MYOPIA: CURRENT THEORIES AND TREATMENT

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IT HAS ALL CHANGED SINCE 1971 !!!.

1

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Cooper J, Tkatchenko AV. ***A Review of Current Concepts of the Etiology and Treatment of Myopia.*** Eye Contact Lens. 2018;44(4):231-47.

Cooper J, Weibel K, Borukhov G. ***Use of Atropine to Slow the Progression of Myopia: A Literature Review and Guidelines for Clinical Use.*** Vision Development & Rehabilitation. 2018;4(1):12-28.

Cooper J, O'Connor B., Watanabe, R, I Fuerst R,.Berger, S Dilehay ***Series Analysis of Myopic Progression Control With a Unique Extended Depth of Focus Multifocal Contact Lens.*** Eye Contact Lens. 2018;44(5):e16-e24.

Cooper J, Schulman E, Jamal N. ***Current status on the development and treatment of myopia***. Optometry. 2012;83(5):179-99. PubMed PMID: 23249121.

- Available on ***Coopereyecare.com***/Publications
- Or AOA website ***Optometry*** Journal

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CHARACTERISTICS OF MYOPIA

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Myopia Statistics

- US population 25% from 1975-1995 40% in 2010
  - 84% of young Asians develop myopia
- Women > Men
- Caucasian > Blacks
- 7 – 16 years –initial development and greatest progression
- Mean rate of myopia progression in 0.35 – 0.60D for children aged 6 to 15 years
- Early myopia = faster progression and more myopia

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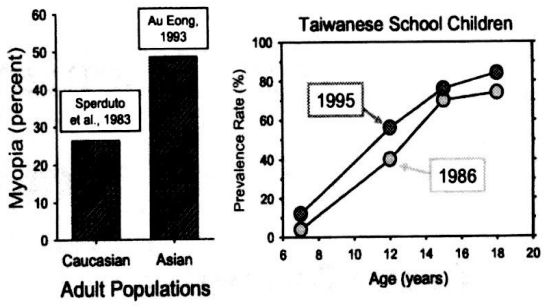
Prevalence of Myopia



From Earl Smith III OD, PhD

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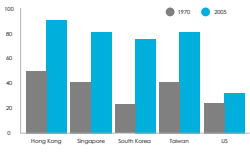
Myopia Is A Major Public Health Issue

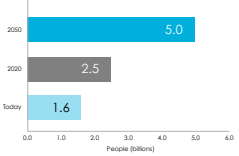
Myopia is **increasing**

- 40-50% prevalence in US and Europe[1]
- Almost **80%** prevalence in some Asian countries[2]
- **5 billion affected people by 2050**[3]
- Earlier onset means higher myopia[4]

Prevalence worldwide - rates around the world[1,2]



Myopia prevalence projections[3]



1 Vitale, S., Sperduto, R., & Ferris, F. (2009). Increased Prevalence of Myopia in the United States Between 1971-1972 and 1999-2004. *Archives of Ophthalmology*. 127(12): 1632.
2 Dolgin, E. (2015). The myopia boom. *Nature*. 519(7543): 276-278.
3 Holden, B. A., et al. (2016). Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050. *Ophthalmology*. 123(5): 1036-1042.
4 Flitcroft, D. (2012). The complex interactions of retinal, optical and environmental factors in myopia aetiology. *Progress in Retinal and Eye Research*. 31(6): 622-660.

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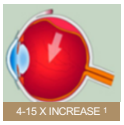
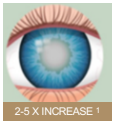
Myopia Is The 6th Leading Cause Of Visual Loss



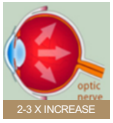
Retinal Detachment[2]

- The retina pulls away from the eye's supportive tissue
- Can cause permanent vision loss



Cataracts[2]

- Typically associated with the aging process
- Tend to develop sooner in nearsighted eyes



Glaucoma[2]

- Due to higher pressure in the eye
- Damages the optic nerve and causes vision loss

Myopic Maculopathy (macular degeneration)[3]

- The **most common** complication of high myopia[1]
- A **slowly progressive and sight threatening condition** in which visual loss develops from atrophy of the retinal pigment epithelium and/or secondary complications such as sub-retinal neovascularization[3]
- The only disease amongst the top five causes of blindness that remains **entirely untreatable**[1]

1 Flitcroft, D. (2012). The complex interactions of retinal, optical and environmental factors in myopia aetiology. *Progress in Retinal and Eye Research*. 31(6): 622-660.
2 Baxter, N. (2017). Retinal detachment, Cataracts and Glaucoma images and explanations of retinal detachment, cataracts and glaucoma from Infographic: What You Should Know If Your Child Is Nearsighted – AllAboutVision.com. Accessed 25 April 2017. http://www.allaboutvision.com/parents/myopia-facts-infographic.htm.
3 Myopic Maculopathy image from: Myopic Maculopathy - Singapore National Eye Centre. (n.d.). Accessed 18 April 2017. https://www.snec.com.sg/eye-conditions-and-treatments/common-eye-conditions-and-procedures/Pages/myopic-maculopathy.aspx.

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Data Make Tx of Myopia A Public Health Issue – Reduce Myopia and Reduce Risk

- Consider the increase of urban, educated, people
  - Population is increasing with more people living in urban environments
- Consider the increase incidence of myopia
  - USA approaching 40%, Asia 80%
- Consider the increased degree of myopia
  - Larger proportion becoming 4-5 D of myopia

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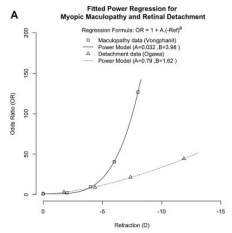
Ocular Consequences of Myopia



Myopia is 6th leading cause of permanent blindness. The prevalence and risk of pathology increase with both the magnitude of myopia and axial lengthelongation.

Filcroft

Level of Myopia (D)	Axial Elongation (mm)	Cataract	Glaucoma	Peripheral Retinal Degeneration	Retinal Detachment	MMD	Myopic Choroidal Neovascularisation
1-3	0.3 -1	2x	4x	6x	3x	2x	2x
3-6	1-2	3x	4x	18x	9x	10x	9x
>6	>2	5x	14x	40x	22x	41x	40x

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Longitudinal Studies of Untreated Childhood Myopia-Rate of Progression

Study	Age (years)	Mean progression rate (diopters/year)
Kennedy (1995)	6 – 15	0.36
Jensen (1991)	7 – 13	0.65
Yen (1989)	6 – 14	0.91
Grovesnor (1987)	6 – 15	0.34
Goss (1987)	6 – 15	0.44
Brodstein (1984)	8 – 12	0.62
Oakley (1975)	6 – 21	0.38
Slataper (1959)	8 - 15	0.24

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Occupational Myopia

- Professionals, writers etc have more myopia than farm construction workers or seamen
  - Tscherning (1882), Seggel (1884), Duke Elder (1930), Goldschmidt (1968)
- Increase in myopia after VDT use Tokoro (1988)
- Adams McBrien (1992) showed that 66% of microscopist become myopic

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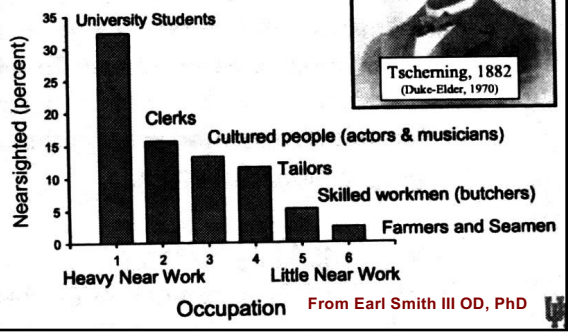
Myopia has historically been associated with nearwork.



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A L or Refraction Best Way to Monitor Myopia Progression

- Cycloplegic or Non-cycloplegic refraction
  - Accurate to +/- .25
  - Greater variability
  - Need .50 before knowing that a change has occurred
- Axial Length
  - Contact A-scan not accurate enough
  - IOL Master accurate to .04 mm or .1 D
  - Need 25 measurements
  - Problem – normal increase in AL with age, BUT still the best and most accurate
  - Want to slow AL elongation

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Normal Growth of Emmetropic Eye -Myopia

At Birth
17 x
17mm

2 Yrs Age
21.5 x 21.5 mm

Grows by
1:2 ratio
Up to
24mm
Emmetropic
Eye

From 24
mm
Grows .8:1
&
Becomes
Myopic

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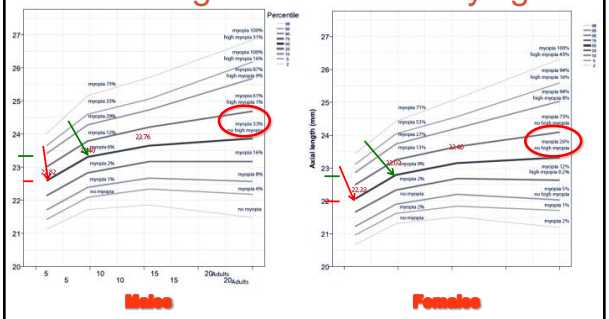
Axial Length Measurement by Age



Lodewijk JW, et al., Axial Length and the Risk of Developing Myopia in European Children, Acta Ophthalmologia, 2017 & Zadnik et al Ocular Component Data in Schoolchildren as a Function of Age and Gender, OVS 2003

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AL Take Away

- Emmetropic children grow approximately 0.19 mm/year between 6 and 9 years of age. At a later age this will decrease.
- The highest predictors for myopia were children who were increasing faster than the growth line, i.e. if you increase more than 10 percentiles (60th to the 70th percentile for example) your risk is 46% to develop myopia, compared to only <5% if you increase less.

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At What Age Does Myopia Progression Stop?

- Myopia thought to stop at age 20 (1960 data)
- Change in environment
  - Increase in number of college graduates
  - Increase in the number of graduate school students
  - Increase of near work with computers etc
  - Increase use of mobile phones, I-pads, etc
- Studies show that 10% of the work force after graduate school continued their progression of myopia well into their 30s

Fernandez-Montero A, Olmo-Jimenez JM, Olmo N, et al. The impact of computer use in myopia progression: a cohort study in Spain. Preventive medicine. Feb 2015;71:67-71.

