

Update on the Management of Myopia in Children

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since 1974

眼科專科中心
The Hong Kong
Ophthalmic Associates

Refractive Error

- Common refractive errors
 - 近視 Myopia (short-sightedness)
 - 遠視 Hyperopia (long-sightedness)
 - 散光 Astigmatism
 - Anisometropia



信息名称: 教育部等八部门关于印发《综合防控儿童青少年近视实施方案》的通知

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内容概述: 教育部等八部门印发《综合防控儿童青少年近视实施方案》的通知。

教 育 部 文 件

教体艺〔2018〕3号

教育部等八部门关于印发《综合防控儿童青少年近视实施方案》的通知

各省、自治区、直辖市人民政府，新疆生产建设兵团：

为贯彻落实习近平总书记关于学生近视问题的重要指示批示精神，切实加强新时代儿童青少年近视防控工作，教育部会同国家卫生健康委员会等八部门制定了《综合防控儿童青少年近视实施方案》，经国务院同意，现予以印

Myopia - Risks

- Parental myopia
 - Genetic?
 - Environment?
- Near work load
- Lack outdoor exposure
- 遺傳
- 環境影響
 - 長時間近距離工作
 - 缺乏戶外活動
 - 不良的閱讀習慣



Prevalence of Myopia in Children

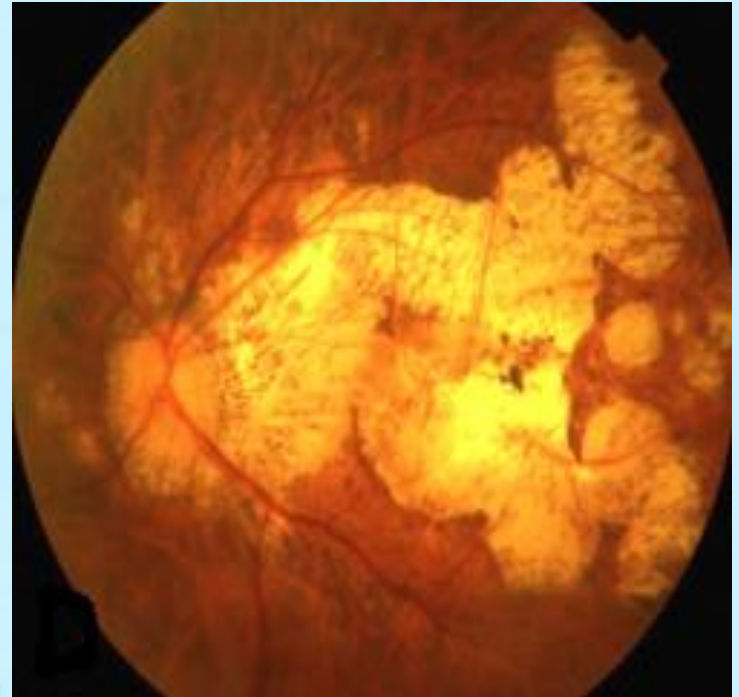
近視 年輕化

	Preschool	Age 6	Age 12
Myopia %	6.3 ⁽¹⁾	18.3 ⁽²⁾	61.5 ⁽²⁾

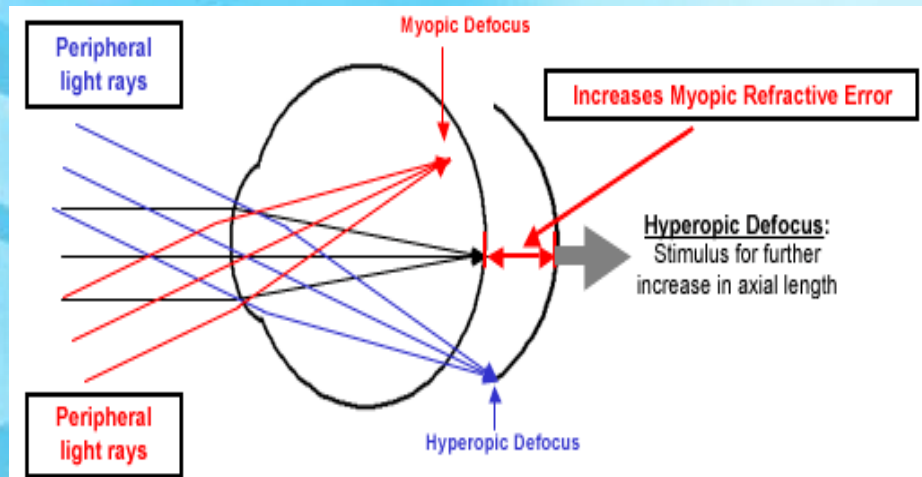
Age	6	7	8	9	10	11	12
Myopia %	17.6	26.4	45.0	49.8	57.6	60.1	57.7
High Myopia %	0.7	0.0	1.4	1.6	1.7	3.8	3.8 ⁽²⁾

Myopia-associated Diseases

- Cataract
- Glaucoma
- Retinal detachment
- Maculopathy



Myopia - Mechanism

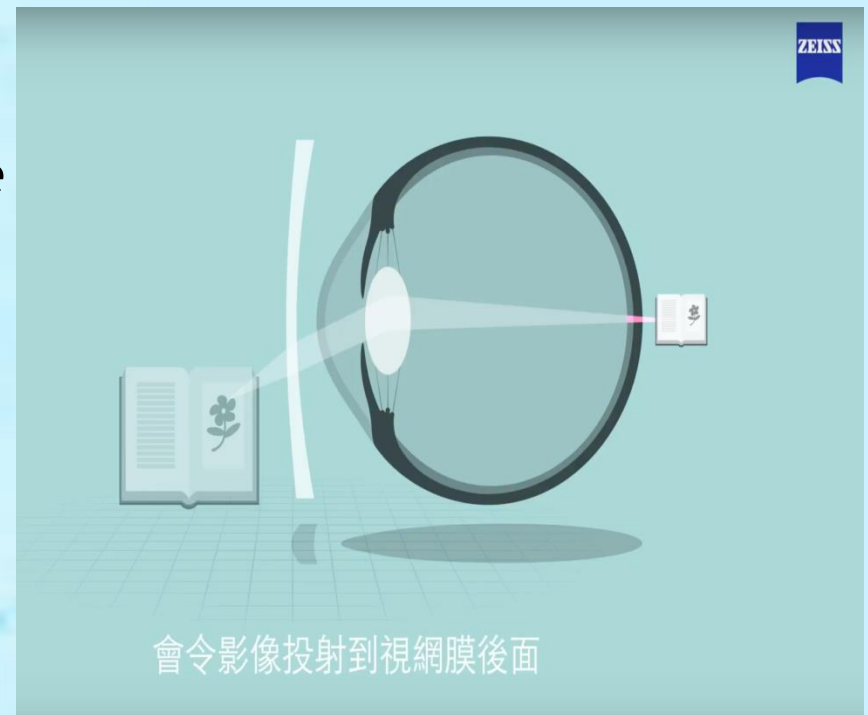


Optical Defocus 光學離焦

- Hyperopic defocus (image behind retina).
- peripheral defocus can dominate central refractive development, regardless of the presence of unaffected central vision.
- Human: myopic unaided eyes tend to show hyperopic Relative Peripheral defocus in the horizontal meridian
- Changes *Choroidal thickness?*

Myopia - Mechanism

- 2. Accommodative lag
 - Myopia: for near vision, accommodation required
 - Accommodative lag → image behind fovea → hyperopic defocusing signal

