INTERNATIONAL CONGRESS OF THE EGYPTIAN OPHTHALMOLOGICAL SOCIETY

EOS 1902

In collaboration with: MEACO
MIDDLE EAST AFRICA COUNCIL OF OPHTHALMOLOGY

Myopia Prevention

Petros Smahliou, MD, FRCS, FEBO

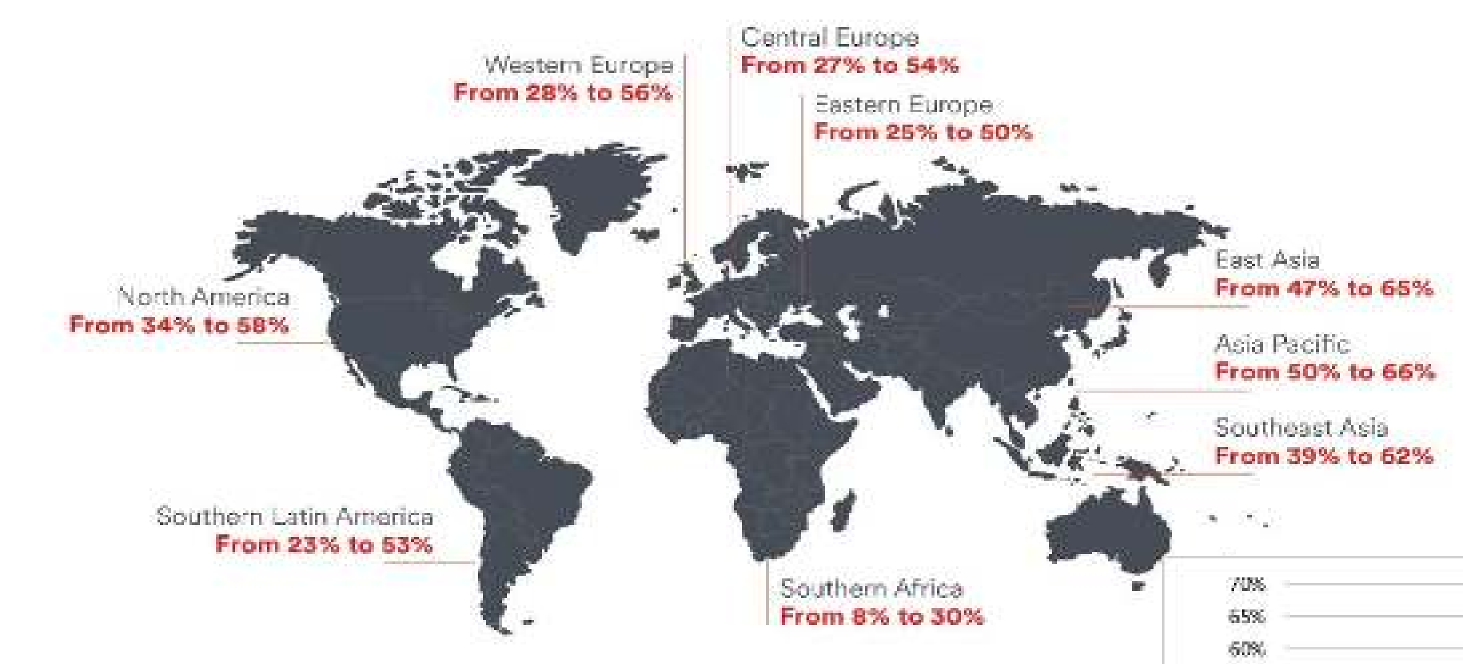
Vasiliki Mela, OD, MSc

Smahliou Eye Clinic

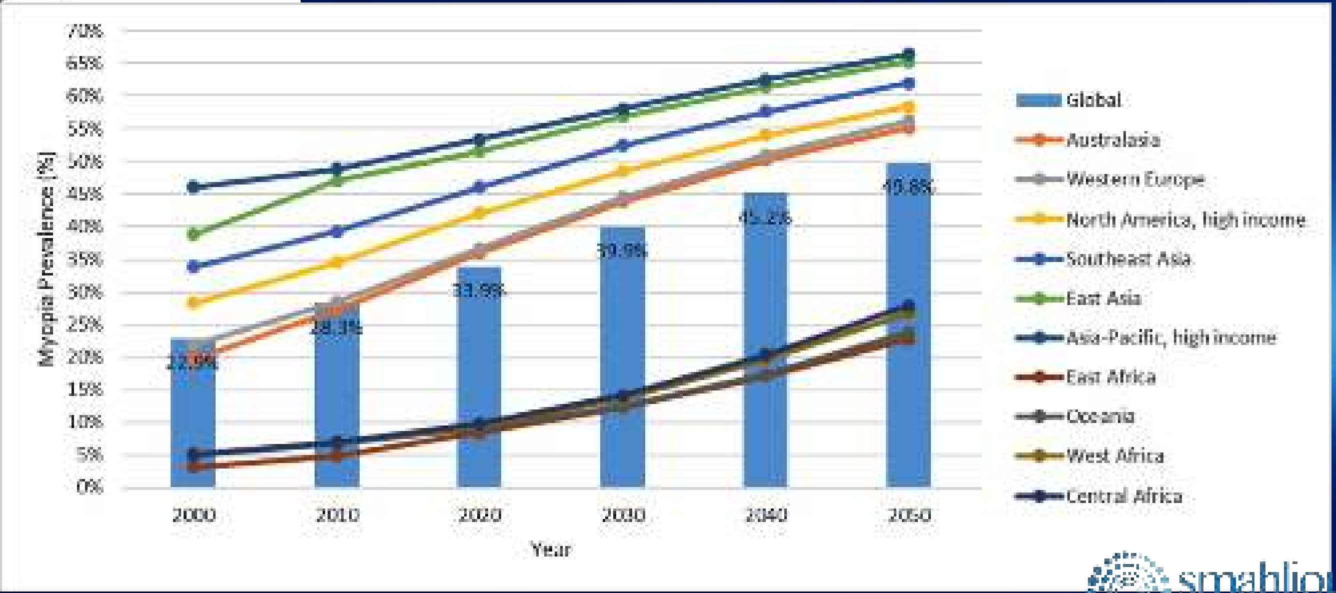
HSIOIRS

NO FINANCIAL DISCLOSURE

Prevalence of Myopia



Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050



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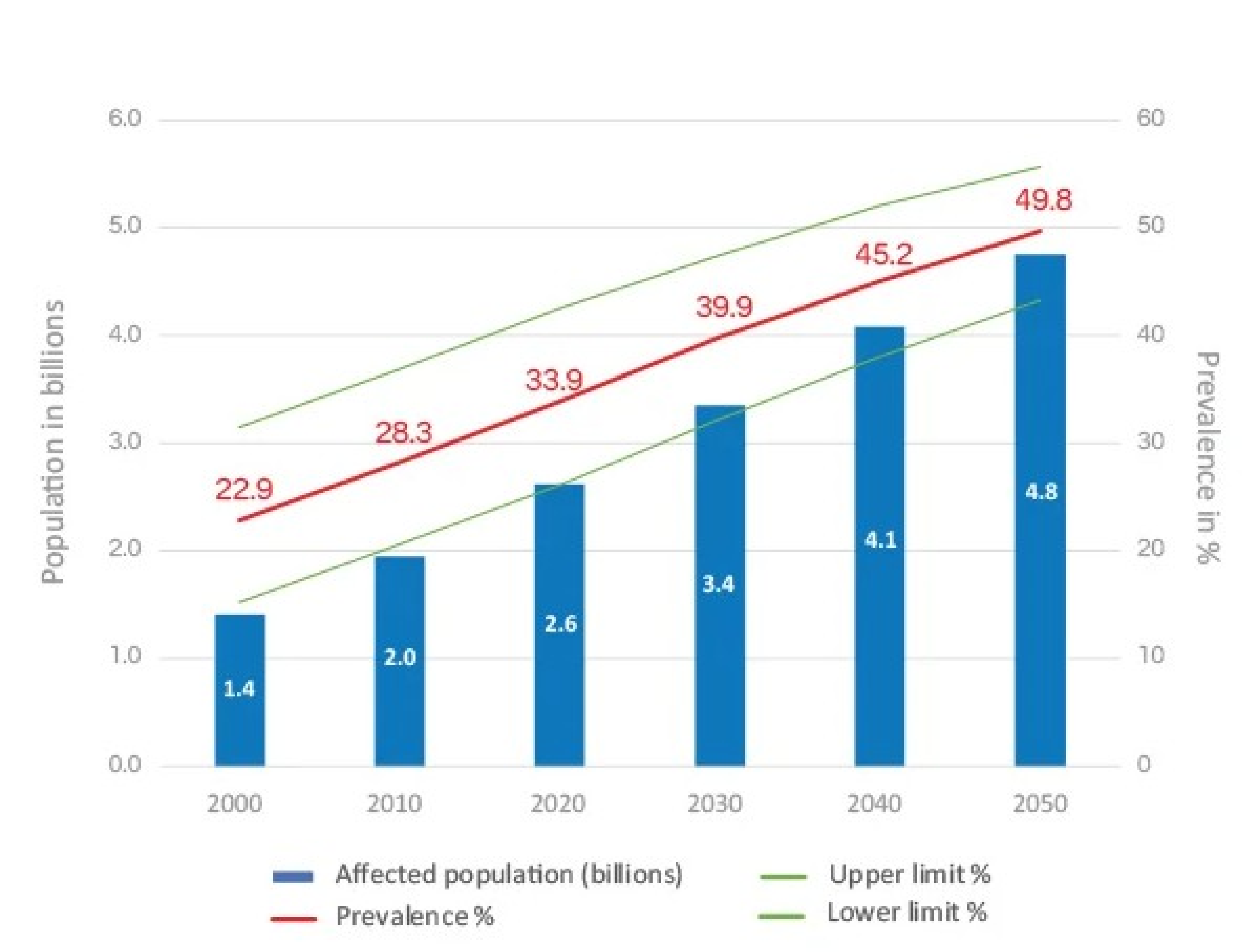
Future Epidemic



The recent Sydney Myopia Study found 31% of 17 year-olds were myopic, double the prevalence reported by the Blue Mountain Eye Study more than a decade ago. But in the future, even nations which have little myopia today, will be severely affected.

Is myopia a Global Public Health Problem?

- **Widespread Occurrence**
  - High prevalence
  - Affects all countries

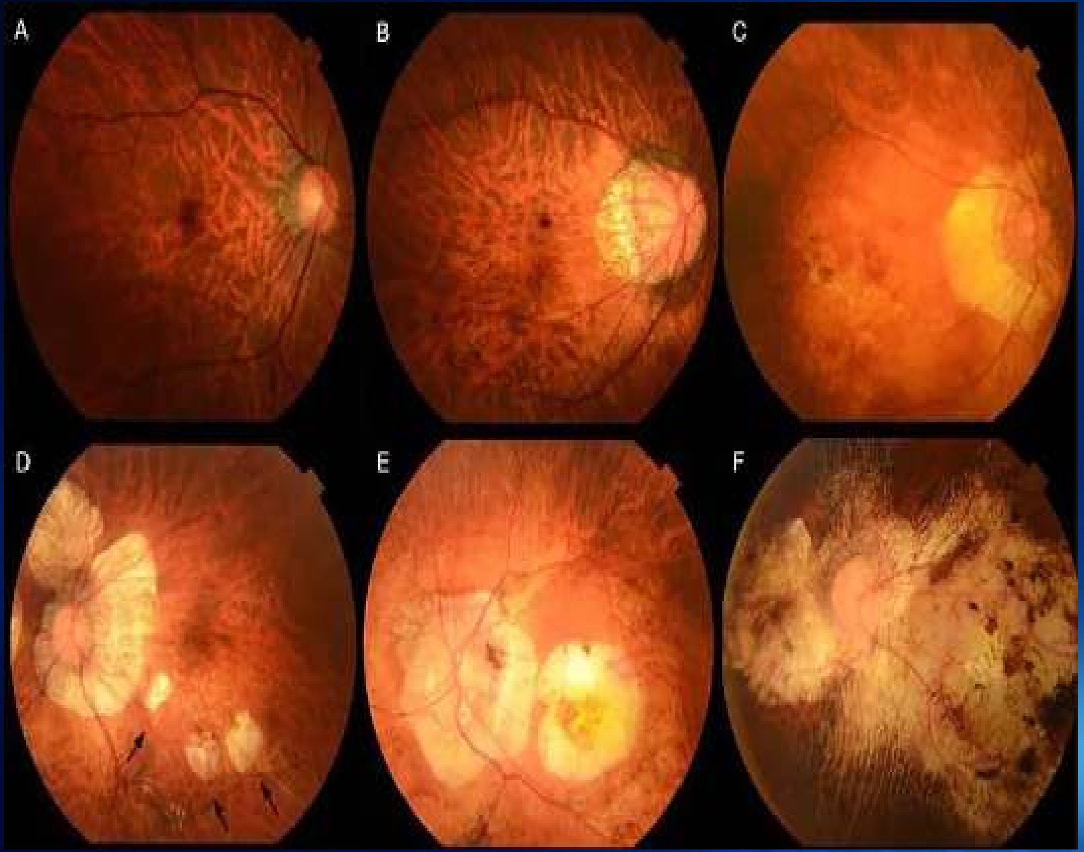
- **Significant Impact**
  - Morbidity
  - Burden on Healthcare Systems
  - Quality of life
  - Economic and social Burden

- **Need for Public Health Action**
  - From Policy-Level to Individual-Level interventions (prevention, treatment, rehabilitation)
  - Multidisciplinary Approaches

YES IT IS !

Controlling myopia is crucial for slowing progression and reducing the risk of future visual impairment

- **Slowing myopia progression by 1D can significantly reduce the risk of vision-threatening conditions:**
  - **58% increased risk of MMD**
  - **30% increased risk of Retinal Detachment**
  - **21% increased risk of posterior subcapsular cataract**
  - **20% increased risk of open angle glaucoma**



INTERNATIONAL **MYOPIA** INSTITUTE

International Myopia Institute (IMI) Facts and Findings: 2023

myopiainstitute.org

Impact of myopia

2020
Myopia affects almost
30% of the world's population

2050
Myopia affects almost
50% of the world's population

High myopia will affect
10% of the world's population

Myopia
-0.50 D or worse

High myopia
-5.00 D or worse

Risk of vision impairment
Uncorrected myopia is a leading cause of avoidable vision impairment. Complications associated with high myopia can be sight threatening e.g. myopic macular degeneration.