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Lack of Outside Exposure is a Risk Factor For the Development of Myopia

- Not the inverse of reading or near work
- Not necessary related to sports involvement
- May be related to amount of light
- Animal studies show that amount of light exposure is related to myopia development
  - Rose KA, Morgan IG, Ip J, et al. Outdoor activity reduces the prevalence of myopia in children. *Ophthalmology. 2008;115(8):1279-1285.*
  - Cui, Dongmei et al. Effect of Day Length on Eye Growth, Myopia Progression, and Change of Corneal Power in Myopic Children. *Ophthalmology. 2013;120(5):1074-107*
  - Wu, Pei-Chang et al. Outdoor Activity during Class Recess Reduces Myopia Onset and Progression in School Children. *Ophthalmology.2013;120(5):1080-1085*

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FOUR DIFFERENCES BETWEEN INSIDE AND OUTSIDE WHICH MIGHT CAUSE MYOPIA TO DEVELOP

1. Brightness
2. Spectral Composition
3. Dioptric Demand and Differences Between Distance and Near
4. Constant Accommodative Demand at Near – Slow Accommodation

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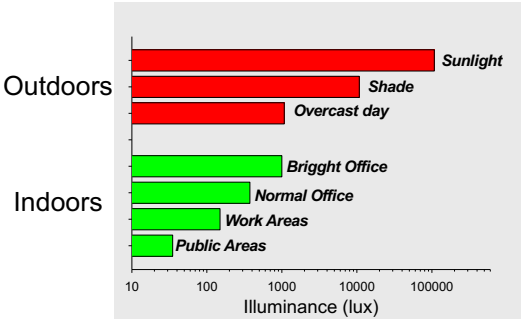
Ambient Lighting Levels are Much Higher outdoors



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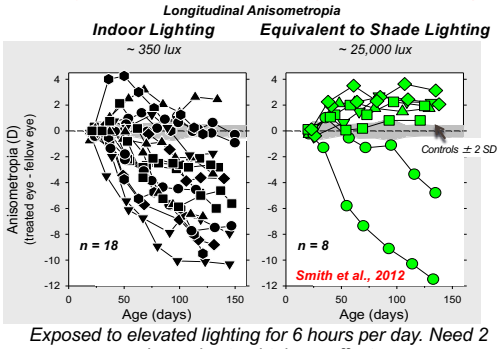
1- Form Deprivation Myopia is Suppressed in Monkeys When Raised in High Ambient Light



Exposed to elevated lighting for 6 hours per day. Need 2 hrs a day to obtain an effect

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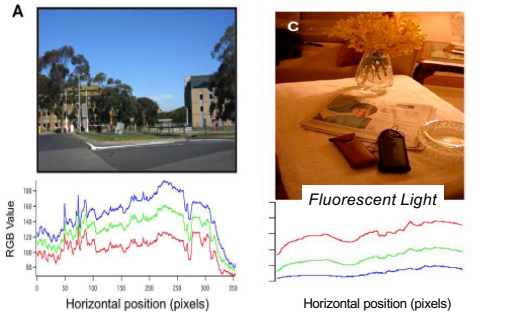
2. Outdoors and Indoors Differ In Spectral Light Compensation

Indoor scenes are dominated by long-wavelength light.



Foulds et al., 2014

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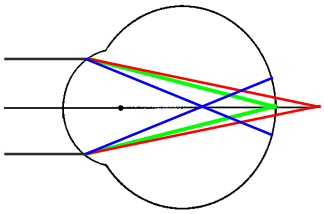
Ambient Light: Spectral Composition

Longitudinal Chromatic Aberration



The refracting power varies with wavelength, thus, the defocus signal regulating eye growth varies with wavelength).

Red lighting could be misinterpreted as chronic myopic defocus and be a risk factor for the development of myopia

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Which Explains the- Relationship of Violet Light and Myopia

- VL suppressed the axial length (AL) elongation in the chick myopia model.
- Retrospectively to compare the AL elongation among myopic children who wore eyeglasses (VL blocked) and two types of contact lenses (partially VL blocked and VL transmitting).
- VL transmitting contact lenses suppressed myopia progression the most.
- VL important outdoor factors for myopia control. VL is eliminated due to the excessive UV protection, VL may be a preventive against myopia progression.
- **Violet Light Exposure Can Be a Preventive Strategy Against Myopia Progression**, Hidemasa et. al. EBioMedicine 2017

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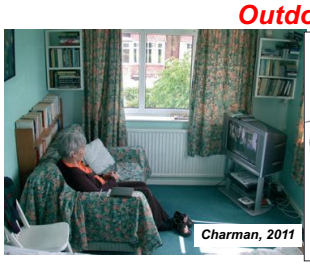
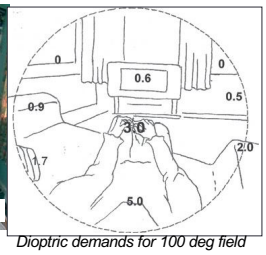
3. Dioptric Demand and Image Shell Are Different Indoors and Outdoors





Dioptric demands for 100 deg field

Hyperopic defocus that is distributed across the visual field. BUT at distance everything is in focus

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Clinical Dictum-Outdoors

Emmetropic children with two myopic parents (the largest genetic risk) who spent the lowest amount of time outside (5 hours or less per week) have a 60% chance of becoming myopic. Emmetropic children with two myopic parents who spent 14 hours per week or more outside, the probability of becoming myopic was reduced to 20%- Donald O. Mutti, OD, PhD

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Outdoor Time is A Factor But

- Can not explain the increase in myopia noted in office workers on computers
- Can not explain the high percentage of myopia in professionals, microscopists, Orthodox religious vs secular Jews
- Relationship with intelligence

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Animals Become Myopic

- Barrett (1932) differences in refractive error between domestic and wild animals
  - Caged cats 75% myopic, wild 85% hyperopic (Belkin et al 1977)
- Young (1964) laboratory, hooded monkeys became more myopic than there counterparts.

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What Can We Learn From Animal Studies

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Experimentally Induced Myopia

- Neonatal **form deprivation and defocused light induces significant myopic changes** Wallman et al (1978), Raviola and Wiesel (1985)
  - Monkeys, chicken or tree shrews are monocularly lid sutured, or translucent occluded
  - Local axial change occurring in the sclera at the specific site (VF) where deprivation takes place. *Occurs in the presence of a severed optic nerve*

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Blur Induced RE

- Schaeffel et al (1988) **used both plus and minus lenses to induce refractive changes in the chick** (one eye +, other -, or control)
  - Eye with plus becomes pseudo myopic and develops hyperopia
  - Eyes with minus become pseudo hyperopic and develop myopia
  - Measurements are cycloplegic

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Blur Induced RE

- Fairly linear changes in refractive power from -10 to +20 D
  - Choroid thickens to reduce blur in with plus
  - CNS is not necessary for the response
    - *Happens with optic N severed*
    - Brain removed
    - Happens if ganglionic cell activity is blocked (tetrodotoxin)
    - **Regulated by retinal signals**

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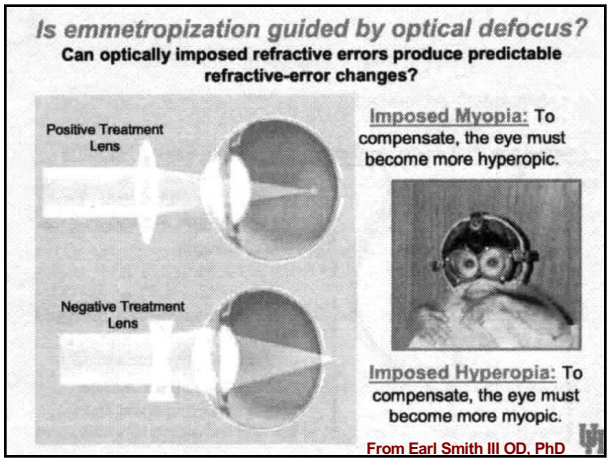

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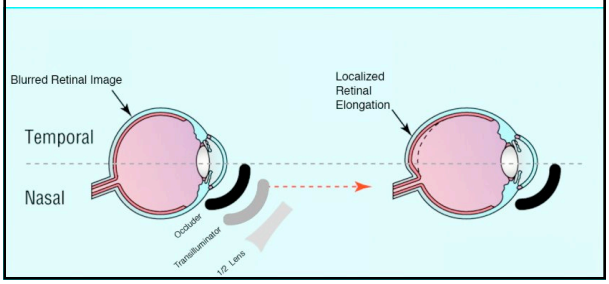
Blur by Occluder, Translucent, or Minus Lens Causes Elongation



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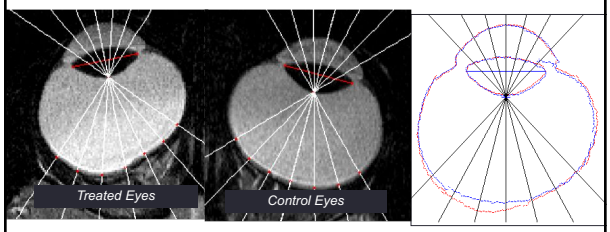
MRI Images of Elongation Due to Nasally De-Focused Light



Nasal translucent lens causing regional axial elongation, more prominent para macularly. Composite image showing difference in the third image.
Courtesy of Earl Smith

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Happens Even If You Cut the Optic Nerve Regional Retinal Signals

- Doesn't occur if you use atropine
- Atropine works by non-accommodative mechanism
  - When the optic N is cut
  - Segmental occluders or lenses
  - Animals that use non-muscarinic mechanisms to accommodate

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Blur Induced RE

- These results suggest that the ocular system **can determine the direction of defocused light**
  - Thus growth regulating systems mechanism changes the size of the vitreous cavity
  - Change occurs in the sclera

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Smith Demonstrates that the Periphery is More Important in Emmetropization

Peripheral blur drives the system towards "emmetropization"

Ablate the macula, peripheral blur results in change in length of the eyeball

Smith, E. Charles F. Prentice Award Lecture 2010: A Case for Peripheral Optical Treatment Strategies for Myopia OPTOMETRY AND VISUAL SCIENCE. 88(9): 2011

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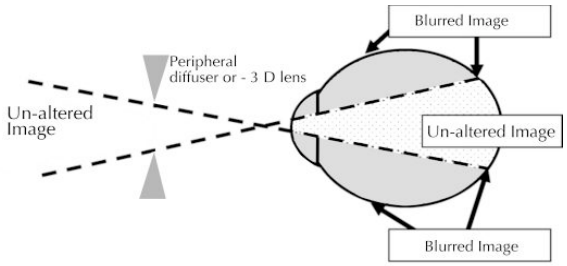
Peripheral Blur Causes Elongation of the Eye Even When Central Vision is Clear



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Peripheral Defocus Dominates

- In Monkeys if the fovea is ablated
- Either Peripheral form deprivation and hyperopic defocus produces changes in refractive error
- If there is a conflict between peripheral and retina signals, peripheral dominate
- Repeated with contact lenses with center plano and peripheral -5D or +5D (Troilo 2014) and the effect is larger with smaller pupil plano lenses in adolescent monkeys

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Smith's Conclusions

- **Ocular Growth and Refractive Development Are Controlled by Visual Feedback**
- **The Mechanisms That Regulate Refractive Development are Regional or Local**
- **Visual Signals From the Fovea Are Not Essential for Visual Dependent Growth and When in Conflict with Peripheral Signals, Peripheral Signals Dominate**
- **Refractive Errors Usually Vary with Eccentricity and Can Alter Central Refractive Development**

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Minus lenses correct at the center of the retina for clear vision…

However, peripheral light rays at the edge of the eye are now moved behind the retina.

This is believed to create a signal that results in lengthening of the eye.