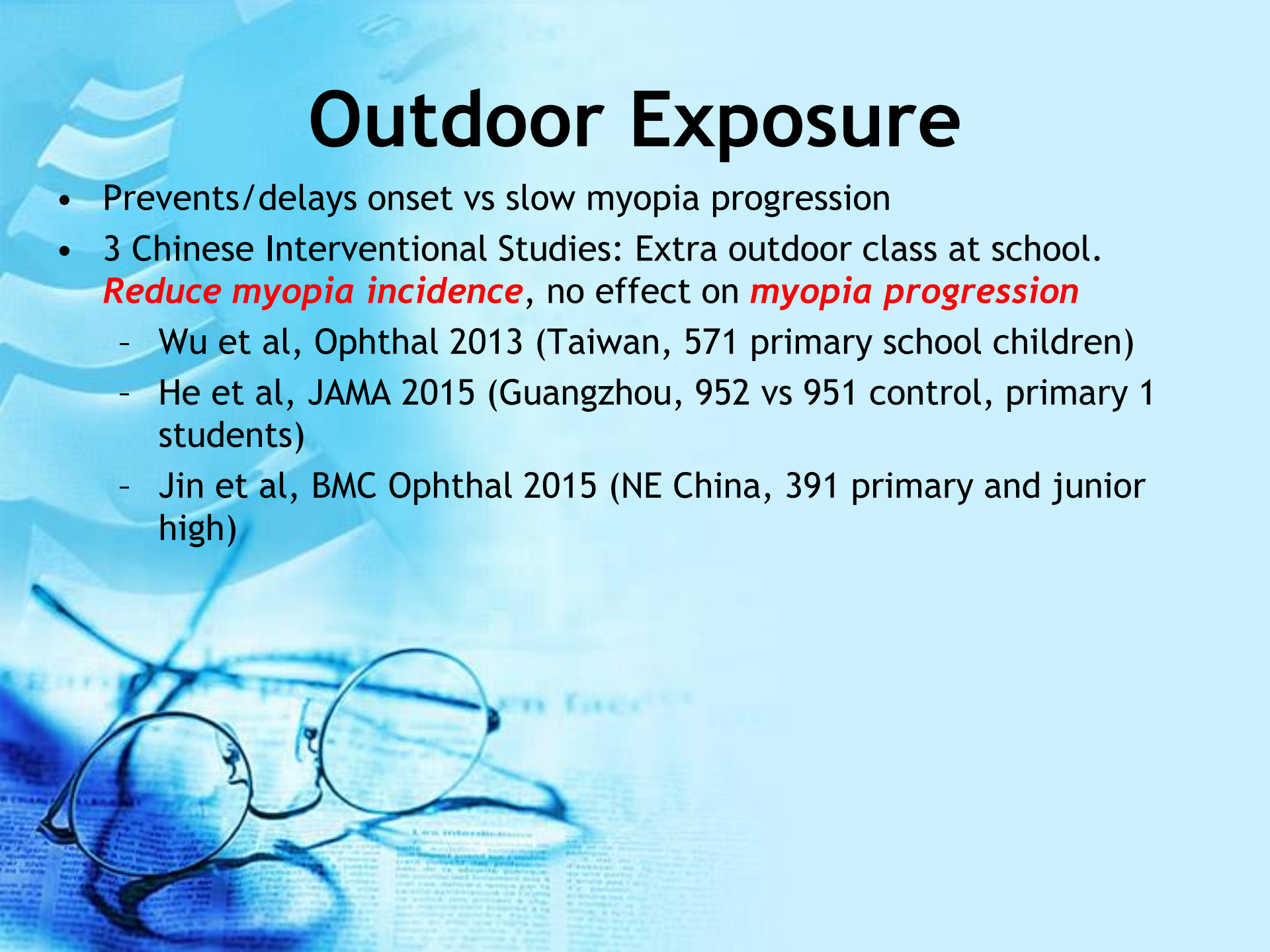


Outdoor Exposure

- Rose et al, Ophthalmology 2008, Sydney Eye Study
 - “More time spent outdoors, rather than sport per se, were associated with less myopia and a more hyperopic mean refraction, after adjusting for near work, parental myopia, and ethnicity.”
- Rose et al, Arch Ophthalmol. 2008
 - 6-7 years old Chinese children in Sydney vs Singapore
 - **Myopia: 3.3% Sydney, 29% Singapore**
 - Sydney more reading time and more near work, but outdoor time was *14 hours vs 3 hours per week*

Outdoor Exposure

- Prevents/delays onset vs slow myopia progression
- 3 Chinese Interventional Studies: Extra outdoor class at school.
Reduce myopia incidence, no effect on *myopia progression*
 - Wu et al, Ophthal 2013 (Taiwan, 571 primary school children)
 - He et al, JAMA 2015 (Guangzhou, 952 vs 951 control, primary 1 students)
 - Jin et al, BMC Ophthal 2015 (NE China, 391 primary and junior high)



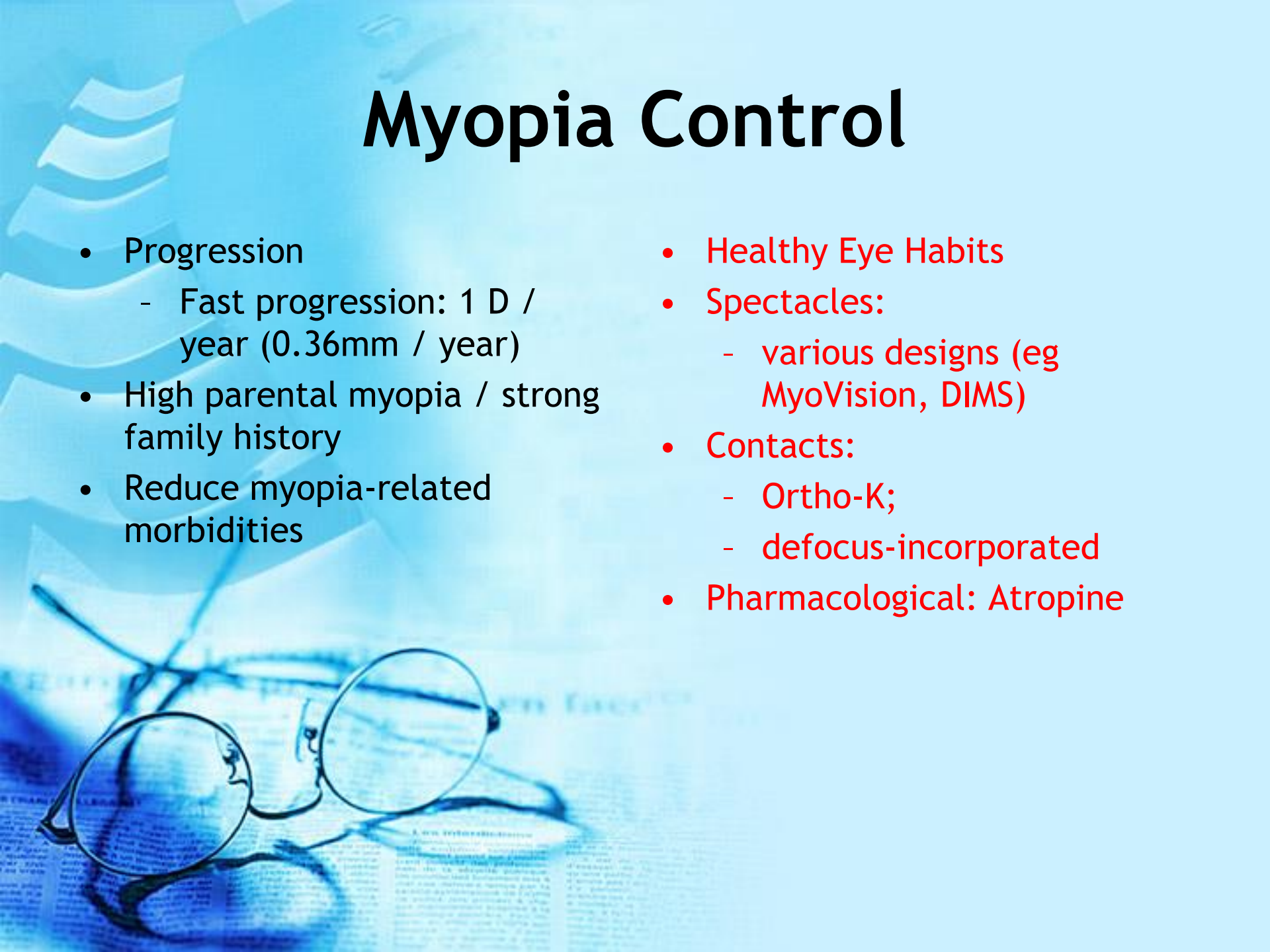
Myopia Progression

- Jones LA et al. IOVS 2005:
- Between age 7 to 12, the average rate of axial length elongation is approximately
 - 0.12 mm/year in emmetropes
 - **0.28 mm/year** in myopes. (**~ 0.75D**)

Jones LA et al. Comparison of ocular component growth curves among refractive error groups in children. Invest Ophthalmol Vis Sci 2005;46:2317-27

Myopia Control

- Progression
 - Fast progression: 1 D / year (0.36mm / year)
- High parental myopia / strong family history
- Reduce myopia-related morbidities
- Healthy Eye Habits
- Spectacles:
 - various designs (eg MyoVision, DIMS)
- Contacts:
 - Ortho-K;
 - defocus-incorporated
- Pharmacological: Atropine



Healthy Eye Habits !!