Education
In children, poor vision or uncorrected vision can impact scholastic performance and result in psychosocial stress. Negative attitudes to spectacle wear may also affect psychosocial well-being.

Quality of Life (QOL)
Reduced QOL has been demonstrated for myopia and myopia-related complications. QOL is impacted whether myopia is corrected or uncorrected and varies according to the type of corrective modality worn.

Economic impact
Given the progressive nature of myopia, direct costs (expenditure on diagnosis, correction/management, transport and treatment of morbidity) and lost productivity costs are substantial.

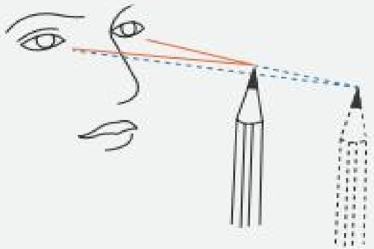
Risk factors

Higher levels of education and near work

Less time outdoors

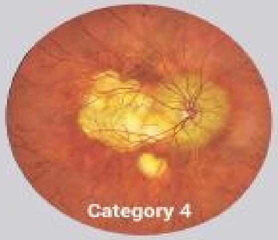
- East Asian ethnicity
- Parents with myopia
- Girls more susceptible according to some studies

Binocular vision



- Link with myopia development is unclear
- Important to optimize accommodation and vergence in children to provide single, clear comfortable vision

Pathologic myopia



META-PM classification system

Category	Retinal signs
0	No myopic retinal lesions
1	Tessellated (or tigroid) fundus
2	Diffuse choroidal atrophy
3	Patchy choroidal atrophy
4	Macular atrophy
Plus lesion	Lacquer cracks, myopic choroidal neovascularization, Fuchs spot
Posterior staphyloma	

3% of the world's population is affected by pathologic myopia

1-3% Asians

1% Europeans

Increases with age and spherical equivalent refractive error/ axial length

Increases in prevalence and severity 40+ years

Affects 50-70% of those with high myopia

Source: IMI white papers, 2019, 2021, 2023
https://myopiainstitute.org/imi-white-papers/
Investigative Ophthalmology & Vision Science
IMI Special issues 60(3) 2019, 62(5) 2021 and 64(6) 2023

Elimination VS Eradication

- Elimination as a Public Health Problem
  - NOT about Eradication, NOT about zero cases

- Example: elimination of Trahoma

Elimination as a Public Health issue: Is about reducing the burden of a disease to a level where its impact on patients, health system and the economy is minimal and manageable.

Etiology and Mechanisms

- Complex interplay between genetic and environmental factors
- Emmetropization: Normal eye growth regulatory mechanism disrupted
- Retinal defocus theory: Peripheral hyperopic defocus triggers axial elongation
- Dopamine pathway: Light exposure stimulates dopamine release, inhibiting eye growth
- Inflammatory pathways and scleral remodeling involved in myopia progression
- Genetic susceptibility interacting with environmental triggers

Risk Factors – Environmental

- **Near work**: Prolonged screen time, reading at close distances
- **Educational pressure**: Correlation between academic achievement and myopia
- **Limited outdoor time**: < 1-2 hours /day associated with increased risk
- **Urban living environments**: Limited distance viewing opportunities
- **Light characteristics**: Spectrum, intensity, timing of exposure
- **Modern lifestyle changes** correlate with increasing prevalence
- **Screen time**

Risk Factors – Genetic

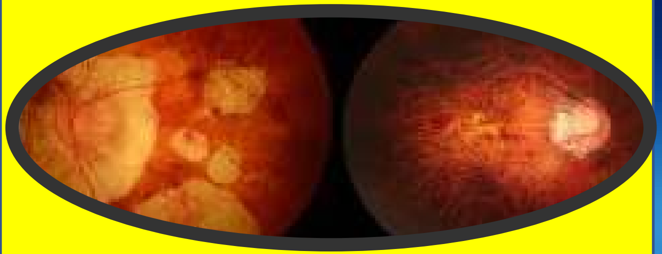
- **Parental myopia:** 2-3× increased risk with one myopic parent, 5-6× with two
- **Identified genetic loci:** Multiple genes implicated (>200 loci identified)
- **Key pathways:** Retinal signaling, light processing, extracellular matrix remodeling
- **Genetic risk assessment:** Polygenic risk scores being developed
- **Gene-environment interactions:** Genetic susceptibility amplified by environmental risks