- The eye growth repeats itself over and over
- Resulting in higher and higher amounts of myopia

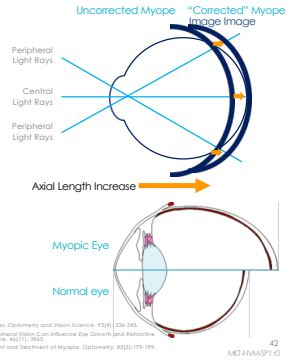

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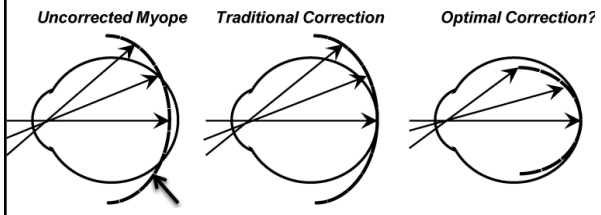
Image Shells



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Greater Peripheral Accommodative Differences Occur During Near Viewing

- When viewing outside both central and peripheral stimuli are in focus, minimal dioptric difference
- When viewing at near, central targets are accurately accommodated for and are clear but peripheral targets at near are out of focus due to the dioptric difference

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Atropine and Animals

- Atropine, a non-selective muscarinic stopped the progression of myopia in stump tailed monkeys but not rhesus monkeys
  - Thus accommodation per say was not the mechanism
- Chicks demonstrated regional myopia depending on the area of the retina deprived – thus, not accommodative nor central
  - Chicks have striated muscle in the ciliary body, thus, accommodation occurs by nicotinic action, not muscarinic

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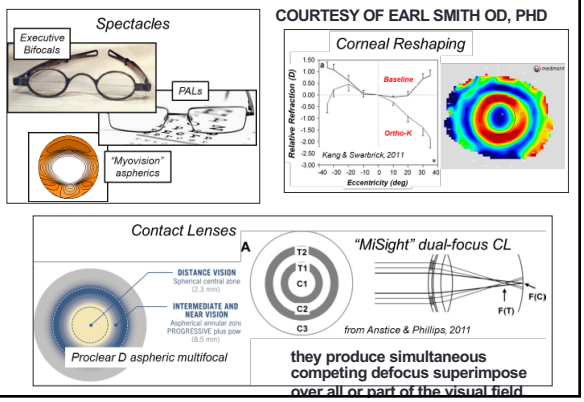
Optical Tx Impose Simultaneous Competing Defocus



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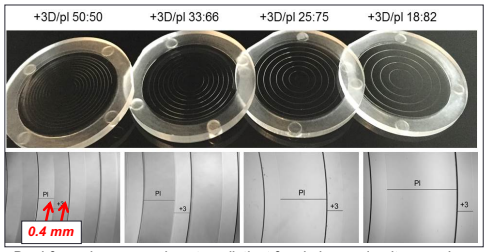
Dual Focus Lenses

Effects of Varying Surface Areas



Dual-focus lenses produce two distinct focal planes simultaneously across the visual field. The relative strengths of the image planes reflect the relative surface areas devoted to the two power zones.

Arumugam B, Hung LF, To CH, Holden B, Smith EL, 3rd. The effects of simultaneous dual focus lenses on refractive development in infant monkeys. *Invest Ophthalmol Vis Sci.* 2014;55(11):7423-7432.

COURTESY OF EARL SMITH OD, PHD

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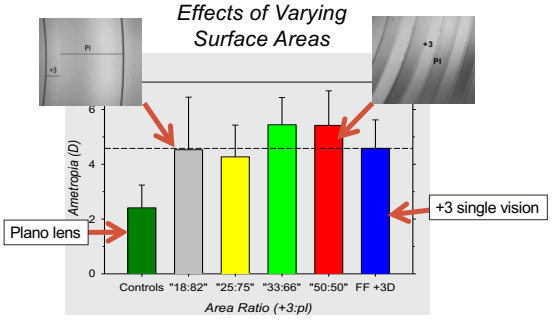
Dual Focus Lenses

Effects of Varying Surface Areas



Even when the positive portion of the lens is 4.5 times smaller than the plano portion, the eye develops hyperopia.

COURTESY OF EARL SMITH OD, PHD

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Myopic Gene is Turned On by a Near World Environment

- Some mice have the **APLP2 gene** and if those mice were **exposed to a near vision environment** they became myopic. If they were not exposed to a near vision demand they did not develop myopia
- The same gene has been **found in humans**. "These variants showed evidence of differential effect on childhood longitudinal refractive error trajectories depending on time spent reading (gene x time spent reading x age interaction"
- Tkatchenko AV, Tkatchenko TV, Guggenheim JA, et al. APLP2 Regulates Refractive Error and Myopia Development in Mice and Humans. PLoS Genet. Aug 2015;11(8)

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How Do We Change the Process

- Can either change the stimulus (glasses, contact lenses, prisms, vision therapy, sunlight) which contributes to myopic elongation.
- OR block or interfere with biochemical process

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Risk Factors (Development & Progression)

- Number of Parents with Myopia
  - Genetic vs. environmental
- Initial AL measurements predict progression
- Time spent outside
  - Sports, UV light, brightness, dopamine, image shell at NV
- Amount of time reading or close work
  - Flat 2 dimensional objects
- Amount of time on computers
- Education Level
- Urban vs Rural

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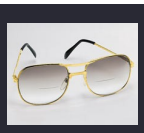
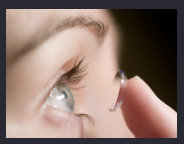
Prediction of Myopia

- 2 Parents
- Axial Length at 5 or 9
- Asian vs Caucasian
- Amount of close work
- Amount of time outdoors
- Educational level
- Urban vs. Rural environment

52





TREATMENT -MYOPIA CONTROL

Bifocal lenses
Multifocal lenses
Contact lenses
Orthokeratology
Atropine
VT
Surgery

53

SPECTACLE TREATMENT

54

Treatment with Bifocals

- Oakley Young (1975), Daubs and Shotwell (1983), and Goss (1986) show positive effects of bifocals
  - It seems that patients with esophoria did better than others
- Grovenor et al (1987), Hemminki and Parssinen (1987) did not

55

Oakley and Young (1975)

- N= 43 Native American (NA) and 226 Caucasian (C), ages 6 - 15
- All subjects were under corrected by 0.50D
- Bifocal Add +1.50 or +2.00, regardless of phoria
- Under correction effect? Increase -0.50 D/yr
- ***Native Americans: bifocal: -0.11D/yr control: -0.37D/yr***
- ***Caucasions: bifocal: -0.03 D/yr control: -0.53 D/yr***

56

Fulk and Cyert (1996)

- Prospective study
- N = 32 children with esophoria at near
- Randomly divided into single-vision or +1.25 D bifocal.
- Last 6 months: ***SV: 0.80D/yr BF: 0.37D/yr***
- Conclusion: bifocals help in esophores

57

Houston Myopia Study (1987)

- N= 207 Multicultural patients
- 3 year randomized clinical trial
- 3 groups: single vision, +1.00, +2.00 add
- Progression: -0.34, -0.36, -0.34 D/year
- ***No statistically significant difference between groups***
- Highly criticized for not taking phoria measurements into account.

58

Hong Kong Bifocal Study

- 2 year study of myopic children 9-12 (initial myopia -3.70)
- 32 SV; 22 +1.50; 14 +2.00 add
- Mean progression after 2yrs. SV – 1.23; +1.50 -.76;
- +2.00 -.66
- Progressive lenses slow myopia
- Progression of Myopia in Hong Kong Chinese Schoolchildren is slowed by wearing progressive lenses (Leung JT, Brown B) *Optom Vis Sci* 1999

59

Correction Of Myopia Evaluation Trial Study

- N=469, 4 Optom schools; 6-11 yrs myopia 1.25-4.50
- SV or +2.00 PALs, evaluated yearly for 3 yrs.
- ***Mean progression SV = 1.48 D; PAL 1.28 D a diff of .20 D*** which was significant @ p=.004
- Change was due to an increase in axial length
- Most of the change occurred in the first yr
- **A Randomized Clinical Trial Of Progressive Addition Lenses Versus Single Vision Lenses On The Progression Of Myopia In Children** (Gwiazda, Hyman et al) *Investigative Ophtal* 2003; 44 1492

60

Bifocals and PALs

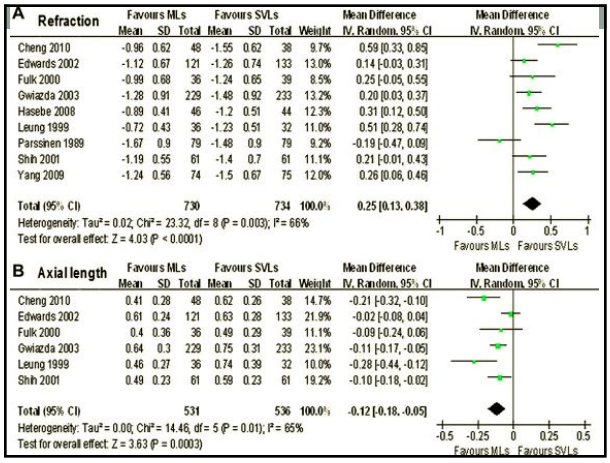
- COMET: Correction of Myopia Evaluation Trial Study: Children with **larger lags of accommodation** in combination with **near esophoria**, shorter reading distances, or lower baseline myopia showed a statistically significant treatment effect at 5 years.
- BUT not clinically significant

61

Bifocal with BI prism

- Rapidly progressing Chinese/Canadian children
- Cheng, D., K. L. Schmid, et al. in OVS
- In this unmasked study myopic progression averaged .77D/year in the single-vision lenses group; .48 D/year in the +1.50 executive bifocal group, and .35 D/year for prismatic bifocal group (+1.50 Add with 3Δ BI in each eye
- Best result of any bifocal or multi-focal lens
- High fitting

62



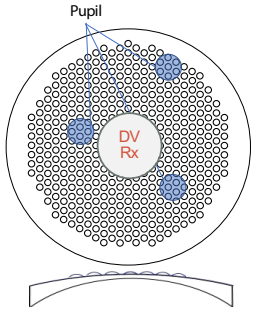
64

Newer Designs

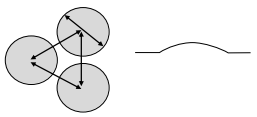
- DIMs Design from Hong Kong
  - Unpublished but well designed study with 60% reduction
  - HOYA manufacturing it in Europe
- Sight Glass Inc
  - Small sample, but major trial underway

65

D.I.M.S. Technology
Defocused Incorporated Multiple Segments

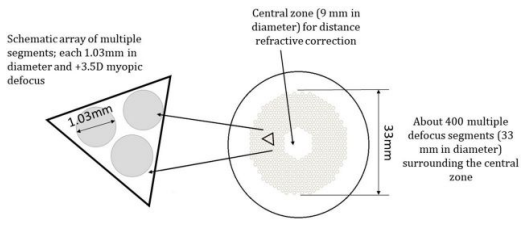


- Except at the center which is only the DV Rx, there are two focal powers (distance and +3.50 D of defocus) and these powers fall within the pupil s area in a honeycomb fashion
- The ratio of two focus areas has to be kept stable, no significant change with position
- The ratio of two focus areas within a pupil size is always kept at about 50:50 at everywhere of the lens



66

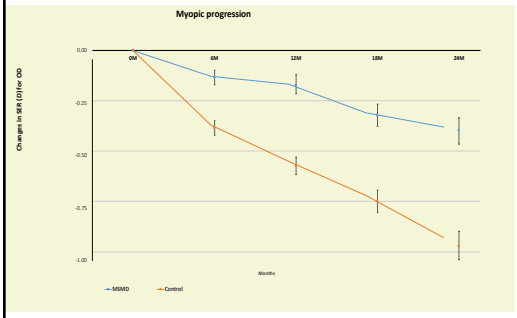
The Design of the Defocus Incorporated Multiple Segments (DIMS) Spectacle Lens.