“ 預防近視小貼士 ”

Tips for Preventing Myopia



研究顯示每週進行14小時戶外活動、減少看近距離的事物及多看遠距離的事物、多接觸自然光可有效增加視網膜釋放神經遞質，減慢眼球增長，有助防止近視出現。

Some studies have shown that exposure to sunlight is benefits to the developing eyes and children who spend 14 hours a week outdoors have a reduced chance of developing myopia.



避免太早教幼兒識字。

Early childhood literacy is not preferred.



減少近距離閱讀、寫字、繪畫圖畫的時間。

Reduce the time spent on near task, e.g. Reading, writing and drawing.



要有充足的睡眠及適當的休息，減少眼睛疲勞。

Get adequate sleep and reduce eye strain.



保持健康身體，均衡飲食。

Keep a healthy and balanced diet.



閱讀、書寫或使用電腦時，須保持良好姿勢，不要躺著或趴在桌上，眼睛與書本應保持最少30厘米距離。

Keep a good posture when you are reading, writing or using a computer. Do not bend over the desk and keep a reading distance of at least 30 cm.



雙眼如需從事近距離工作，每隔三十分鐘讓雙眼休息三十秒，可望向遠方街景或綠色植物，讓眼睛肌肉得到放鬆。

During prolonged near work, look at a distant object (eg out of the window) for 30 seconds every 30 minutes. This will relax your eye muscles.



避免在搖晃不定的環境閱讀或玩電子遊戲，例如乘車期間，以免加重雙眼負荷。

Avoid reading or playing video games in shaky environments such as moving cars.



每年至少驗眼一次，包括視力和度數檢查、視覺功能和眼睛健康評估。

Get your eyes tested comprehensively at least once a year.

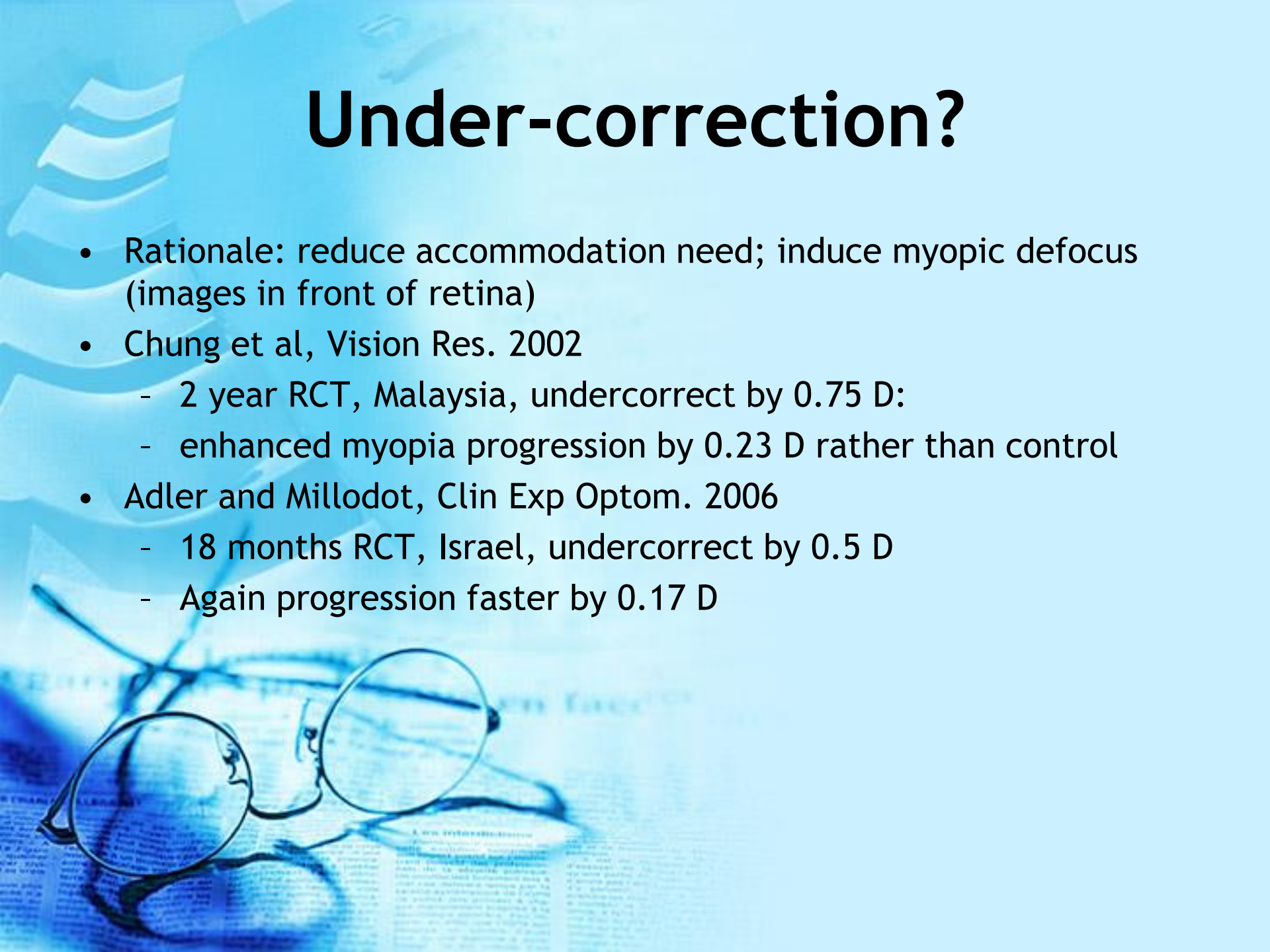


SPECTACLES

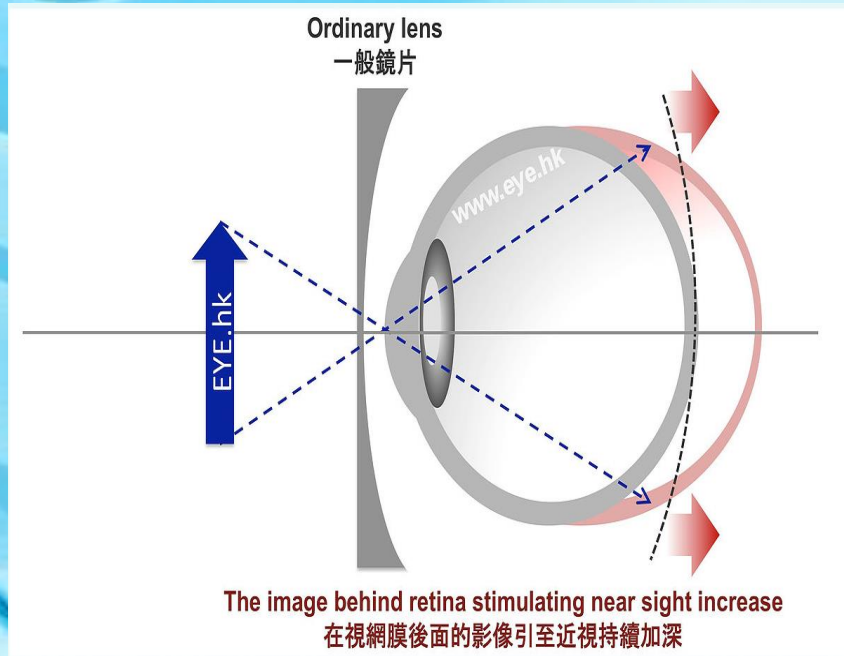


Under-correction?