Myopia care is fragmented

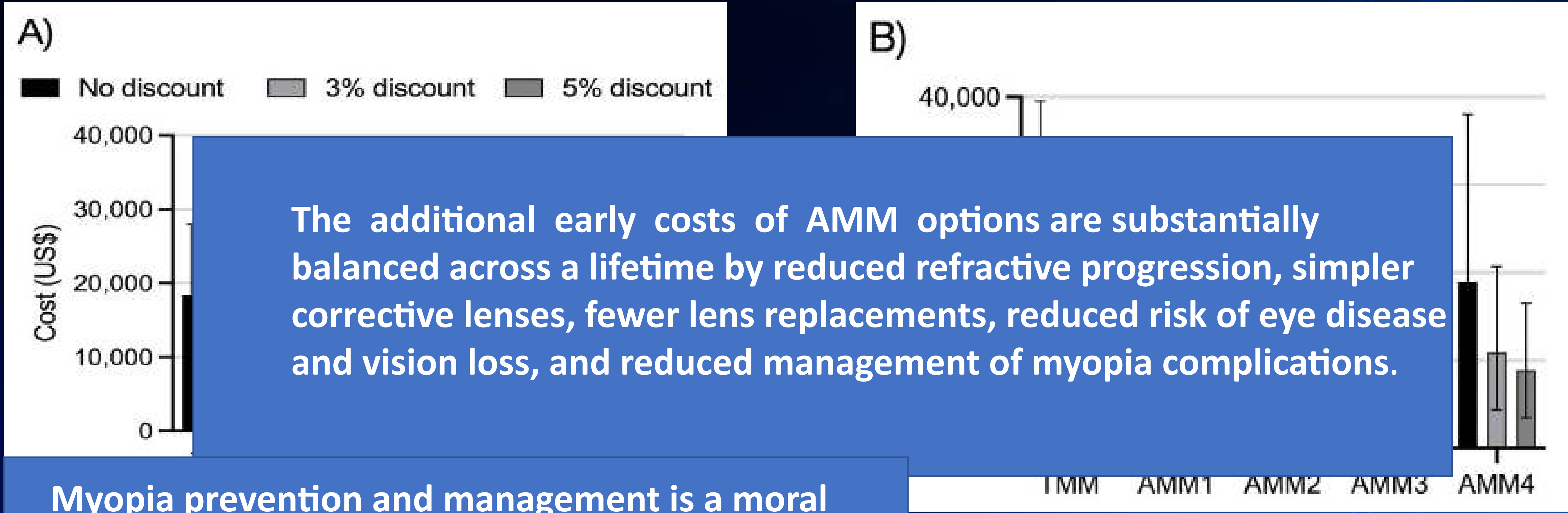
Community school screening

Primary Eye Care

Ophthalmologists



Lifetime Cost of different Myopia Management options

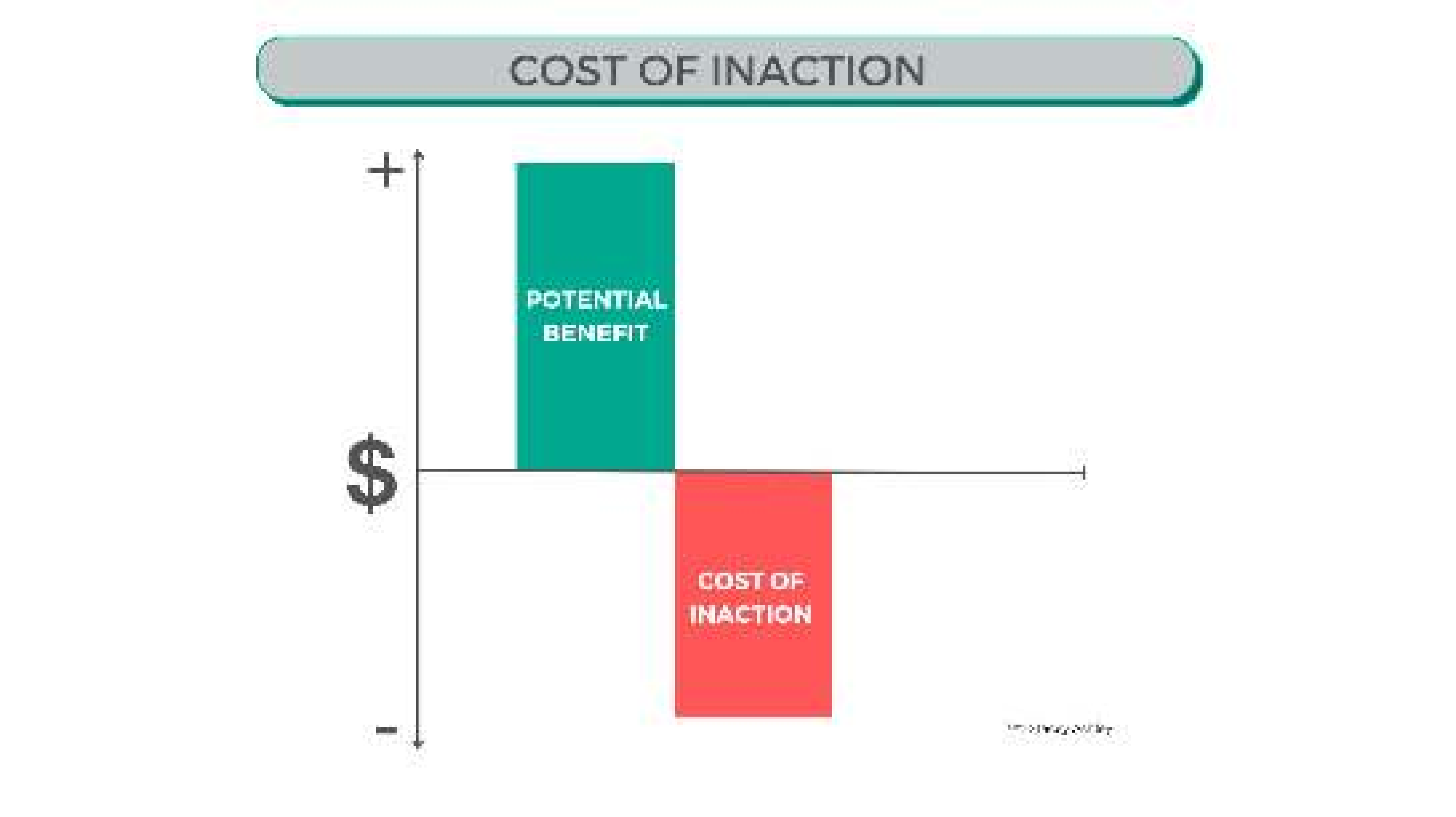


The additional early costs of AMM options are substantially balanced across a lifetime by reduced refractive progression, simpler corrective lenses, fewer lens replacements, reduced risk of eye disease and vision loss, and reduced management of myopia complications.

Myopia prevention and management is a moral imperative.

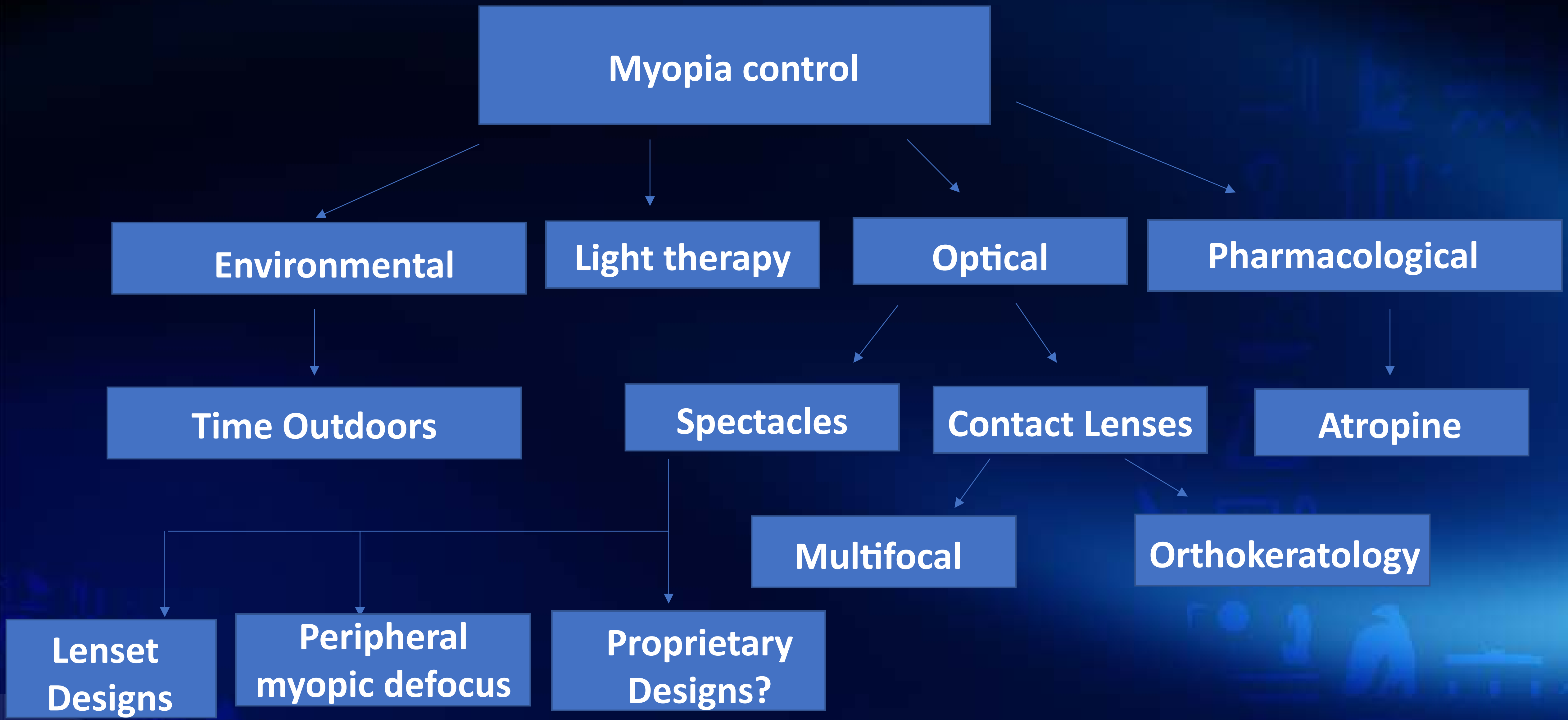
…a for five interventions in urban Australia (A) and China (B). Error bars show bounds of sensitivity analysis. AMM, active myopia management; AMM1, low- dose atropine; AMM2, antimyopia spectacles; AMM3, antimyopia multifocal soft contact lenses; AMM4, orthokeratology; TMM, traditional myopia management.