Carly Siu Yin Lam et al. Br J Ophthalmol
doi:10.1136/bjophthalmol-2018-313739

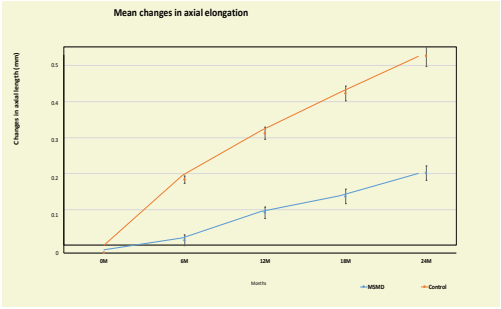
BJO ONLINE

67



Myopic progression was slowed down in average by 59%
Drop out rate of exp lens was 15% and control was 10%

68



Axial elongation was slowed in average by 60%

69

Under-Correcting Myopia

- The ***under-corrected eyes elongated faster (became more myopic) than fully corrected eyes***
- Thus, under-correcting may actually stimulate more myopia. Studies were stopped

- Chung K, Mohidin N, O'Leary DJ. Undercorrection of myopia enhances rather than inhibits myopia progression. *Vision Res* 2002;42(22):2555-9.
- Adler D, Millodot M. The possible effect of undercorrection on myopic progression in children. *Clin Exp Optom* 2006;89(5):315-21.

70

Holden Study on Glasses (2010)

- Three experimental designs
- Peripherally correcting lenses
- Minimal effect on slowing myopia
- Not a surprise, can control where someone is looking

71

CONTACT LENSES

72

Regular Soft and Gas Permable Lenses Have No Effect in Slowing Myopia

- CLAMP study by Walline 2004
- No change in axial length with rigid contact lenses

73

Orthokeratology

- Reim 2003 performed a retrospective study on 253 children age 6-18, -.50 to -5.25 for 3 yrs. Mean increase .13D/yr
- Walline COOK study 29 children between 8-11 with ortho K fitting was safe
- Cho et al LORIC age 7-12, -.25 to -4.50, SV control from another study demonstrated reduction in axial length growth. Large variation in effect.

74

Walline Study

- CRAYON Study – 40 children age 8-11yr
  - -.75 to -4.00 fit w CRT
- 70% completed the study
- A scan of children fitted with Ortho-K lenses demonstrated less change than a matched control group soft contact lenses

75

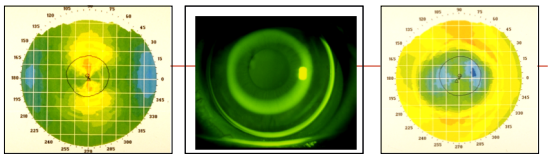
Swathbick et al

- 26 Myopic children wore a RGP lens in one eye during the day and a reverse geometry Ortho-K in the other eye
- 6 mos later A scan measurements were taken and the eyes were crossed over (A-B reversal design)
- 40% reduction in myopic elongations
- ***Axial length increased more in the RGP eyes***
- Small N, no long term data

- Swarbrick, Alharbi, Watt, Lum, Kang *Myopia Control during Orthokeratology Lens Wear in Children Using a Novel Study Design* Ophthalmology 3:620-30, 2015

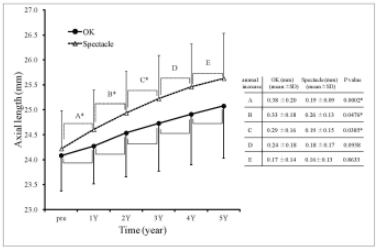
76

Corneal Refractive Therapy



77

5 Yr Orthokeratology Results



Hiraoka et al. Invest Ophthalmol Vis Sci. 2012 Jun 22;53(7):3913-9

Long-term effect of overnight orthokeratology on axial length elongation in childhood myopia: a 5-year follow-up study.

79

Seven Year Ortho-K Retrospective Study

- Kwok-Hei Mok, and Sin-Ting Chung (*Clinical Optometry 2011*) measured refractive and central corneal curvature after a washout period
- Myopic progression was calculated as a change of myopia from the baseline to the final visit.
- **Average myopic progression of Ortho-K contact lens was –0.37 ± 0.49 D (.05 D/yr)**
- **Average myopic progression of the single-vision spectacle group was –2.06 ± 0.81 D (.29D/yr)**

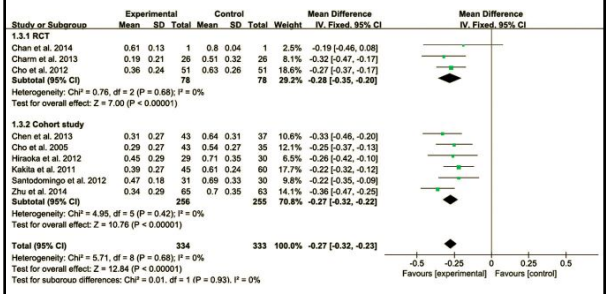
80

Orthokeratology Meta- Analysis

- Jun-Kang, et al. Orthokeratology for Myopia Control: A Meta-analysis. Optometry & Vision Science: March 2015 - Volume 92 - Issue 3 - p 252–257

- 7 studies, 435 subjects, 218 OK and 217 Control, 2 year follow up.
- Axial Length was the outcome measure
- "At 2 years follow-up, the AL elongation of the orthokeratology group was significantly slower than that of the control group (WMD, −0.26 mm; 95% CI, −0.31 to −0.21; p < 0.001)"

81



82

Low Risk of Microbial Infection

1. 2/10,000 for DW GP contact lenses
2. 8/10,000 for CRT
3. 2-12/10,000 for DW soft contact lenses
4. 18-25/10,000 for EW soft contact lenses

Incidence of MK based on at least 3 months' wear

	Children	Adults	Overall
n	677	640	1317
Cases	2	0	2
Years at risk	1435	1164	2599
Incidence rate (95% CI)	0.00139 (0.00017 to 0.00504)	0 (0 to 0.00317)	0.00077 (0.00009 to 0.00278)
Rescaled incidence rate (95% CI)	13.9 (1.7 to 50.4)	0 (0 to 31.7)	7.7 (0.9 to 27.8)

Rate is per year of wear. Rescaled rate is per 10,000 patient-years.
CI, confidence interval.

Bullimore et al. Optom Vis Sci 2013;90:937-944

83

Who Does The Best w Ortho K

- The **larger the refractive error** the better the response or stated another way – the lower the prescription the less effective Ortho-K is
- The **smaller the treatment zone** the more effective Ortho K is. Stated another way ortho K lenses designed to slow myopia use smaller OZ
- The **larger the pupil** the more effective Ortho K is (get more surface area with corrected hyperopic defocus, thus, atropine should improve results just by pupillary dilation

84

Summary

- Ortho-K results in a 30-50% reduction in the progression of myopia
- Ortho-K and LASIK/PRK are different
  - Ortho
- Can be used in young children
- High drop out rate – about 20%
- Concern for corneal infection
- WOW factor – happy kids

85

Soft Lenses to Correct Peripheral Defocus

- Phillips and Antstice demonstrate that dual-focus multi-focal lenses can slow the progression of myopia
- One group wore the multifocal while a second group wore multifocal lenses with 2D of defocused light for 10 months
- .44 D/yr for dual focus compared to .69 D/yr for the control
- Mysosite lens

86

Holden Study on Multifocal Contact Lenses (2011)

- 6 mos of wear
- .26 D/year vs .60 D/yr
- No long term data
- Remember bifocals/progressives were effective in the first year, but the effect dissipated

87

Multifocal Contact Lens Myopia Control

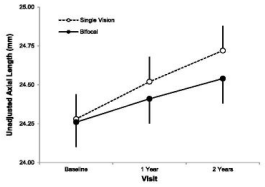
- **Walline, J; Greiner, Katie L, McVey, E; Jones-Jordan Optom Vis Sci. 2013 Nov;90(11):1207-14**
- Determine the progression with Cooper "D" lens over time compared to Historical controls
- Adjusted mean standard error sph eq progression of myopia at 2 years was -1.03 D for SV CL and -0.51 for Cooper "D"
- Axial length changes were 0.41 for SV and 0.29 Cooper
- Cooper "D" reduced the progression of myopia by 50% and reduced axial elongation by 29%

88

Soft Bifocals

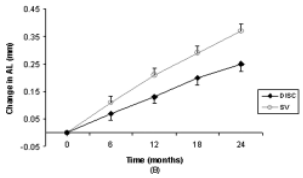
Walline et al. Optom Vis Sci 2013;90:1207-1214

- Slows axial length growth 29%
- 33% Dropout



Lam CSY, et al. Br J Ophthalmol 2014;98:40–45.

- Slows axial length growth 31%
- 42% Dropout



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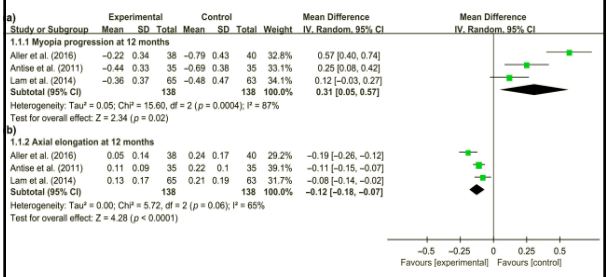
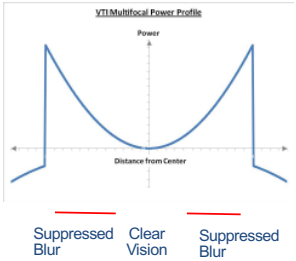


90

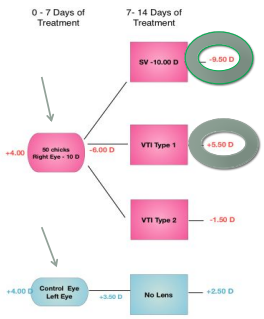
The VTI Multifocal Center Distance CL

- Center-distance design. As one moves radially outward from the center of the lens, power rises dramatically and creates an annular blur zone.



91

Reversal Of Induced Myopia in Chicks with VTI Contact Lens - Natural Vue



Irving EL, Yakobchuk-Stanger C. **Myopia Progression –Control Lens Reverses Induced Myopia in Chicks**. *Ophthalmic Physiol Opt.* 2017;37(5):576-584.