- Rationale: reduce accommodation need; induce myopic defocus (images in front of retina)
- Chung et al, Vision Res. 2002
 - 2 year RCT, Malaysia, undercorrect by 0.75 D:
 - enhanced myopia progression by 0.23 D rather than control
- Adler and Millodot, Clin Exp Optom. 2006
 - 18 months RCT, Israel, undercorrect by 0.5 D
 - Again progression faster by 0.17 D



Special - design Spectacles



- When compared with the uncorrected situation, *peripheral hyperopic defocus was increased* by single vision lenses (SVLs) in myopic eyes

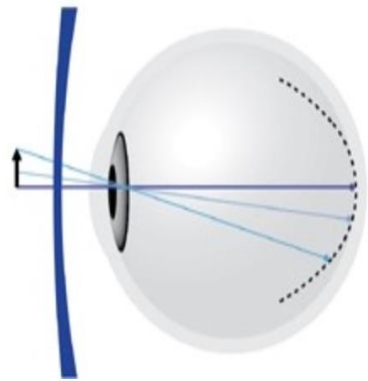


MyoVision (Zeiss)

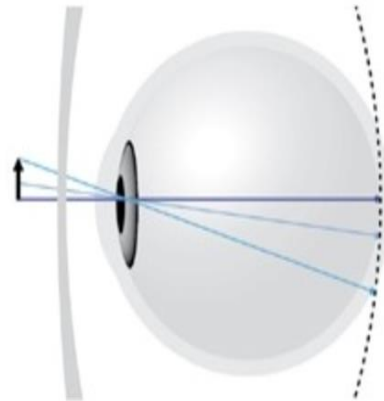
Optom Vis Sci. 2010 Sep;87(9):631-41. doi: 10.1097/OPX.0b013e3181ea19c7.

Spectacle lenses designed to reduce progression of myopia: 12-month results.

Sankaridurg P¹, Donovan L, Varnas S, Ho A, Chen X, Martinez A, Fisher S, Lin Z, Smith EL 3rd, Ge J, Holden B.



A corrected myopic eye with MyoVision™. The image is projected onto the retina centrally, BUT in front of (or on) the retina peripherally



A corrected myopic eye with a flat-form lens. The image is projected onto the retina centrally, BUT behind the retina peripherally

- *Reduced peripheral hyperopic defocus*
- 1 year, 201 Chinese school children aged 6 - 16 years old with myopia (-0.75 D to -3.5 D)
 - 30% reduction in myopia
 - (-0.68 D vs -0.97 D) in a subgroup of 19 younger children (6 to 12 years old) with at least one myopic parent.

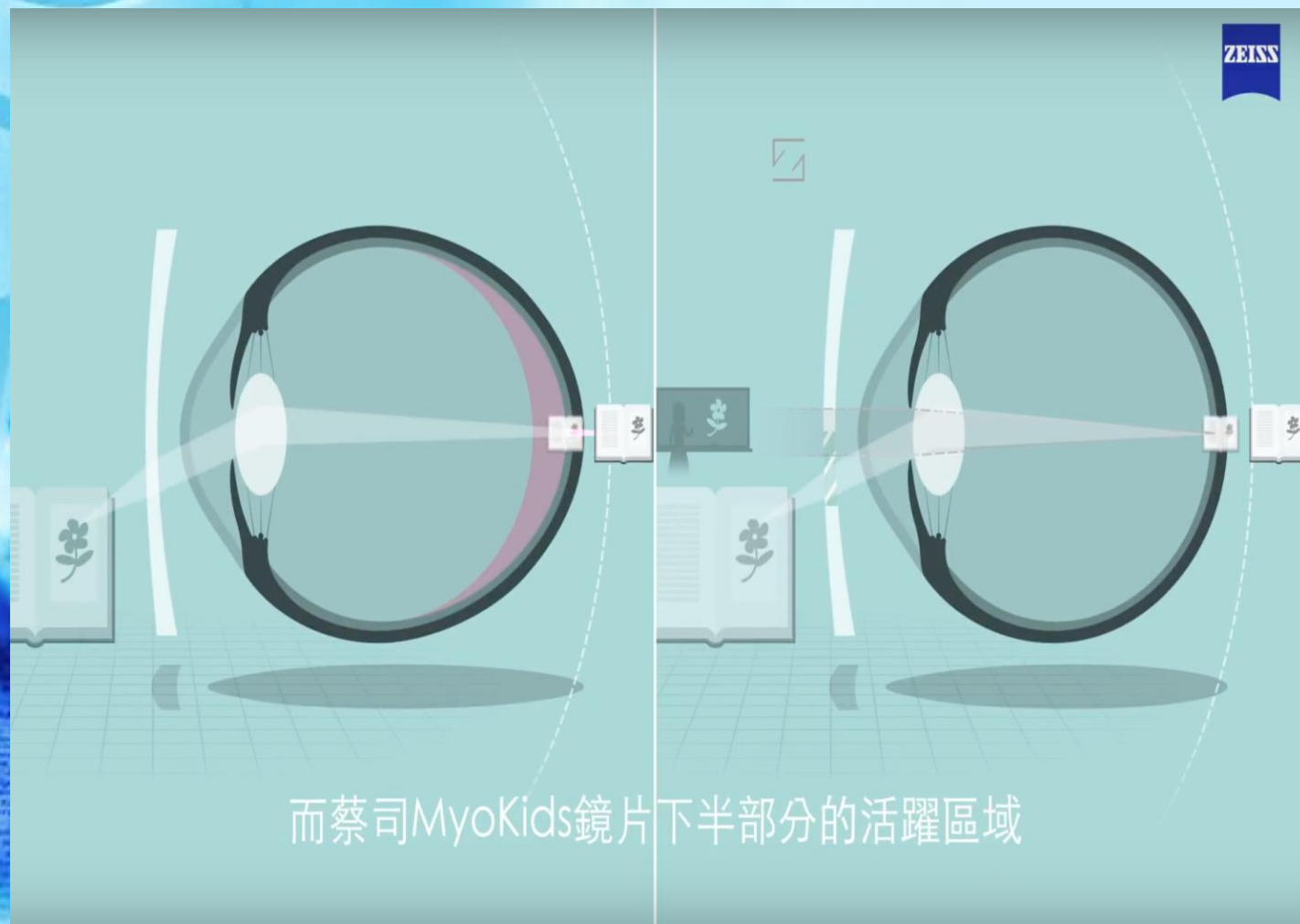
Myovision 眼鏡

- **Myovision眼鏡**
- Myovision眼鏡外表與一般光學鏡片無異，除了為配戴者提供清晰視力之外，還可減慢近視加深速度約30%。Myovision眼鏡的用法比較簡單而且容易適應，最適合選擇配戴有框眼鏡而希望能控制近視加深之兒童。



MyoKids (Zeiss)

- reduces accommodative lag
- Good for kids on high dose atropine



而蔡司MyoKids鏡片下半部分的活躍區域

PASLs - Progressive additional spectacle lens

- eg Kidspro Swisscoat; Essilor Myopilux
- reduce hyperopic defocus and compensate for reduced accommodative response
- **Conflicting results from RCTs** Different lens design?
 - HK Study 0.5 D less over 2 years in PASLs group; COMET Study 0.2 D over 3 years
 - More near-add has more effect
 - More beneficial in *esophoria* kids (uncommon in myopia)
- Most other studies showed *mild effect: < 0.25 D over 2 years*



Bifocals

Randomized Trial of Effect of Bifocal and Prismatic Bifocal Spectacles on Myopic Progression

Two-Year Results

Desmond Cheng, OD, MSc, PhD; Katrina L. Schmid, PhD; George C. Woo, OD, MSc, PhD; Bjorn Drobe, MSc, PhD

Objective: To determine whether bifocal and prismatic bifocal spectacles could control myopia in children with high rates of myopic progression.