The importance of myopia control strategies and the cost of inaction



A lot remain unknown in all fields

- Epidemiology and Risk Factors
- Environment (light, image complexity)
- Natural history of emetropization
- Pathophysiology
- Pharmacology
- Treatment targets
- Combined therapies
- Technology and AI


Myopia control
Environmental
Light therapy
Optical
Pharmacological
Time Outdoors
Spectacles
Contact Lenses
Atropine
Multifocal
Orthokeratology
Lenset Designs
Peripheral myopic defocus
Proprietary Designs?

Clinical Interventions – Optical

- **Specialized spectacle lenses:**

1. Defocus Incorporated Multiple Segments (DIMS) lenses
2. Highly Aspherical Lenslet (HALT) technology
3. Executive bifocals with base-in prism

- **Multifocal soft contact lenses** with peripheral defocus designs
- **Orthokeratology:** Overnight reshaping contact lenses

Pharmacological Interventions

- **Atropine:** Concentration-dependent efficacy and side effects: 1.0% most effective but more side effects 0.01-0.05%: Better tolerated with moderate efficacy
- **Emerging pharmacological agents:**

1. 7-methylxanthine (7-MX)
2. Pirenzepine
3. Dopamine agonists

- **Combination therapies showing promising results**

Atropine eyedrops

- Non selective muscarinic antagonist
- Wells 19th century
- 1990s Asia
- Clinical effect on the progression of myopia
- ? Mechanism of action
- Non accommodative (prevents myopia in chicks with striated ciliary muscle innervated by nicotinic receptors rather than muscarinic receptors)

Review > Curr Pharm Des. 2015;21(32):4718-30. doi: 10.2174/1381612821666150909095403.

The Role of Atropine Eye Drops in Myopia Control

Andrzej Grzybowski [1], Alejandro Armesto, Maria Szwajkowska, Guillermo Iribarren, Rafael Iribarren

Affiliations + expand

PMID: 26350533 DOI: 10.2174/1381612821666150909095403

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Five-Year Clinical Trial on Atropine for the Treatment of Myopia 2

Myopia Control with Atropine 0.01% Eyedrops

Audrey Chia, FRANZCO, PhD,[1,2] Qing-Shu Lu, PhD,[3,4] Donald Tan, FRCS, FRCOphth[1,2,4,5]

Purpose: To compare the safety and efficacy of different concentrations of atropine eyedrops in controlling myopia progression over 5 years.
Design: Randomized, double-masked clinical trial.
Participants: A total of 400 children originally randomized to receive atropine 0.5%, 0.1%, or 0.01% once daily in both eyes in a 2:2:1 ratio.
Methods: Children received atropine for 24 months (phase 1), after which medication was stopped for 12 months (phase 2). Children who had myopia progression (≥ -0.50 diopters [D] in at least 1 eye) during phase 2 were restarted on atropine 0.01% for a further 24 months (phase 3).
Main Outcome Measures: Change in spherical equivalent and axial length over 5 years.
Results: There was a dose-related response in phase 1 with a greater effect in higher doses, but an inverse dose-related increase in myopia during phase 2 (washout), resulting in atropine 0.01% being most effective in reducing myopia progression at 3 years. Some 24%, 59%, and 68% of children originally in the atropine 0.01%, 0.1%, and 0.5% groups, respectively, who progressed in phase 2 were restarted on atropine 0.01%. Younger children and those with greater myopic progression in year 1 were more likely to require re-treatment. The lower myopia progression in the 0.01% group persisted during phase 3, with overall myopia progression and change in axial elongation at the end of 5 years being lowest in this group (-1.38 ± 0.98 D; 0.75 ± 0.48 mm) compared with the 0.1% (-1.83 ± 1.16 D, $P = 0.003$; 0.85 ± 0.53 mm, $P = 0.144$) and 0.5% (-1.98 ± 1.10 D, $P < 0.001$; 0.87 ± 0.49 mm, $P = 0.075$) groups. Atropine 0.01% also caused minimal pupil dilation (0.8 mm), minimal loss of accommodation (2–3 D), and no near visual loss compared with higher doses.
Conclusions: Over 5 years, atropine 0.01% eyedrops were more effective in slowing myopia progression with less visual side effects compared with higher doses of atropine. *Ophthalmology 2015;■:1–9 © 2015 by the American Academy of Ophthalmology.*

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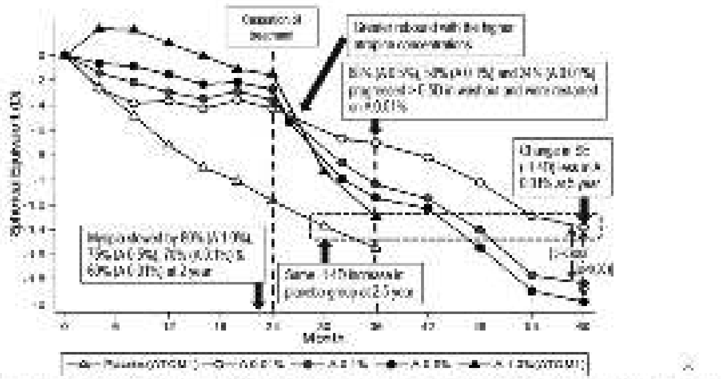
Low-Concentration Atropine for Myopia Progression (LAMP) Study

A Randomized, Double-Blinded, Placebo-Controlled Trial of 0.05%, 0.025%, and 0.01% Atropine Eye Drops in Myopia Control

Jason C. Yam, FCOphthHK, FRCS(Edin),[1] Yuning Jiang, MMED,[1] Shu Min Tang, PhD,[1] Antony K.P. Law, MSc,[1] Joyce J. Chan, MRCSEd(Ophth),[1] Emily Wong, MBChB, MRCS(Edin),[1] Simon T. Ko, FCOphthHK, FHKAM(Oph),[1] Alvin L. Young, MMedSc(Hons), FRCOphth,[1,2] Clement C. Tham, FCOphthHK, FRCOphth,[1] Li Jia Chen, MRCSEd(Ophth), PhD,[1,2] Chi Pui Pang, DPhil[1]