92

What is Wrong With These Studies

- No long term studies
  - Remember both atropine and bifocal studies did much better in year one
  - No studies that looked at what happened when the lenses were discontinued
  - No real controls

93

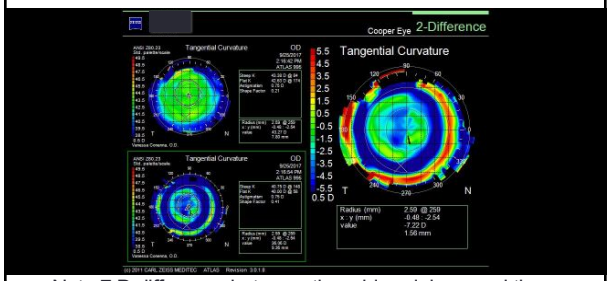
Case Series Analysis of Myopic Progression Control With A Unique Extended Depth of Focus Multifocal Contact Lens

Jeffrey Cooper, MS, OD, FAAO, Brett O'Connor, OD, Ronald Watanabe, OD, FAAO, Randall Fuerst, OD, FAAO, Sharon Berger, OD, COVD, Sally M. Dillehay Edd, OD, FAAO

. EYE CONTACT LENS. 2018;44(5):E16-E24

94

2 Difference with NaturalVue CL On and Off



- Note 7 D difference between the mid-periphery and the central zone

95

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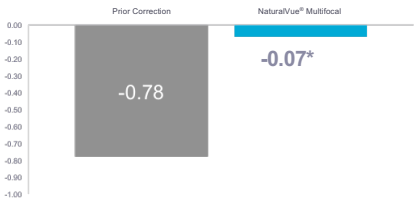
NaturalVue® Multifocal – Refractive Error Change Vs. Prior Correction

In children who have worn NaturalVue® Multifocal for 6-16 months:

Annualized Refractive Error Change



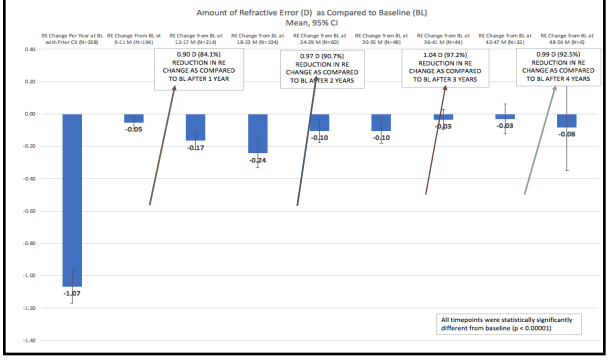
Percentage decrease with NaturalVue Multifocal = 91.6%

VTI Data on file. 2017. (N = 14 children)
*p < 0.0000

MKT-NMMSP1-r0

96

Retrospective Study of 141 Children Followed For 6-48 Mos With Average Slowing By 90%



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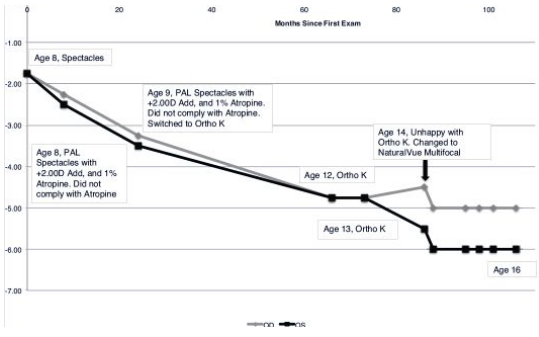
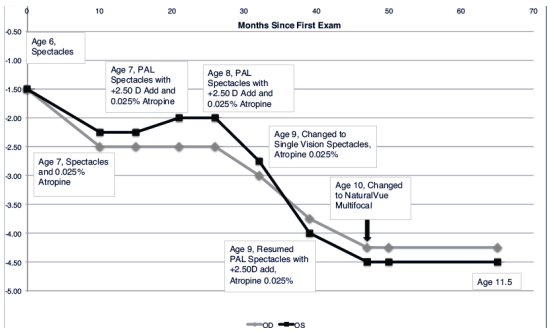
Atropine, Ortho K Failure -Multifocal Success



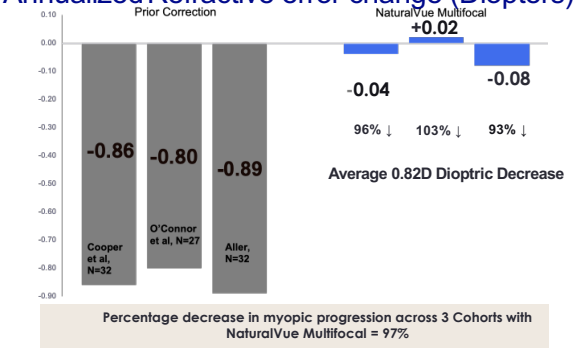
98

PAL and Atropine Failure - Multifocal Success



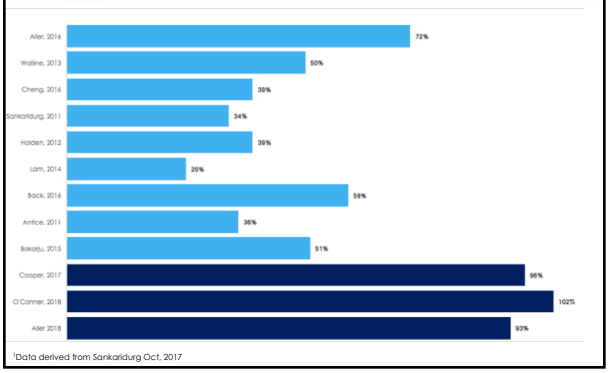
99

NaturalVue® Multifocal – Annualized Refractive error change (Diopters)



100

Multifocal Soft Lens Percentage Decrease in Myopic Progression[1]



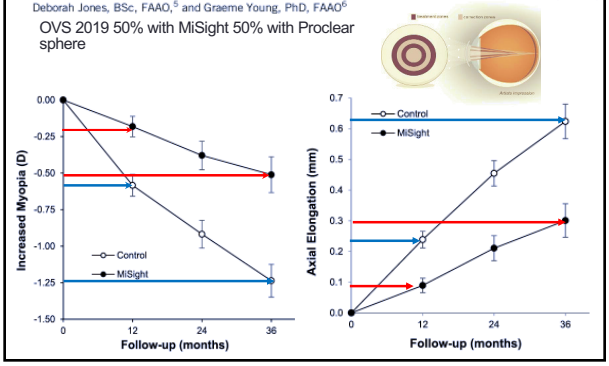
[1]Data derived from Sankaridurg Oct. 2017

101

A 3-Year Randomized Clinical Trial of MiSight Lenses for Myopia Control

Paul Chamberlain, BSc,[1*] Sofia C. Peixoto-de-Matos, MSc,[2] Nicola S. Logan, PhD,[3] Cheryl Ngo, MBBS, MMed,[4] Deborah Jones, BSc, FAAO,[5] and Graeme Young, PhD, FAAO[6]

OVS 2019 50% with MiSight 50% with Proclear sphere



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Summary of Soft CL Studies

Study	Year	Lens Name	type of lens	amount of add	No of subjects	Length	Control	Change in Control (D)	change in Exp Group (D)	change in control AL	change in exp group AL	Comparison to control	Progression AL/yr
Aller, Liu, Wildsoet	2016	acuvue presbyopia	gradient	2	86	12	SV soft	0.79	0.22	0.24	0.05	79%	0.19
Walline NS, Phillips	2011	custom	dual focus	2	40	10	Other Eye	0.69	0.44	0.22	0.11	49%	0.11
Lam CSY, Tang WC,	2014	custom	concentric	2.5	221	24	random CL	-0.3	-0.4	0.18	0.13	32%	0.12
Fujikado	2014	custom	gradient	low	24	12	crossover		0.09	0.17		25%	0.05
Walline JJ, Greiner KL	2013	proclear	gradient	2	27	24	historical	-0.52	-0.26	0.21	-0.15	29%	0.13
Sankaridurg P, Holden	2011	custom	gradient	?	95	12	spectacle	-0.86	-0.45	0.4	0.27	38%	0.15
Ruiz J, Morales	2015	custom	Radial ref gradient		40		spectacle	-98	-0.56			27%	0.14
Cooper	2018	VTI Naturalvue	gradient	6	32	6-25	Historical	0.85	0.04				
Cheng	2015	custom	positive sph ab	?	82	24	Random CL	0.14	0.14	0.14	0.11	39%	0.14
Chen et al	2013	custom	aberration control	?	96	24	Random CL					-1%	-0.01
Lio pomeda	2018	misight	dual focus	3.5	74	24	spectacle	0.74	0.45	0.44	0.28	36%	0.16
Chamberlain et al	2019	Misight	dual focus	3.5	109	36	Random CL	-0.41	-0.17	0.21	0.11	52%	0.12
Sankaridurg P, Bakaraju	2019	----	different designs	1.525	508	24		-0.575	-0.4	0.29	0.205	30%	0.09

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What Can I Prescribe Now Using Soft Lenses

- Cooper multifocal D +2.00 add and Acuvue Oasys for Presbyopia lenses are weak Myopia Control Lenses
- **VTI NaturalVue** is the **first soft CL that has the correct design to slow the progression of myopia and really works**
- Might add low dosages of atropine with it
- Tom Adler has found that any multifocal works, not much different (His studies were started before peripheral defocus theories got hot)
- VTI might have the lens (based upon Monkey studies)

104

Vision Therapy

- No controlled study
- Tractman – Accommotrac™ – not repeatable

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PHARMACEUTICAL TX

106

Atropine

- **Dobrowolsky** from St. Petersburg and **Hosch** from Basel reported improvement of myopia after atropine use in 1868 and **1871**
- **Gimbel** (1973), **Bedrossian** (1979), **Kennedy** (1995), **Syniuta & Isenberg** (2000) show that myopia progression drops from .35- .85 diopters to . 05 -.12 diopters
  - 22 studies support the use of atropine
- **Problems with light sensitivity, flush, allergies are minimal**

107

Bedrossian - Monocular Treatment (1971)

- N = 62, Ages 8 – 13
- Monocular trial, fellow eye used as control
- 1% Atropine sulfate, 1gtt, QD (morning)
- Patients were not given a bifocal
- Increases in myopia:
  - Treated eye: +0.20D/year
  - Control eye: -0.85D/year

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Chiang (2001) – Atropine and Bifocal Spectacles

- N=706 Ages 6 –16
- 1% atropine solution 1X/week.
- Median treatment was 3.62 years.
- Study involved a homogeneous population of **Caucasian** patients.
- Mean rate of progression was 0.08 D/year

109

Chou (1997) - Atropine to Control Progression in High Myopia

- N = 20 Ages = 7 - 14
- Refraction: >-6.0D
- Time = 5 years
- Treatment = 0.5% atropine QHS
- High compliance/Low drop out rate
- Follow up exams = every 4 months
- Myopic progression: -0.08D/year

110

Reduction in Elongation of the Eye w Atropine

- Chew (1995) study mean progression of -2.00 in control group and +.17 in the atropine group
- Control group **increased** axial length by 1.18mm while atropine group **decreased** length by.017
- Not accommodatively induced, atropine blocks the retinal/choroid signal for elongation