Methods: This was a randomized controlled clinical trial. One hundred thirty-five (73 girls and 62 boys) myopic Chinese Canadian children (myopia of ≥ 1.00 diopters [D]) with myopic progression of at least 0.50 D in the preceding year were randomly assigned to 1 of 3 treatments: (1) single-vision lenses ($n=41$), (2) +1.50-D executive bifocals ($n=48$), or (3) +1.50-D executive bifocals with a 3-prism diopters base-in prism in the near segment of each lens ($n=46$).

Main Outcome Measures: Myopic progression measured by an automated refractor under cycloplegia and increase in axial length (secondary) measured by ultrasonography at 6-month intervals for 24 months. Only the data of the right eye were used.

Results: Of the 135 children (mean age, 10.29 years [SE, 0.15 years]; mean visual acuity, -3.08 D [SE, 0.10 D]), 131 (97%) completed the trial after 24 months. Myopic

progression averaged -1.55 D (SE, 0.12 D) for those who wore single-vision lenses, -0.96 D (SE, 0.09 D) for those who wore bifocals, and -0.70 D (SE, 0.10 D) for those who wore prismatic bifocals. Axial length increased an average of 0.62 mm (SE, 0.04 mm), 0.41 mm (SE, 0.04 mm), and 0.41 mm (SE, 0.05 mm), respectively. The treatment effect of bifocals (0.59 D) and prismatic bifocals (0.85 D) was significant ($P < .001$) and both bifocal groups had less axial elongation (0.21 mm) than the single-vision lens group ($P < .001$).

Conclusions: Bifocal lenses can moderately slow myopic progression in children with high rates of progression after 24 months.

Applications to Clinical Practice: Bifocal spectacles may be considered for slowing myopic progression in children with an annual progression rate of at least 0.50 D.

Trial Registration: clinicaltrials.gov Identifier: NCT00787579

Arch Ophthalmol. 2010;128(1):12-19

- Address problem of accommodative lag
- Esp in near esophoric
- **Cosmetic concern**
- 1 RCT on prism-incorporated bifocal
 - Benefits in fast progressors. Similar to bifocal without prism

DIMS (Hoya)

- PolyU
- Defocus - incorporated multisegments
 - +3.5D myopic defocus
- Same effect at all direction of gaze



DIMS (Hoya)

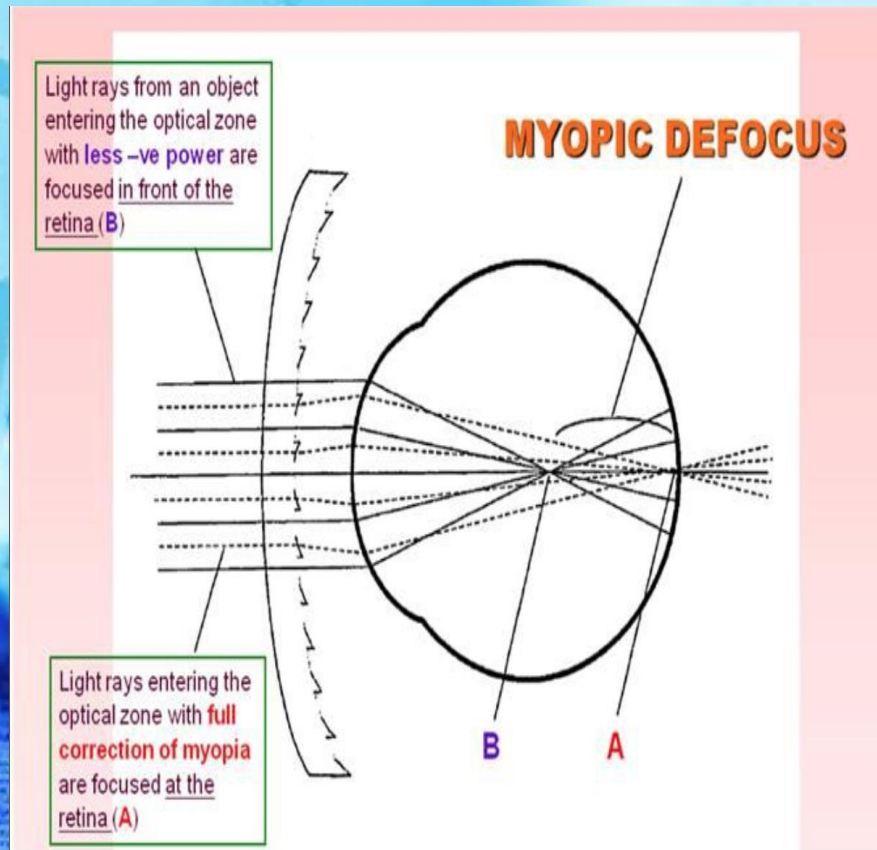
- 2 year RCT
 - **59% (-0.55 +/- 0.09D) myopia reduction**
 - 60% (0.31 +/- 0.04) reduction in axial elongation
 - Same D + N VA at photopic & mesopic; same stereo





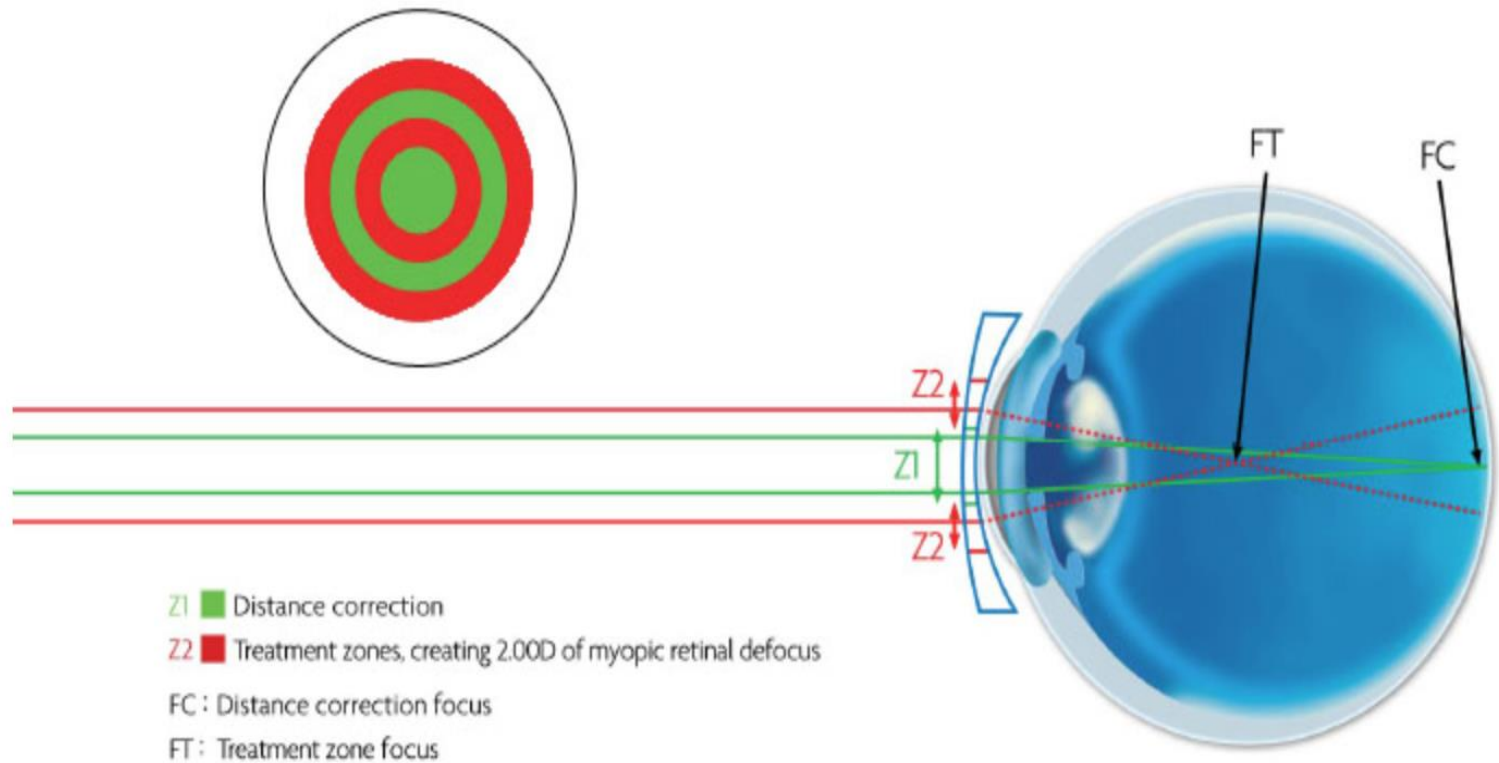
CONTACTS

Defocus-incorporated soft contact lens



- Provides simultaneous clear vision and myopic defocus
- Same effect with all direction of gazes
- Anstice and Phillips, Ophthalmology 2011 :
 - 20-month cross-over study, involving 40 children aged 11-14 years
 - 0.44 D vs 0.69 D in period one; 0.17 D vs 0.38 D in period two