Purpose: Low-concentration atropine is an emerging therapy for myopia progression, but its efficacy and optimal concentration remain uncertain. Our study aimed to evaluate the efficacy and safety of low-concentration atropine eye drops at 0.05%, 0.025%, and 0.01% compared with placebo over a 1-year period.
Design: Randomized, placebo-controlled, double-masked trial.
Participants: A total of 438 children aged 4 to 12 years with myopia of at least -1.0 diopter (D) and astigmatism of -2.5 D or less.
Methods: Participants were randomly assigned in a 1:1:1:1 ratio to receive 0.05%, 0.025%, and 0.01% atropine eye drops, or placebo eye drop, respectively, once nightly to both eyes for 1 year. Cycloplegic refraction, axial length (AL), accommodation amplitude, pupil diameter, and best-corrected visual acuity were measured at baseline, 2 weeks, 4 months, 8 months, and 12 months. Visual Function Questionnaire was administered at the 1-year visit.
Main Outcome Measures: Changes in spherical equivalent (SE) and AL were measured, and their differences among groups were compared using generalized estimating equation.
Results: After 1 year, the mean SE change was -0.27 ± 0.61 D, -0.46 ± 0.45 D, -0.59 ± 0.61 D, and -0.81 ± 0.53 D in the 0.05%, 0.025%, and 0.01% atropine groups, and placebo groups, respectively ($P < 0.001$), with a respective mean increase in AL of 0.20 ± 0.25 mm, 0.29 ± 0.20 mm, 0.36 ± 0.29 mm, and 0.41 ± 0.22 mm ($P < 0.001$). The accommodation amplitude was reduced by 1.98 ± 2.82 D, 1.61 ± 2.61 D, 0.26 ± 3.04 D, and 0.32 ± 2.91 D, respectively ($P < 0.001$). The pupil sizes under photopic and mesopic conditions were increased respectively by 1.03 ± 1.02 mm and 0.58 ± 0.63 mm in the 0.05% atropine group, 0.76 ± 0.90 mm and 0.43 ± 0.61 mm in the 0.025% atropine group, 0.49 ± 0.80 mm and 0.23 ± 0.46 mm in the 0.01% atropine group, and 0.13 ± 1.07 mm and 0.02 ± 0.55 mm in the placebo group ($P < 0.001$). Visual acuity and vision-related quality of life were not affected in each group.
Conclusions: The 0.05%, 0.025%, and 0.01% atropine eye drops reduced myopia progression along a concentration-dependent response. All concentrations were well tolerated without an adverse effect on vision-related quality of life. Of the 3 concentrations used, 0.05% atropine was most effective in controlling SE progression and AL elongation over a period of 1 year. *Ophthalmology 2018;■:1–12 © 2018 by the American Academy of Ophthalmology*



Atropine 0.01% slowed myopia progression by 50% in 5 years

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smahliou

Atropine Dosage

- Dose dependent inhibitory effect on myopia progression
- **Low dose (0.01% to 0.10%): 30-65% efficacy**
- **High dose (0.5% to 1%): 60%-80% efficacy**

Comment > Strabismus. 2018 Mar;26(1):46. doi: 10.1080/09273972.2017.1421675.
Epub 2018 Jan 2.

Dobrowolsky from St. Petersburg and Hosch from Basel reported improvement of myopia after atropine use in 1868 and 1871

Andrzej Grzybowski [1], Bianka Sobolewska [2]

Affiliations + expand

PMID: 29293393 DOI: 10.1080/09273972.2017.1421675

Comparative Efficacy of Interventions

- **Strong evidence for efficacy (>50% reduction in progression):**
  1. Orthokeratology: 43-64% reduction in axial elongation
  2. Atropine 0.5-1.0%: 60-80% reduction in progression
  3. Dual-focus contact lenses: 50-59% reduction
- **Moderate evidence for efficacy (30-50% reduction):**
  1. Low-dose atropine (0.01-0.05%): 30-45% reduction
  2. DIMS spectacles: 33-52% reduction in axial elongation
  3. Multifocal soft contact lenses: 25-46% reduction
- **Limited or inconsistent evidence:**
  1. Traditional bifocal/progressive spectacles: 8-20% reduction
  2. Undercorrection: May actually accelerate progression
  3. Blue-light filtering lenses: No significant effect on myopia progression

Intervention Effectiveness in Detail

- **Orthokeratology:**
  1. Most effective for moderate myopia (-1.00D to -4.00D)
  2. More effective in younger children with faster progression
  3. Requires excellent compliance and hygiene
  4. Benefits maintained only with continued use
- **Atropine therapy:**
  1. Dose-dependent effect and rebound effect upon cessation
  2. **0.01% shows optimal balance of efficacy vs. side effects**
  3. Combination with optical methods shows synergistic effects
  4. Long-term safety profile excellent for low concentrations
- **Specialized optical designs:**
  1. DIMS technology: Honeycomb of lenslets creating myopic defocus
  2. MiSight contact lenses: Concentric ring design with treatment and correction zones
  3. SightGlass D.O.T. technology: Contact lens-free solution for younger children

Interventions to slow the progression of myopia

What Appears to work

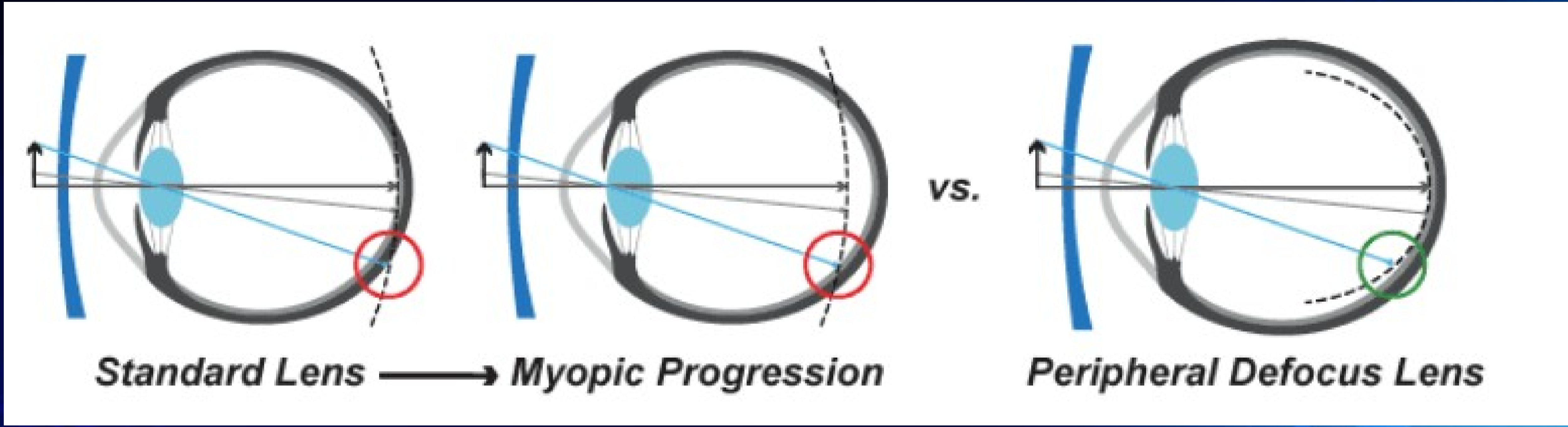
- Behavioral Interventions
- Contact lenses (Dual Focus, OK)
- Pharmacological Treatment
- Spectacle Lenses (Lenslet/Multi Segment spectacle)