111

Early Atropine Studies

Atropine reduces progression by 80%

Minimal complaints

Same failure rate as contact lenses

Author	# of children completed study	Length of study	Treatment	Control Group (mean progression)	Atropine Group (mean progression)
Gimbel(59) 1973	594	3 yrs	Atropine 1%-qhs	0.41 D/yr	0.14D/yr
Kelly et al(60) 1975	282	3 yrs	Atropine 1%-qhs	0.51 D/yr	+0.58D/yr
Kelly et al 1975	168	2-8yrs	Atropine 1%-qhs	Change in myopia: No change or improved: 2% -0.75D: 14% 1.00-1.75D: 35% 2.00-2.75D: 22% 3.00D: 27%	Change in myopia: No change or improved: 47% -0.75D: 34% 1.00-1.75D: 8% 2.00-2.75D:7% 3.00D:1%
Sampson(62) 1979	100	1yr	Atropine 1%-qhs & bifocal 2.25	No control	Change in myopia: -0.25 to +0.50D: 79% +0.75D to +1.00D: 15% >+1.00D: 6%
Bedrossian (64)1979	90 children on atropine (62 followed for 2 yrs, 28 followed for 4)	4 yrs	Atropine 1% in only eye	-0.82 D/yr	+0.21 D/yr
Gruber(65) 1985	200	1-7.5 yrs	Atropine 1%-qhs	-0.28D/Y	-0.11 D/yr
Brodstein(66) 1984	399	1-9 yrs	Atropine 1%-qhs & bifocal 2.25	-0.34D/Y	-0.12 D/yr
Bremner(67) 1985	79	1-9 yrs	No control	-.20	
Yen et al(68) 1989	96	1yr	Atropine 1%-qhs & bifocal 2.25	-0.91D/Y Change in myopia: No change: 6.25% < or = -0.50D: 31.25% -0.51 to -1.0D: 31.25% >-1.0D: 31.25%	-0.22D/Y Change in myopia: No change: 56% < or = -0.50D: 22% -0.51 to -1.0D: 19% >-1.0D: 3%

112

Chua et al - ATOM 1 Study (2006)

- 400 children between 6 and 12 years of age
- Refractive error of spherical equivalent: -1.00D to -6.00D
- Astigmatism: -1.50D or less
- Only 1 eye was chosen for treatment
  - **1 gtt 1% atropine or placebo eye drops qhs x 2 years**
- All children Rx photo-chromatic, progressive lenses

Chua WH, Balakrishnan V, Chan YH, Tong L, Ling Y, Quah BL, et al. Atropine for the treatment of childhood myopia. Ophthalmology. 2006;113(12):2285-91.

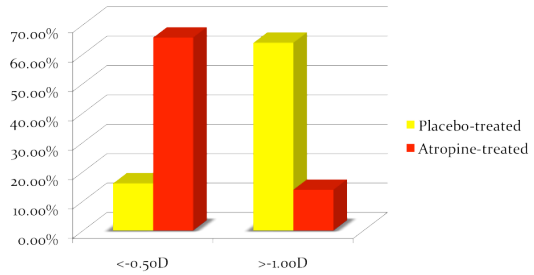
113

Results at 2 years

	PLACEBO	ATROPINE
Change in Refractive Error	-1.20+/-0.69D	-0.28+/-0.92D
Change in Axial Length	+0.38+/-0.38mm	-0.02+/-0.35mm

114

Myopia Progression over 2 years



115

Results

- **Over a 2-year period, atropine treatment achieved approximately a 77% reduction in mean progression of myopia compared with placebo treatment.**

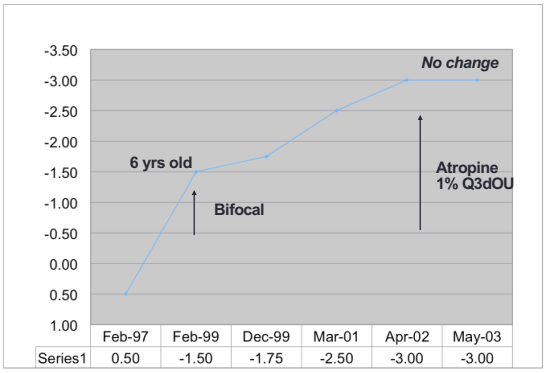
116

Adverse Effects Reported in ATOM Study

- Allergic or hypersensitivity reactions or discomfort (4.5%)
- Glare (1.5%)
- Blurred near vision (1%)
- Logistical difficulties (3.5%)
- Others (0.5%)

117

Yearly Progression of Myopia is Stopped by Atropine



118

Patient is Now 19

- -3.75 Myope
- Was recently fitted with Ortho-K lenses and happy (1 year w/o progression)
- If myopia progresses atropine .025% will be added

119

VARIOUS CONCENTRATIONS OF ATROPINE

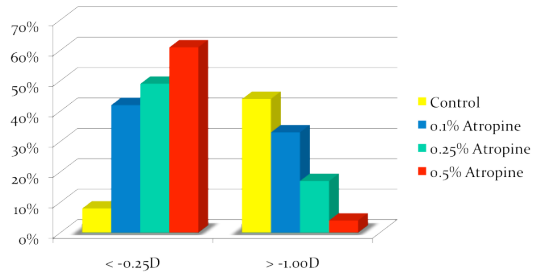
120

Myopia Progression (D/Y)

	CONTROL	0.1% ATROPINE	0.25% ATROPINE	0.5% ATROPINE
MEAN RATE OF MYOPIA PROGRESSION (D/Y)	-1.06+/-0.61	-0.47+/-0.91	-0.45+/-0.55	-0.04+/-0.63

121

Myopia Progression (D/Y)



122

Shin et al –Progression Less than 1D in a Year

- Atropine .5%
  - 61% did not progress
- Atropine .25%
  - 49% did not progress
- Atropine .1%
  - 42% did not progress
- Control
  - 8% did not progress

Shih YF, Chen CH, Chou AC, Ho TC, Lin LL, Hung PT. Effects of different concentrations of atropine on controlling myopia in myopic children. *J Ocul Pharmacol Ther.* 1999;15(1):85-90.

123

Lee et al- Atropine .05%

- Mean myopia progression for the patients treated with atropine .05% was 0.28 D/year, compared to that of the control group of 0.75 D/year
- There was a lower ratio of myopia that progressed greater than 0.50 D in 1 year as compared to controls (16.7% versus 77.8%; P 0.001).

Lee JJ, Fang PC, Yang IH, Chen CH, Lin PW, Lin SA, et al. Prevention of myopia progression with 0.05% atropine solution. J Ocul Pharmacol Ther. 2006;22(1):41-6

124

Atropine .025% Slows the Progression of Early Myopes

- Early myopes less than a diopter
- No accommodative changes
- No pupillary dilation

Fang PC, Chung MY, Yu HJ, Wu PC. Prevention of myopia onset with 0.025% atropine in premyopic children. J Ocul Pharmacol Ther. 2010;26(4):341-5.

125

Seasonal Prescription

- Atropine .1% for the summer
- Atropine .25% for spring and fall
- Atropine .5% for the winter
- UV protecting glasses were used in all glasses
- Progressives in children with near vision blur
- 93% no blur and/or photophobia

Lu P, Chen J. Retarding progression of myopia with seasonal modification of topical atropine. Journal of Ophthalmic and Vision Research. 2010;5:75-81.

126

Low Concentration of Atropine ATOM 2

- Chia, A., W. H. Chua, et al.. "Atropine for the Treatment of Childhood Myopia: Safety and Efficacy of 0.5%, 0.1%, and 0.01% Doses (Atropine for the Treatment of Myopia 2)." Ophthalmology (2011).
- 400 children aged 6-12 years with myopia of at least -2.0 diopters

127

ATOM 2 – Low Concentration

- mean myopia progression at 2 years
- Atropine .5% -0.30+/-0.60 (AL=0.27)
- Atropine .1% -0.38+/-0.60 (AL=0.28)
- Atropine .01% -0.49+/-0.63 (AL=0.41)

- ATOM1 -1.20+/-0.69 D in the placebo
- Atropine 1% -0.28+/-0.92 D

128

Lower Concentration

- Less effect on accommodation and pupil size

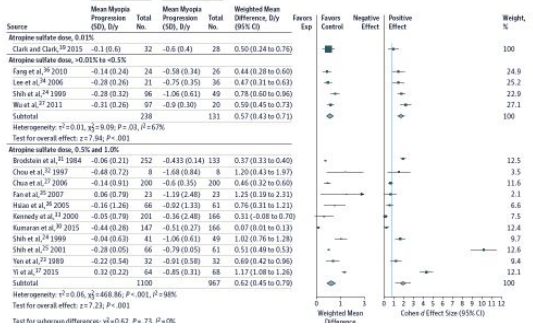
129

Atropine Studies w Various Percentage of Atropine

- Atropine 1% is the gold standard
- Atropine .5% is as effective
- Atropine .1%
- Atropine .025%
- Atropine .01%
- Seasonal prescription

130

Efficacy and Adverse Effects of Atropine in Childhood Myopia – A Meta-analysis (JAMA Ophthalmology 2017)



131

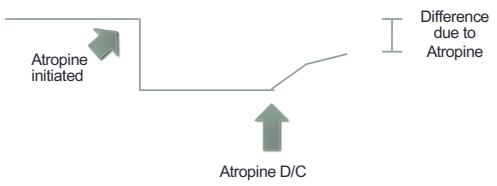
Effect on Myopia Progression after Cessation of Atropine

- 400 children 6 to 12 years old
- Refractive error of SE: -1.00D to -6.00D
- Astigmatism:-1.50D or less
- 12 months after stopping treatment of 1% atropine or vehicle eye drops once nightly for 2 years

132

Results

- **The average rate of myopia progression of the atropine-treated eyes over the entire 3-year period was still less than the rate in placebo treated eyes and axial length measurement differences were greater**



133

Cessation of Low Concentration

- **Chia A, Chua WH, Wen L, Fong A, Goon YY, Tan D. Atropine for the treatment of childhood myopia: changes after stopping atropine 0.01%, 0.1% and 0.5%. Am J Ophthalmol. 2014**

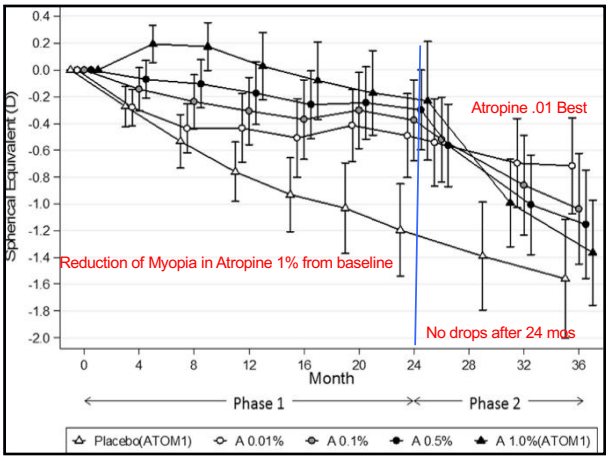
- 400 patients who used low dosage atropine for 24 mos
- Over the following 12 mos, myopic progression was greater in the 0.5% eyes (-0.87 +/- 0.52 D), compared to the 0.1% (-0.68 +/- 0.45 D) and 0.01% eyes (-0.28 +/- 0.33 D, P < 0.001).
- AL growth was also greater in the 0.5% (0.35 +/- 0.20 mm) and 0.1% (0.33 +/- 0.18 mm) eyes, compared to the 0.01% eyes (0.19 +/- 0.13 mm, P < 0.001).