MiSight (CooperVision)



- Daily disposable soft lenes
- No cylinder.
- If > 1.0 cylinder may need additional spectacles
- May affect BCVA esp if large pupils?



DISC (VST)

- PolyU-designed
- incorporated concentric rings: +2.5D defocus, alternating with the normal distance correction. **3-monthly** (\$9000/year)
- 2-year RCT:
 - 221 children, aged 8 - 13 years, -1.0 to -5.0 D
 - **0.3 D / year (DISC) vs 0.4 D / year (control) - "25%"**
 - Treatment effect correlated positively with wearing time; **7-8 hr / day optimal, ~ 60% reduction in progression (0.53D)**
 - **42 % drop out rate**: Poor compliance. Needs high motivation

Defocus Incorporated Soft Contact (DISC) lens slows myopia progression in Hong Kong Chinese schoolchildren: a 2-year randomised clinical trial

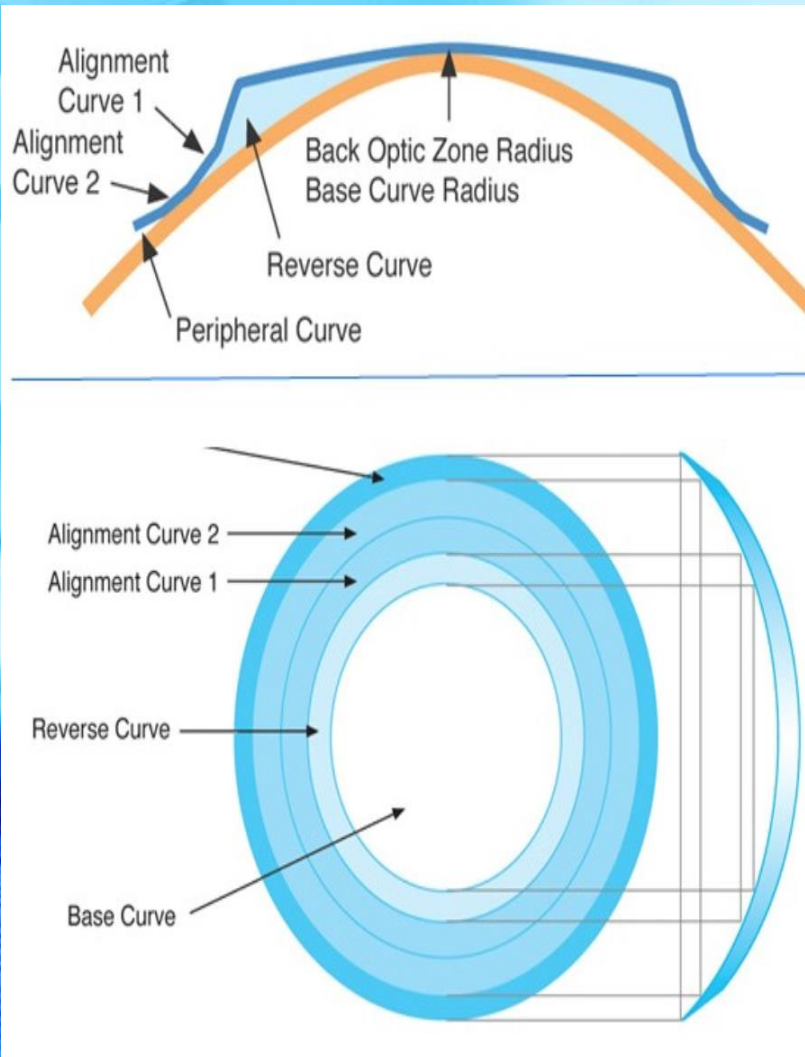
Carly Siu Yin Lam,¹ Wing Chun Tang,¹ Dennis Yan-Yin Tse,^{1,2} Ying Yung Tang,¹ Chi Ho To^{1,3}

Ortho-K

- Custom designed rigid lenses, overnight wear, temporarily modify the curvature of cornea
- Breathable rigid lens material
- **Reverse geometry** designs
 - Central flattening and Mid-peripheral steeping
- Central flattening → correction of daytime myopia
- Changes peripheral hyperopic defocus into **myopia defocus**
- FDA approved 2002 (Paragon vision sciences) and 2004 (B&L)

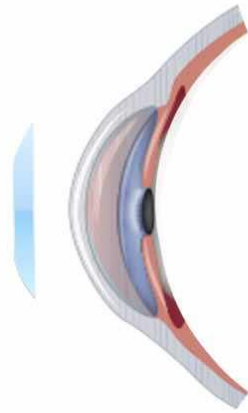
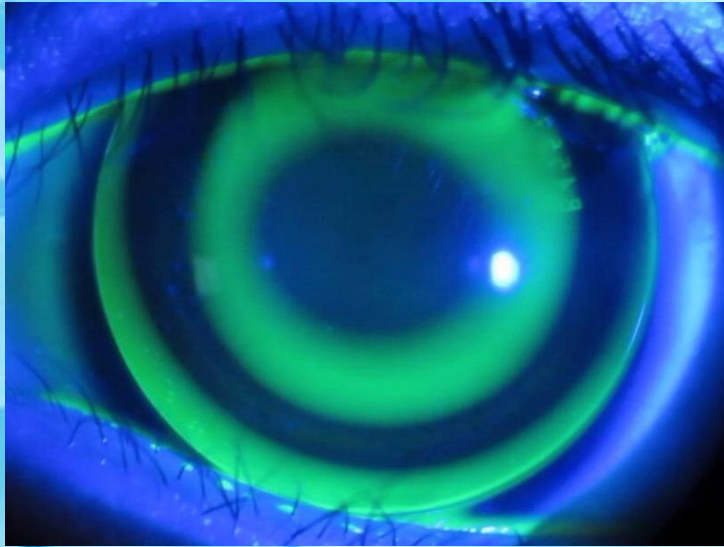


Ortho-K

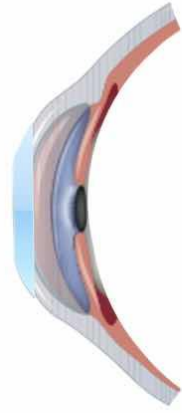


- Practical considerations:
- Cooperation / willingness
 - Gender
 - Age
 - Parents motivation
 - Costs
- Sports
- Anisometropia

OK 鏡 (矯視隱形眼鏡)



Corneal Shape Before
Ortho K Lens



Corneal Shape After
Ortho K Lens



Ortho-K

1. Improves daytime unaided VA

- Effective in correcting myopia < 4-6 D (spectacle free)
- Partial-reduction orthokeratology for higher myopia
- Temporary effect
- Toric ortho-K

2. Slows Myopia Progression

- Slows rate of **axial length elongation**

Meta-analysis

ARTICLE IN PRESS



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OF OPHTHALMOLOGY

Efficacy Comparison of 16 Interventions for Myopia Control in Children

A Network Meta-analysis

Jinhai Huang, MD,^{1,2,*} Daizong Wen, MD,^{1,3,*} Qinmei Wang, MD,^{1,2,*} Colm McAlinden, MB BCh, PhD,^{1,4,5,*} Ian Flitcroft, FRCOphth, DPhil,^{6,*} Haisi Chen, MD,^{1,2} Seang Mei Saw, PhD,⁷ Hao Chen, MD,¹ Fangjun Bao, MD,^{1,2} Yune Zhao, MD,^{1,2} Liang Hu, MD,^{1,2} Xuexi Li, MD,³ Rongrong Gao, MD,^{1,2} Weicong Lu, MD,^{1,2} Yaoqiang Du, MD,¹ Zhengxuan Jinag, PhD,⁸ Ayong Yu, PhD,^{1,2} Hengli Lian, MS,⁹ Qiumo Jiang, MD,^{1,2} Ye Yu, MD,^{1,2} Jia Qu, MD, PhD^{1,2}

Purpose: To determine the effectiveness of different interventions to slow down the progression of myopia in children.

