared to single vision (Anstice, Opthalmol, 2011)
3. Clinical study of aspheric design lens showed refractive error and axial length progression reduced compared to historical spectacle control group (Sankaridurg, IOVS, 2011)
4. BLIMP study: CooperVision Proclear Multifocal showed reduction in axial length compared to historical soft sphere contact lens group (Walline, OVS, 2013)
5. DISC study: slowing of myopia progression with concentric ring design vs. single vision CLs in a 2-year randomized clinical trial (Lam, Br J Ophthalmol, 2014)

b. Orthokeratology
i. Theory: uncorrected cornea creates positive defocus in periphery

ii. Human studies
1. Retrospective record reviews and case reports suggest potential for slowing myopia (Reim, Contact Lens Spectrum, 2003; Cheung, OVS, 2004)
2. CRAYON study: reduction in axial length with CRT as compared to soft contact historical control group (Walline, BJO, 2009)
3. MCOS and ROMIO studies: reduction in axial length with orthok compared to spectacles (Santodomingo-Rubido, IOVS, 2012; Cho and Cheung, IOVS, 2012)
4. IOOALECM study: Long-term follow up shows that slowing of myopia progression is retained over time (Hiraoka, IOVS, 2012)
5. High myopia may also be successfully treated with partial ortho-k and spectacles (Charm, OVS, 2013).

iii. Known and presumed risk factors for soft contact lens complications
1. Modifiable risk factors
   a. Overnight wear (e.g. Poggio, NEJM 1989, Cheng, Lancet, 1999; Lam, Eye, 2002, Morgan, IOVS, 2005; Stapleton, Ophth, 2008)
   b. Longer CL replacement schedule (e.g. Dart, Ophthalmal, 2008, Chalmers OVS 2010, Wagner, OVS, 2011)
c. Longer use of CL case / lack of cleaning case (e.g. Pens, Parasitol Res, 2008; Stapleton, Ophthal, 2008; Larkin, BJO, 1990; Wu, OVS, 2011)
d. Lack of/poor hand washing (e.g., Dart, Ophthal, 2008; Lam, Eye, 2002; Radford, Ophth, 2009; Wu, CLAE, 2010)
e. Exposure of CL or case to water (e.g. Joslin, AJO, 2007; Awaad, Eye Cont Lens, 2007; Kilvington, IOVS, 2004)
f. Smoking (e.g., Stapleton, Ophthal., 2008; Radford, Ophthal, 2009; Lam, Eye, 2002; Chalmers, OVS, 2007; Morgan, IOVS, 2005)
g. Multipurpose systems and topping off (e.g., Carnt, Arch Ophth, 2009; Joslin, AJO, 2007; Verani, Emerg Infect Dis; 2009; Chang, JAMA, 2006)
h. Ocular microbiota/bioburden (e.g., Szczotka-Flynn, OVS, 2009; Szczotka-Flynn, IOVS, 2010)

2. Non-modifiable risks
   a. High refractive error (e.g., Chalmers, OVS, 2007; Zadnik, OVS, 2001)
   b. Compromised systemic health (e.g., Keay, OVS, 2009; Radford, Ophthal, 2009; Morgan, IOVS, 2005)
   c. Genetic susceptibility (e.g., Carnt, Ophthal, 2012; Keijser, Exp Eye Res, 2009)
   d. Age
      iv. Safety profile with age
         1. CLAY study showed risk of complications, including CIEs, peaks in 15 to 25 year old wearers (Wagner, OVS, 2011; Chalmers, IOVS, 2011)
   b. Benefits of contact lens wear for children and teenagers
      i. Optical
      ii. Psychological
      iii. Myopia progression
   c. Fitting contact lens fitting in pediatrics
      i. Patient/parent considerations: cost, acceptance, safety, etc
      ii. Doctor/practice considerations: chair time, expertise, profit, risk, etc
      iii. Minimizing risk with proper patient education: AOCLE, IER, industry
      iv. Current contact lens options for myopia control in the US
         1. Big four and custom soft multifocal lens design options
            a. Center distance vs. center near
            b. Add power
         2. CRT and VST orthokeratology options
         3. Clinical trials: NIH and Industry sponsored

VI. Adopting new technologies
   a. Key stakeholders
   b. Technology adoption lifecycle and challenges
Representative References


Benavente-Perez, A., Nour, A., & Troilo, D. (2014). Axial eye growth and refractive error development can be modified by exposing the peripheral retina to relative myopic or hyperopic defocus. under review.


children. IOVS, 41 (5), 1022-1030.