134

5 Yr. Out Come From Chia et al Atropine .5%, .1% and .01%

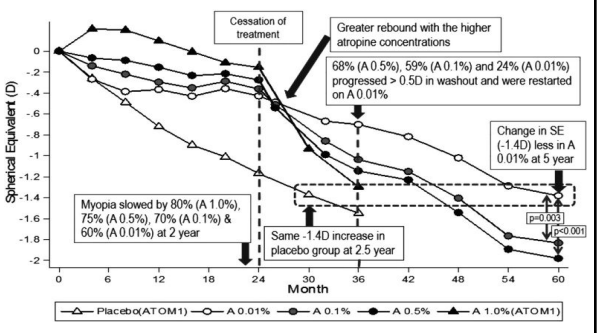
- Phase 1 - 2 yrs of treatment with various concentrations of atropine
- Phase 2 – 1 year of washout – No treatment
- Phase 3 – Treatment of those that progressed during Phase 2

135

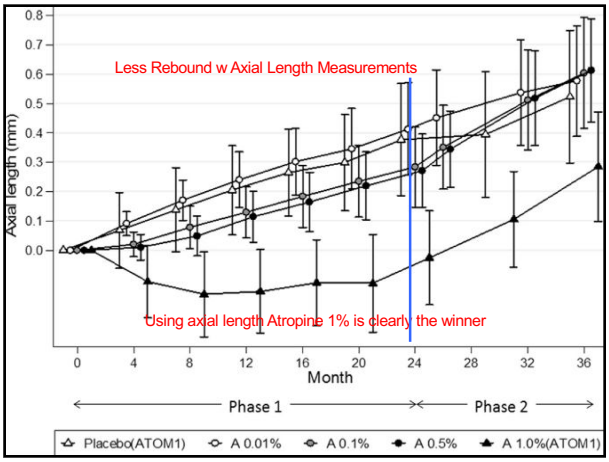


136

Summary of ATOM 1 & 2

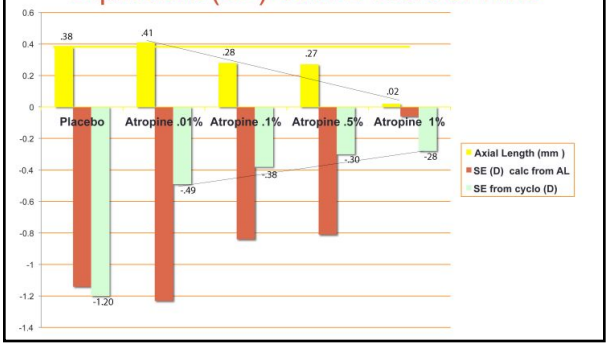


137



138

Changes in Axial Length and Spherical Equivalent (SE) Over 2 Years of Time



139

Biometric Measurements in ATOM2

In the atropine-treated eyes, there was a hyperopic shift between baseline and 4 months associate a reduction in LT, VCD, and AL (.1 mm). Between 4 and 24 months, a gradual increase in myopia, which was accompanied by reduction in K and ACD), and increase in VCD and AL. Compared with placebo-treated eyes, atropine-treated eyes showed less myopic progression and less increase in LT, VCD, and AL between 4 and 24 months

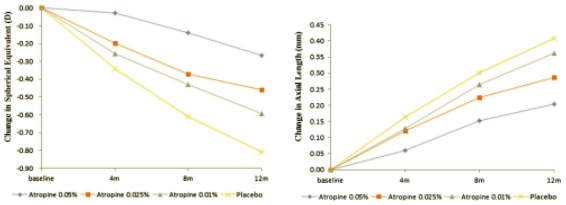
140

Stopping Atropine (Rebound) Biometrically

When atropine was stopped (between 24 and 30 months), there was a marked increase in myopia and greater reduction in ACD, and increase in LT, VCD, and compared with placebo-treated eyes. Atropine-treated eyes continued to demonstrate greater rates of myopic progression compared with placebo-treated eyes between 30 and 36 months, but these were mainly accompanied by an increase in VCD and AL

141

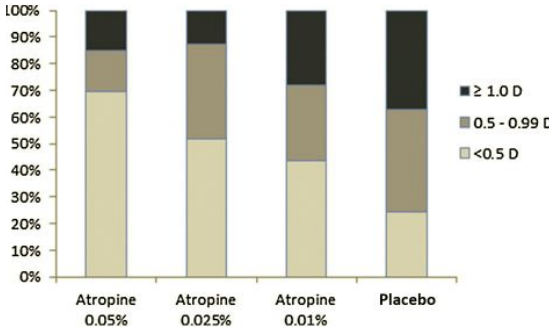
Low Dose Atropine for Myopia Progression (LAMP) Study: A Double-Blinded Randomized Placebo - Controlled Trial on Atropine 0.05%, 0.025%, and 0.01%



Jason YAM, Yuning Jiang, Shu Min Tang[1], Antony La

143

LAMP



145

Phase 2

- Rebound discussed
- Interesting finding **approximately 50% of the kids on atopine did not progress** during the 1 yr washout period suggesting that atropine **might create a stop signal**

146

Percentage That Needed Retreatment

Concentration	0.5	0.1	0.01
6.0-8.0	100	90	63
8.1-10	87	80	27
10.1-13	41	27	8
AGE			

147

Take Away

- Might be able to titrate or stop the use of atropine
- Can probably stop after 15
- Data also suggest that one needs to titrate concentration like we do in steroids to stop a rebound effect
- In any case the progression of myopia and the need to continue treatment decreases with age.

148

Chia Implies

- That atropine .01% is more effective than Atropine 1%
- **Just not true because you don't go cold turkey**
- BUT agree that older children (after age 8) and more moderately progressive children can be started on Atropine .01 or .02
- BUT I have found that very progressive kids still need Atropine 1%

149

Must Keep Children on Atropine for 2 Years

- Get more of an effect in year 2 than 1
- I would not stop until child is a least 15 yrs of age

150

What Is Wrong With Rebound Studies

- All atropine 1% patients **stay on treatment** usually
  - 4 yr to 10 yr on atropine 1%
  - Atropine .02% or ortho K
- It is **not how the medication is used**, ie.
  - 2 years use
  - Washout
  - 1 year w/o treatment

151

Summary

- Although the effect of the drug on myopia was relatively reduced after cessation for 1 year, the change in the axial length was significantly less than in eyes not treated with atropine.
- Future studies needed:
  - Is 2 years of Atropine enough?
  - What happens after a longer period of drug-free treatment?

152

Prescription Of Atropine Eye Drops Among Children Diagnosed With Myopia In Taiwan From 2000 To 2007: A Nationwide Study

- Fang, Chou,Pu, et al. Eye 2013 pp 1–7
- Atropine is prescribed routinely in Taiwan since it was advocated by the Taiwan Ophthalmology Association in 2000.
- Taiwan has one of the highest incidense and progression rates
- National Health Institute covers 99% of the population

153

Atropine Tx Has Increased

- Five different concentrations of atropine eye drops are available under the NHI program. Atropine 0.5 and 1% since 1995, 0.3% since 2001, and 0.1% since 2004.
- Other treatments such as ortho-K, contact lenses, bifocals are not reimbursed and thus not prescribed very often

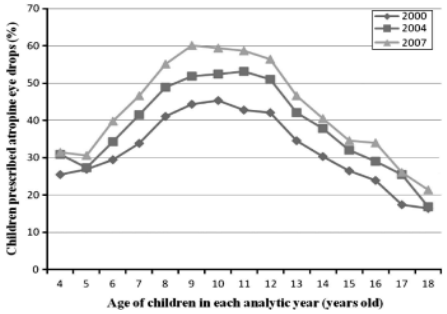
154

Prescription Of Atropine Eye Drops Among Children Diagnosed With Myopia In Taiwan From 2000 To 2007: A Nationwide Study

- Fang, Chou,Pu, et al. Eye 2013 pp 1–7
- Atropine is prescribed routinely in Taiwan since it was advocated by the Taiwan Ophthalmology Association in 2000.
- Taiwan has one of the highest incidense and progression rates
- National Health Institute covers 99% of the population

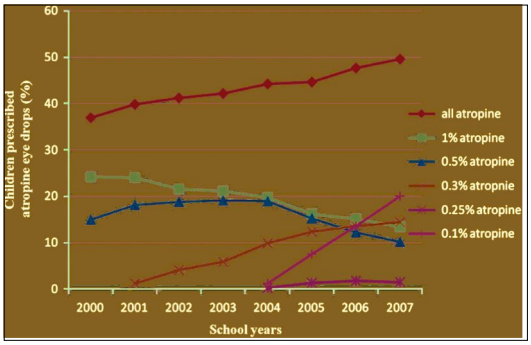
155

Percentage of Children on Atropine



156

Atropine Use By Concentration



157

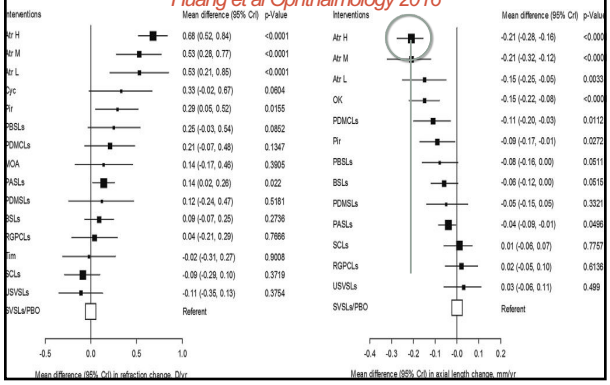
Atropine 1% vs Lower Concentrations

- By combining the 2 studies, they found that in the initial 8 months, there was a hyperopic shift in the 1.0% group and continued myopic progression in the other groups, which was greater in the lower doses, before growth slowed between the 8- and 24- month periods.

158

Meta Analysis of Tx for Myopia

Huang et al Ophthalmology 2016



159

Mechanism of Atropine

- it is believed that atropine acts directly or indirectly on the retina or scleral, inhibiting thinning or stretching of the scleral, and thereby eye growth.2
- However, the rate of growth seemed to continue at a steady pace over the washout year in children previously receiving the higher 0.1% and 0.5% doses of atropine, slowing only when atropine 0.01% was restarted.

160

Case Example

- A -6.50 myope has been put on Atropine 1%
- Developed symptoms was switched to Atropine .02%
- 6 mos follow up and had increased to -7.25
- Put back on Atropine 1%
- Refraction -6.50
- Conclusion: false rebound

161

Conclusions

- From clinical experience, that by slowly tapering the frequency of atropine, we can dampen the change in myopia and retain the beneficial effect on myopia progression.
- On the basis of these results, they conclude that low-dose (0.01%) atropine for periods up to 5 years is a clinical viable treatment of myopia

162

What to do if Atropine .01% Does Not Work

- Increase dosage
- Add multifocal or ortho K lenses
- Stop all treatment, in some cases nothing will work

163

Summary

- Although the effect of the drug on myopia was relatively reduced after cessation for 1 year, the change in the axial length was significantly less than in eyes not treated with atropine.
- Future studies needed:
  - Is 2 years of Atropine enough?
  - What happens after a longer period of drug-free treatment?

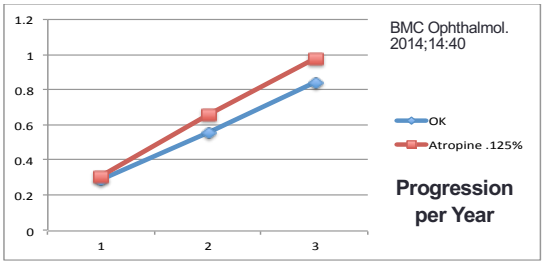
164

What Is The Strongest Concentration That Will Not Cause Clinically Significant Mydriasis Or Blur Secondary To Cycloplegia?