Methods: We searched MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, World Health Organization International Clinical Trials Registry Platform, and [ClinicalTrials.gov](https://www.clinicaltrials.gov) from inception to August 2014. We selected randomized controlled trials (RCTs) involving interventions for controlling the progression of myopia in children with a treatment duration of at least 1 year for analysis.

Main Outcome Measures: The primary outcomes were mean annual change in refraction (diopters/year) and mean annual change in axial length (millimeters/year).

Results: Thirty RCTs (involving 5422 eyes) were identified. Network meta-analysis showed that in comparison with placebo or single vision spectacle lenses, high-dose atropine (refraction change: 0.68 [0.52–0.84]; axial length change: –0.21 [–0.28 to –0.16]), moderate-dose atropine (refraction change: 0.53 [0.28–0.77]; axial length change: –0.21 [–0.32 to –0.12]), and low-dose atropine (refraction change: 0.53 [0.21–0.85]; axial length change: –0.15 [–0.25 to –0.05]) markedly slowed myopia progression. Pirenzepine (refraction change: 0.29 [0.05–0.52]; axial length change: –0.09 [–0.17 to –0.01]), orthokeratology (axial length change: –0.15 [–0.22 to –0.08]), and peripheral defocus modifying contact lenses (axial length change: –0.11 [–0.20 to –0.03]) showed moderate effects. Progressive addition spectacle lenses (refraction change: 0.14 [0.02–0.26]; axial length change: –0.04 [–0.09 to –0.01]) showed slight effects.

Conclusions: This network analysis indicates that a range of interventions can significantly reduce myopia progression when compared with single vision spectacle lenses or placebo. In terms of refraction, atropine,

- Sun et al, PLoS One 2015:
 - 7 studies (2 RCTs)
 - **– 0.14 mm/year** than control
 - No keratitis
- Huang et al, Ophthalmology 2016:
 - Network meta-analysis:
 - **– 0.15 mm/year** than control

OK & Myopia Progression - Summary

- Slows AL elongation by ~ 40-50%
- Advantage of being spectacle-free in daytime
- Not all children tolerate OK (up to 30% drop out in some studies)
- Unanswered question:
 - Exact mechanism? / Exact duration of use? / Risks?
 - Rebound after cessation?
- Most patients in studies continued OK use till adulthood, used to spectacle-free in daytime



Microbial Keratitis

- Watt & Swarbrick, Eye Contact Lens 2007
- 123 cases of OK -associated infectious keratitis 1997 to 2007
- **Pseudomonas aeruginosa: 37% of the cases**
- **Acanthamoeba: 33% of the cases**
- *peak year for occurrence was 2001 (> 50%, majority from China)*
- decreasing trend afterwards
- initial high incidence attributable to the unregulated use of orthokeratology (China FDA regulated OK use since 2002)

Microbial keratitis - Summary

- All are retrospective series
- Not reported in all prospective studies
- Overall incidence unknown (since we don't know how many patients are using OK lens)
- Practitioners and parents must be aware of this risk
- Compliance to **rigorous lens care regime, proper lens fitting, regular monitoring and FU essential**
- Warn parents about signs and symptoms of MK → **timely treatment**



ATROPINE !!



ATOM2 study Phase 1 (0-2 year)

- Myopia progression:

- 0.01%:	0.49 D;	AL:	0.41mm
- 0.1%:	0.38 D		0.28mm
- 0.5%:	0.30 D		0.27mm

- Clinically insignificant difference at 24 months



ATOM2 Phase 2 (3rd year)

- 1 year washout phase
- *Rebound also dose-dependent*
- Over progression over entire 3 years:
 - **0.01%** **0.72 D** **0.58 mm**
 - 0.1% 1.04 D 0.60 mm
 - 0.5% 1.15 D 0.61 mm

ATOM2 Phase 3 (4-5th year)

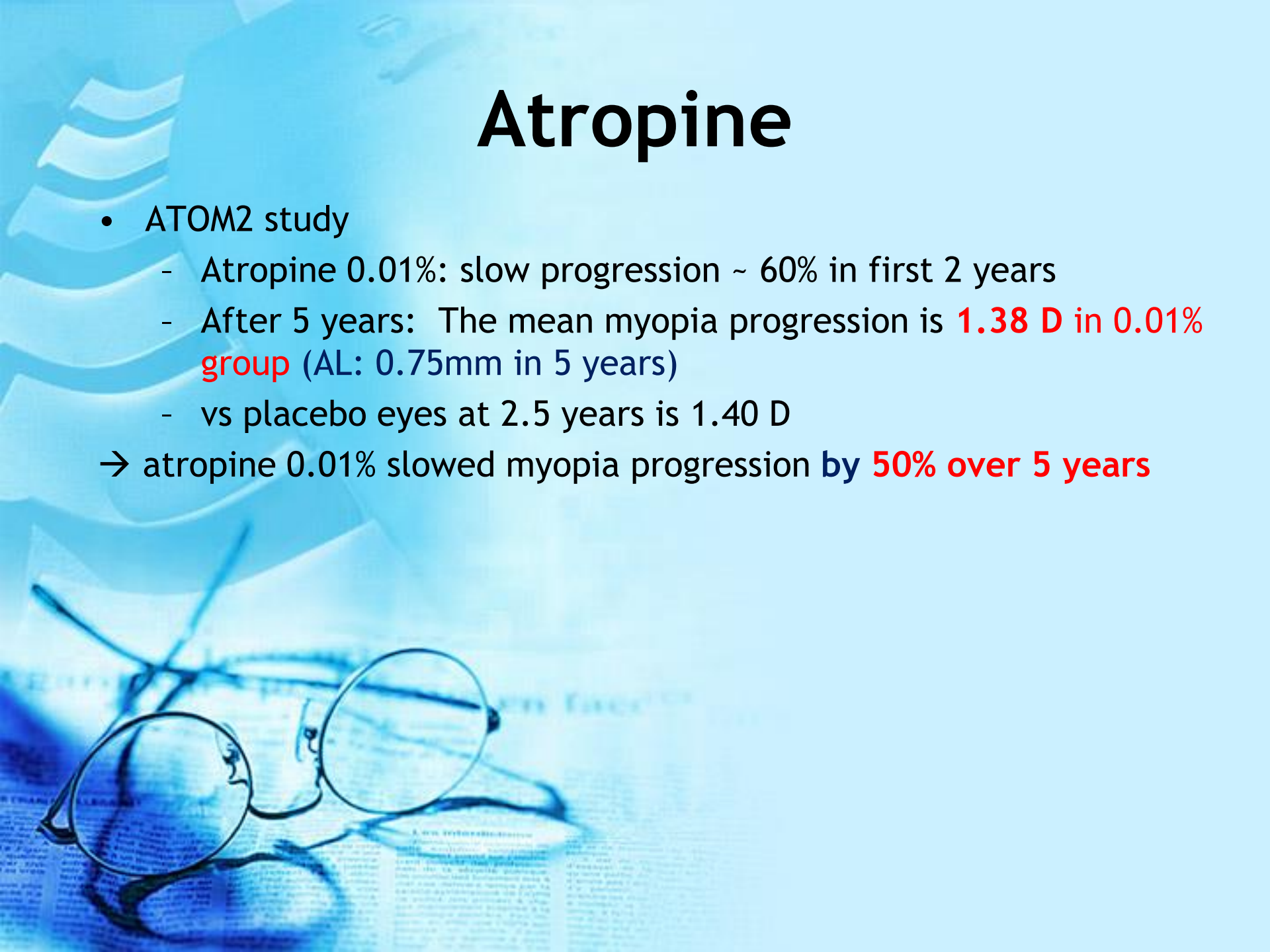
- Those *continued to progress* (> 0.5 D/year) during phase 2 were re-treated with atropine 0.01%.
 - Progress in 1st year and young case more re-treat
- Overall myopia progression at the end of 5 years:

- 0.01%	1.38 D	0.75 mm
- 0.1%	1.83 D	0.85 mm
- 0.5%	1.98 D	0.87 mm

 - Atropine 0.01%
 - minimal pupil dilation (0.8 mm)
 - minimal loss of accommodation (2 - 3 D)
 - No near visual loss compared with higher doses.