Interventions to slow the progression of myopia

What Does not work or has minimal effect

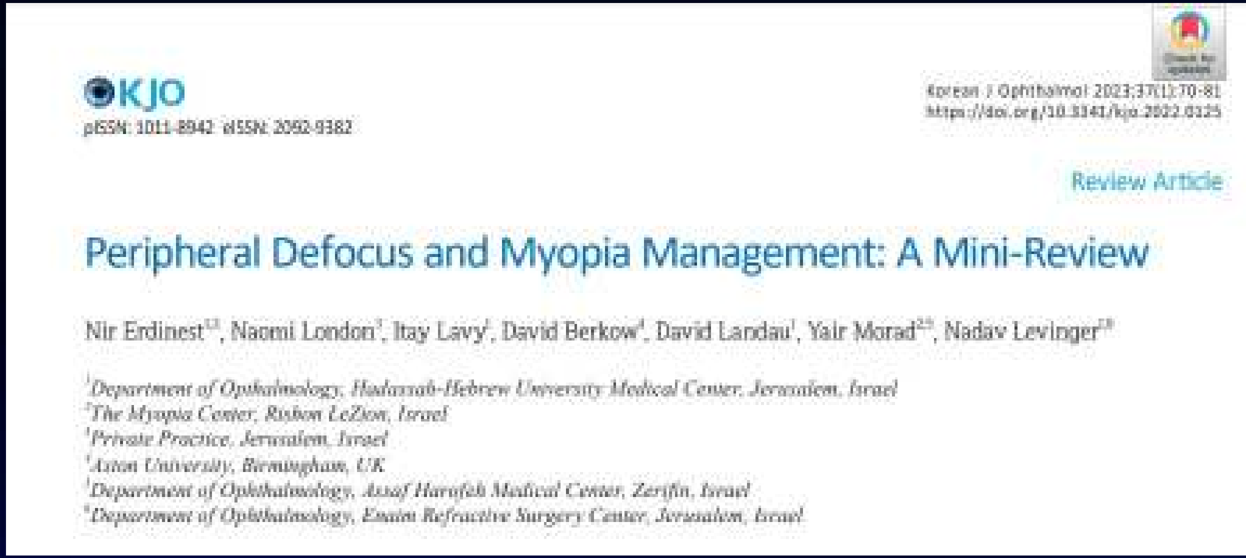
- Undercorrection of myopia
- Pinhole glasses
- Blue light blocking glasses
- Bifocal glasses
- Progressive addition spectacle lenses

Prevention of myopia and its progression



The newest myopia controlling spectacles can both **correct** and **control** myopia as well as the most effective contact lens options.

Progressive myopia and peripheral defocus: Principles



KJO
pISSN: 1011-8942 eISSN: 2092-9382

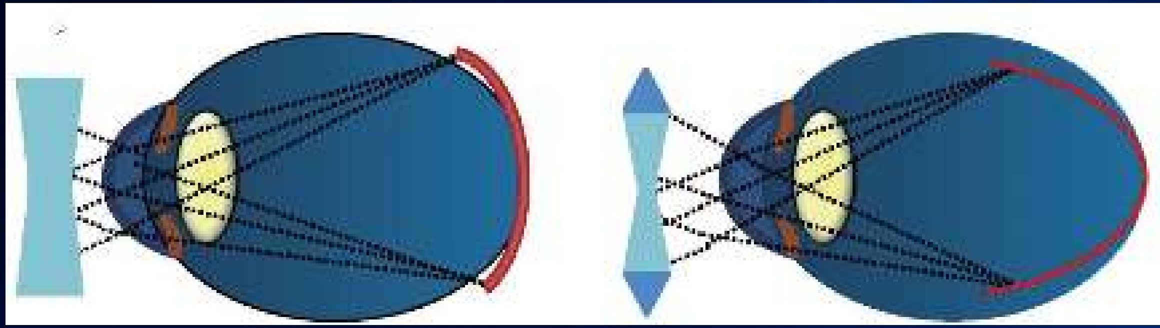
Korean J Ophthalmol 2023;37(1):70-81
https://doi.org/10.3341/kjo.2022.0125

Review Article

Peripheral Defocus and Myopia Management: A Mini-Review

Nir Erdinest, Naomi London, Itay Lavy, David Berkow, David Landau, Yair Morad, Nadav Levinger

Department of Ophthalmology, Hadassah-Hebrew University Medical Center, Jerusalem, Israel
The Myopia Center, Rishon LeZion, Israel
Private Practice, Jerusalem, Israel
Aston University, Birmingham, UK
Department of Ophthalmology, Assaf Harofeh Medical Center, Zerifin, Israel
Department of Ophthalmology, Enaim Refractive Surgery Center, Jerusalem, Israel



Myopic correction with single vision contact lenses or single vision spectacles correct myopia at both the fovea and the peripheral retina in equal amounts. This causes the myopic eye's fovea and peripheral retina to be in different myopic states. **(A) The peripheral retina is more hyperopic; therefore, equal myopic correction peripherally and centrally is likely to enhance myopia progression.** (B) As illustrated, **myopic correction with peripheral myopic defocus contact lenses or spectacle lenses correct the full degree of myopia at the fovea but create myopic defocus in the peripheral retina by providing additional positive power in the periphery, thus retarding myopia progression.**

What are DIMS, H.A.L.T., DOT and CARE technology?