- Concentration of atropine was varied and measured mydriasis and cycloplegia
- measurement of pupil size, AA, and symptom survey the highest dosage of atropine that would not induce clinical symptoms
- Atropine .02% was the highest percentage that did not caused clinically significant symptoms associated with atropine administration
- Cooper J, Eisenberg N, Schulman E, Wang FM. Maximum Atropine Dose Without Clinical Signs or Symptoms. Optom Vis Sci. 2013 Sep 26.

165

Which is Better **Atropine .125%** or Overnight **Ortho-keratology** in Controlling Myopia.



KLin HJ, Wan L, Tsai FJ, Tsai YY, Chen LA, Tsai AL, et al

166

Atropine Slows Myopia Progression More in Asian than White Children by Meta-analysis

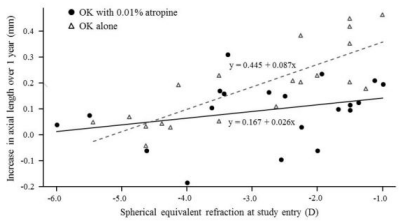
- Meta analysis of retrospective and prospective studies were the same
- Myopia progresses faster in Asian than white children .55 D/yr vs .35 D/yr
- Atropine slows myopic progression more in Asian (.50 D/yr) children than white children D/yr
- Shi-Ming Li, Shan-Shan Wu, Meng-Tian Kang, Ying Liu, Shu-Mei Jia, Si-Yuan Li, Si-Yan Zhan, Luo-Ru Liu, He Li, Wei Chen, Zhou Yang, Yun-Yun Sun, Ningli Wang, and Michel Millodot VOL. 91, NO. 3, PP. 342-350 OPTOMETRY AND VISION SCIENCE

167

ARVO JOURNALS

Nozomi Kinoshita, Yasuhiro Konno, Naoki Hamada, Akihiro Kakehashi. **Suppressive effect of combined treatment of orthokeratology and 0.01% atropine instillation on axial length elongation in childhood myopia**
Invest. Ophthalmol. Vis. Sci.. 2017;58(8):2386.

Evidence that atropine .01% is additive to the effects of ortho-k, Should work with *Natural-Vue*. **OK** increase **.19 mm** (.6D)per yr vs **OK & atropine .09 mm** (.06D)per yr



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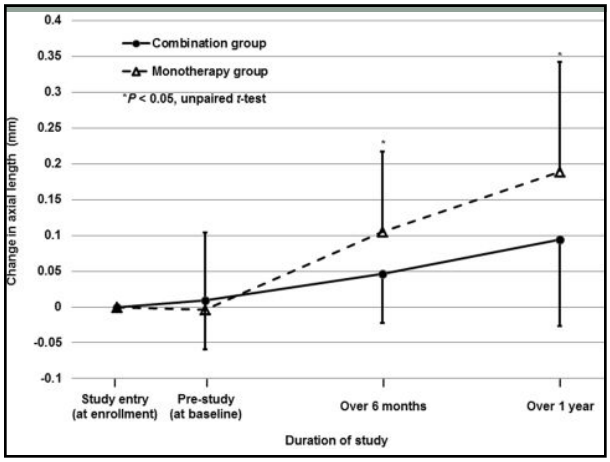

169

The Synergistic Effects of Orthokeratology and Atropine in Slowing the Progression of Myopia

J. Clin. Med. ***2018****, 7, 259*

"Significantly better **LM** control was observed in OA1 patients, compared with OK1 patients. Axial length was significantly shorter in the OA1 group (**24.67** ±1.53 mm) than in the OK1 group (**24.90** ± 1.98 mm) (p = 0.042); similarly, it was shorter in the OA2 group (**24.73** ± 1.53 mm) than in the OK2 group (**25.01** ± 1.26 mm) (p = 0.031). For the **HM** patients, OA3 patients compared with OK3 patients, axial length was significantly shorter in the OA3 group (25.78 ± 1.46 mm) than in the OK3 group (**25.93** ± 1.94 mm) (p = 0.021); similarly, it was shorter in the OA4 patients (**25.86** ± 1.21 mm) than in the OK4 patients (**26.05** ± 1.57 mm) (p = 0.011).Combined treatment with atropine and OK lenses would be a choice of treatment…"

170

The Synergistic Effects of Orthokeratology and Atropine in Slowing the Progression of Myopia

LeiWan Chang-Ching, Wei , Chih Sheng Chen, Ching-Yao Chang , Chao-Jen Lin , Jamie Jin-Yi Chen , Peng-Tai Tien and Hui-Ju Lin

	AL					Sph Equiv		
	baseline	2yrs	difference	D equiv		baseline	2yrs	difference
< 6D								
OK 1	24.32	24.90	0.58	1.76	0.03	4.25	4.80	0.55
OA .125	24.12	24.67	0.55	1.67		4.28	4.75	0.47
		0.23	0.03					
OK 2	24.19	25.01	0.82	2.48	0.52	4.63	5.13	0.50
OA .025	24.08	24.73	0.65	1.97		4.53	4.83	0.30
		0.28	**0.17**	0.52				
> 6D								
OK 3	25.29	25.93	0.64	1.94	0.21	6.75	7.20	0.45
OA .125	25.21	25.78	0.57	1.73		6.75	7.00	0.25
		0.15	0.07					
OK 4	25.65	26.05	0.40	1.21	-0.55	6.67	7.32	0.65
OA .025	25.28	25.86	0.58	1.76		6.63	7.12	0.49
		0.19	**-0.18**	-0.55				

171

Guidelines

- Atropine .5% or1% qhs for young progressive myopes with strong family history
- Atropine .02% or .01% early myopes or additive if Ortho-K is not working (moving towards Atropine .02%)
- See patient every 3, 4, or 6 mos, use IOL Master to determine progression and dosage.
- Choose of atropine vs ortho-K –I let the child make the decision
- Seasonal Atropine for those that want an option in between and who are on Atropine 1%

172

Who Should We Treat?

- Anyone who demonstrates myopia at a young age
- Zadnik K, Mutti DO, et al *Ocular Predictors Of The Onset Of Juvenile Myopia* (1999)
  - Loss of plus lens with cycloplegic refraction
    - 87% sensitivity
    - 73% specificity

173

Treatment Options

- Bifocal vs progressive
  - +2.50
- Early myopia – trial of vision therapy
- Atropine with bifocal
- Ortho K
- Multifocal progressive with low dosage atropine
- LASIK
- Future Pirenzipine (Valley Forge sells rights to Novartis)

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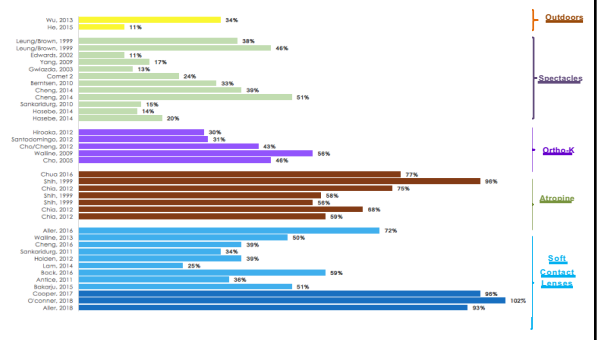
Percentage Decrease in Myopic Progression By Intervention[1]



[1]Data derived from Sankaridurg Oct, 2017

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Comparison of Meta Analysis and Non-Meta Analysis (all studies)

Treatment	Meta	Cooper
Atropine high dosage	65%	85%
Atropine moderate dosage	65%	76%
Atropine low dosage	45%	60%
Ortho K	45%	45%
Multifocal soft contact lens	33%	40%
Out doors		25%
Progressive Lens/Bifocals	12%	16%
Single Vision	0%	0%
Under-Correction	-9%	-8%

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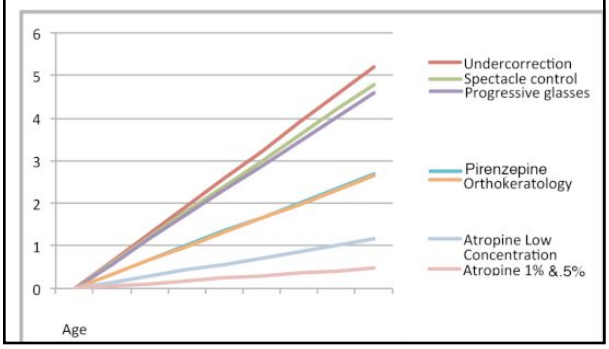
TREATMENT RESULTS OVER TIME



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Flow Chart for Under 6 yrs.

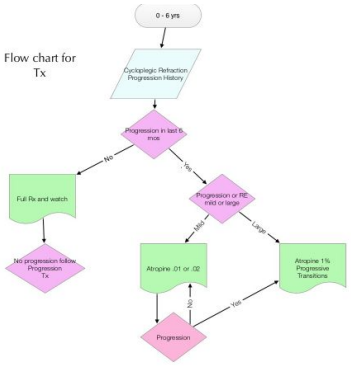
Myopia prevention based on risk (family members, age, and change in refraction) then atropine .01%

Early myopia w/o rapid progression then atropine .02%

Atropine .01% fails then increase to atropine .02%

Early development with evidence of rapid progression then atropine 1%

Too Young for CLs



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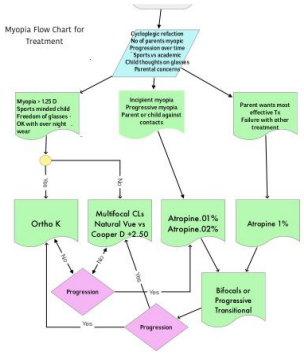
Flow chart for over 6

Atropine .01% for prevention, children who want to wear glasses

Use Atropine.02% in children who are showing more progression or fail with .01%

Multifocal CLs low and higher myopias and those that reject ortho-K

Ortho K, wow phenomenon, athletes, want control of contact lens care (at home only)



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Case 1

- 6 year old boy
- -4.50 OU
- Retinal detachment OD
- What should we do

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Case 2

- 8 year old Asian child with both parents being myopic
- Presents with -1.50 OU
- What do you recommend
- Athletic vs A real reader

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Case 3

- 8 year old with -.50 OU, one parent is myopic
- Parent asks can we do anything to stop the progression of myopia

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Case 4

- 25 year old female who is on computers all day comes in wearing -3.00 OU and now demonstrates -3.75 what can you do

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Case 5

- At age 3 RE= +1.00
- At age 4 RE = +.25
- At age 5 RE= -.25

- What would you do

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Case 6

- 43 year old female keeps increasing, she has increased from a -8.50 to a -9.25. Her sister had a RD. She needs a 1.25 Add
- What would you do?
- Would you prescribe it
- What would you think the effect of accommodation would be.

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Arthur Schopenhauer in the 1800s described three stages of truth: "**All truth passes through three stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident**."

I suspect that after hearing what I have said today, *most of you will be at the first stage*, disbelief and ridicule, some will be in the second stage, and a few will have known this all along.

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THANK YOU

Any Questions

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