Atropine

- ATOM2 study
 - Atropine 0.01%: slow progression ~ 60% in first 2 years
 - After 5 years: The mean myopia progression is **1.38 D** in **0.01% group** (AL: 0.75mm in 5 years)
 - vs placebo eyes at 2.5 years is 1.40 D
- atropine 0.01% slowed myopia progression **by 50% over 5 years**



Practical Concerns

- Pupil size & Accommodation
 - Phase 1 (first 2 years): **7% in 0.01%** vs **70% in high dose (>0.5%)** requested **progressive and/or photochromatic glasses**
- Phase 3 (4-5 year)
 - **None in 0.01%** group requested after restarting treatment
- 2 month after stop: pupil size and accommodation returned to baseline
- Allergy (phase 1 data): **1% allergy in 0.01%** / 4% in >0.5%
- **20-30% on 0.01% may need higher dose/freq.**
- **10-15% may not respond**, clinically hard to predict
- Continue into teens (>12 years); stop/taper if stable for 2 years



Network Meta-analysis



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Methods: We searched MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, World Health Organization International Clinical Trials Registry Platform, and [ClinicalTrials.gov](https://www.clinicaltrials.gov) from inception to August 2014. We selected randomized controlled trials (RCTs) involving interventions for controlling the progression of myopia in children with a treatment duration of **at least 1 year** for analysis.

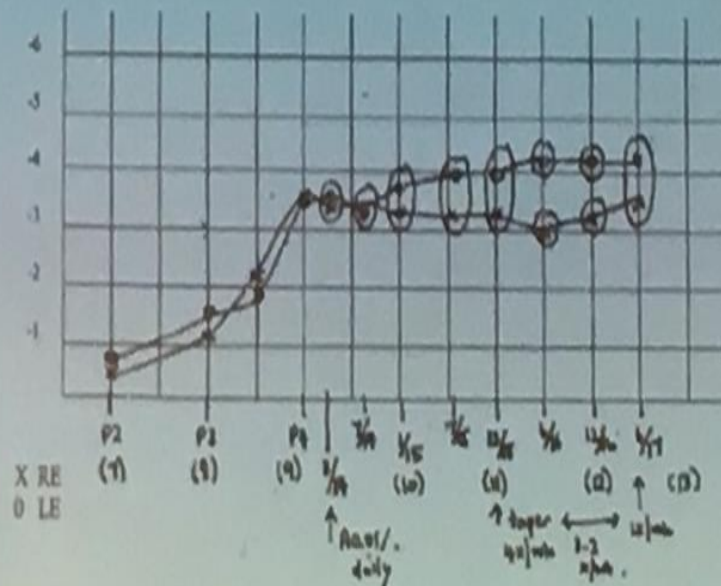
Main Outcome Measures: The primary outcomes were mean annual change in refraction (diopters/year) and mean annual change in axial length (millimeters/year).

Results: Thirty RCTs (involving 5422 eyes) were identified. Network meta-analysis showed that in comparison with placebo or single vision spectacle lenses, **high-dose atropine** (refraction change: 0.68 [0.52–0.84]; axial length change: **–0.21** [–0.28 to –0.16]), **moderate-dose atropine** (refraction change: 0.53 [0.28–0.77]; axial length change: **–0.21** [–0.32 to –0.12]), and **low-dose atropine** (refraction change: 0.53 [0.21–0.85]; axial length change: **–0.15** [–0.25 to –0.05]) markedly slowed myopia progression. Pirenzepine (refraction change: 0.29 [0.05–0.52]; axial length change: **–0.09** [–0.17 to –0.01]), orthokeratology (axial length change: **–0.15** [–0.22 to –0.08]), and **peripheral defocus modifying contact lenses** (axial length change: **–0.11** [–0.20 to –0.03]) showed moderate effects. Progressive addition spectacle lenses (refraction change: 0.14 [0.02–0.26]; axial length change: **–0.04** [–0.09 to –0.01]) showed slight effects.

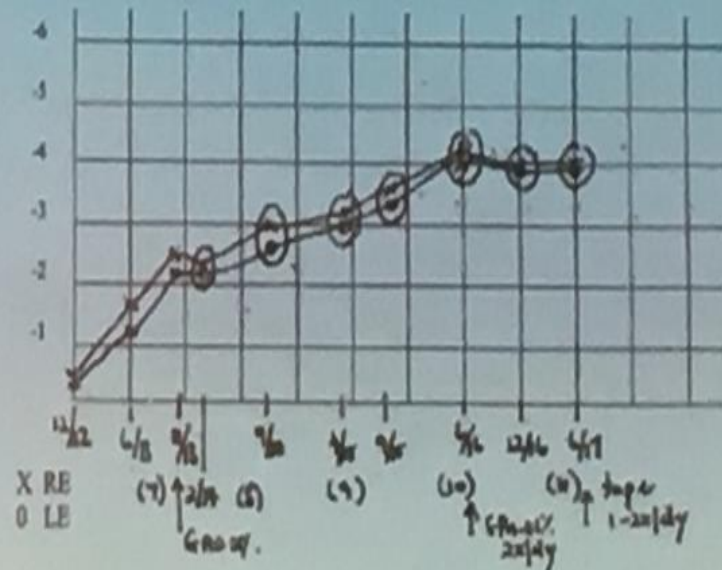
Conclusions: This network analysis indicates that a range of interventions can significantly reduce myopia progression when compared with single vision spectacle lenses or placebo. In terms of refraction, atropine, pirenzepine, and progressive addition spectacle lenses were effective. In terms of axial length, atropine, orthokeratology, peripheral defocus modifying contact lenses, pirenzepine, and progressive addition spectacle lenses

- 30 RCTs, 16 interventions vs placebo/single-vision spectacle lens
- Atropine, ortho-K, peripheral defocus modifying contacts, PASLs
- **Most effective: atropine**

How to use low dose atropine: where it works well



How to use low dose atropine:
where higher dose/freq may be needed



Synopsis

	Consider in:	Special consideration
Spectacles <ul style="list-style-type: none"> - MyoVision - DIMS - PASL 	ALL patients	Prescription Defocusing lens PASL - for high atropine conc
Contacts <ul style="list-style-type: none"> - DISC - Ortho K 	Active kid Sporty Compliance to lens wear protocol / FU Cooperative kid / able to wear contacts Rapid progression	<ul style="list-style-type: none"> - DISC: VA may be affected - Ortho K: reserve geometry effect highest, vs risk of infection
Atropine <ul style="list-style-type: none"> - 0.01% - 0.125% - 1% 	ALL patients <ul style="list-style-type: none"> - Esp if documented progression - High parental myopia - <i>Combine with above</i> 	<ul style="list-style-type: none"> • Higher dose/frequency: check pupil size & near VA • Start when reducing hyperopia?

Summary



- High myopia related risks
- Healthy Eye Habits
- Spectacles/Contacts/Atropine
- Individualized options

THANK YOU !
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