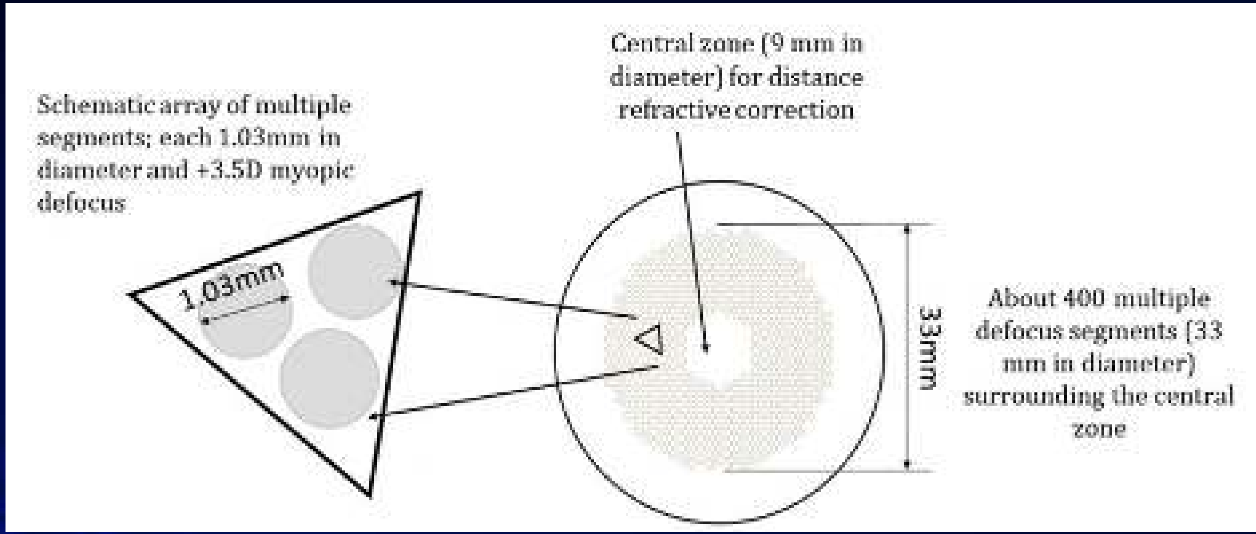
- It is like a single vision lens for myopia correction, with an overlaying 'treatment zone' for myopia control.
- Each has a clear single vision distance zone in the centre of the lens, and a 'background' of single vision correction throughout the periphery of the lens
- There is a surrounding zone of lenslets (DIMS and H.A.L.T.), diffusion microlenses (DOT) or micro-cylinders (CARE) to create a differential myopic defocus across the retina. The lenslet (DIMS and H.A.L.T.) and micro-cylinder spectacles (CARE) have spaces in between the lenslets for the single vision correction

How do they work?

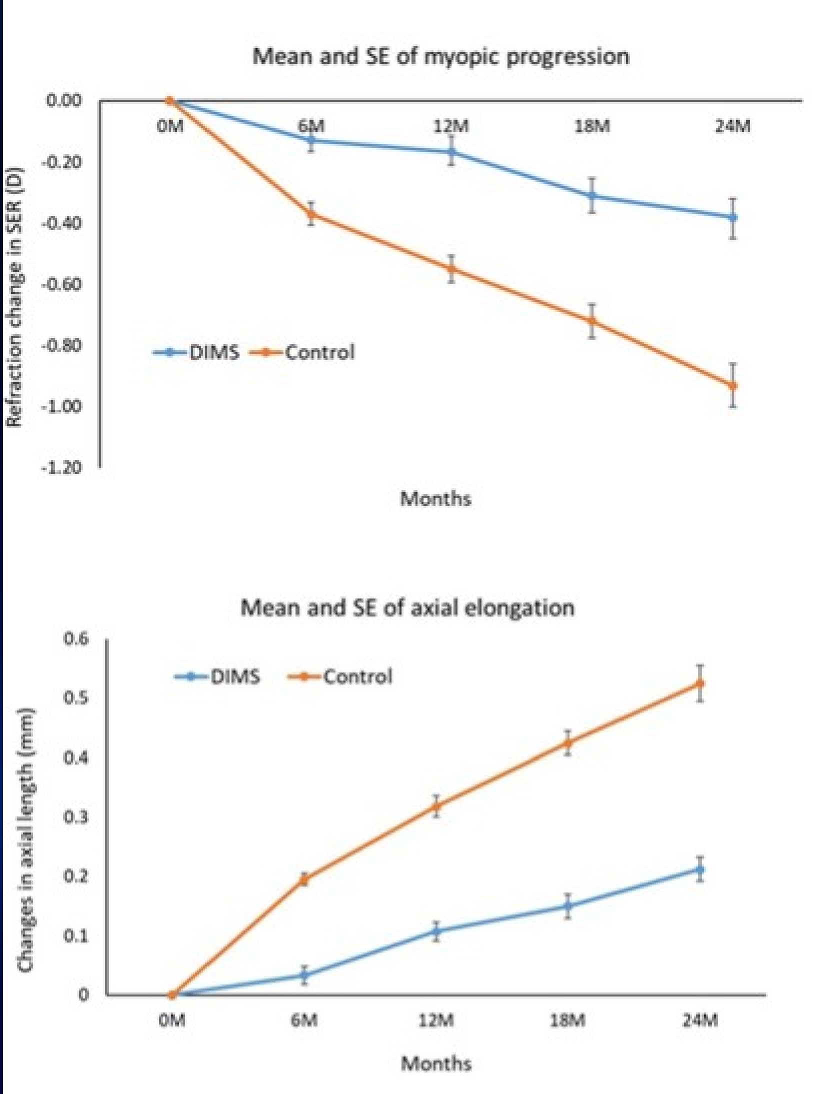
- **The peripheral defocus theory** and the **simultaneous myopic retinal defocus theory** whereby the peripheral retina receives myopic defocus as a slow-down or stop signal for eye growth.
- Think of this as two planes of focus - one being on the retina to correct myopia, and the other in front of the retina for myopic defocus
- **The DIMS technology works on the concept of creating simultaneous defocus**
- **The H.A.L.T. technology takes this a step further by introducing the concept of a 'volume of myopic defocus**

Defocus Incorporated Multiple Segments (DIMS) spectacle lenses slow myopia progression: a 2-year randomised clinical trial

Carly Siu Yin Lam,[1] Wing Chun Tang,[1] Dennis Yan-yin Tse,[1] Roger Pak Kin Lee,[1] Rachel Ka Man Chun,[1] Keigo Hasegawa,[2] Hua Qi,[2] Takashi Hatanaka,[2] Chi Ho To[1]



The design of the Defocus Incorporated Multiple Segments (DIMS) spectacle lens.



Model-adjusted mean and SE of myopia progression and axial length from baseline to 24 months. DIMS, Defocus Incorporated Multiple Segments; SER, spherical equivalent refraction.

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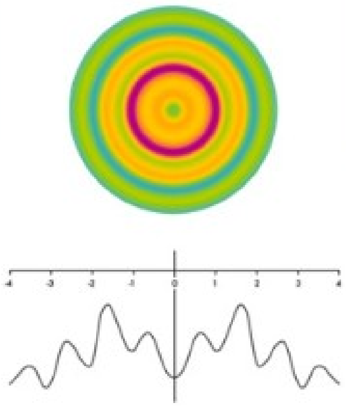
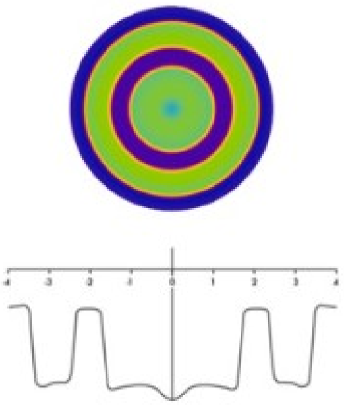
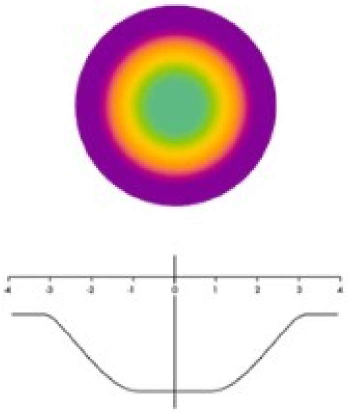
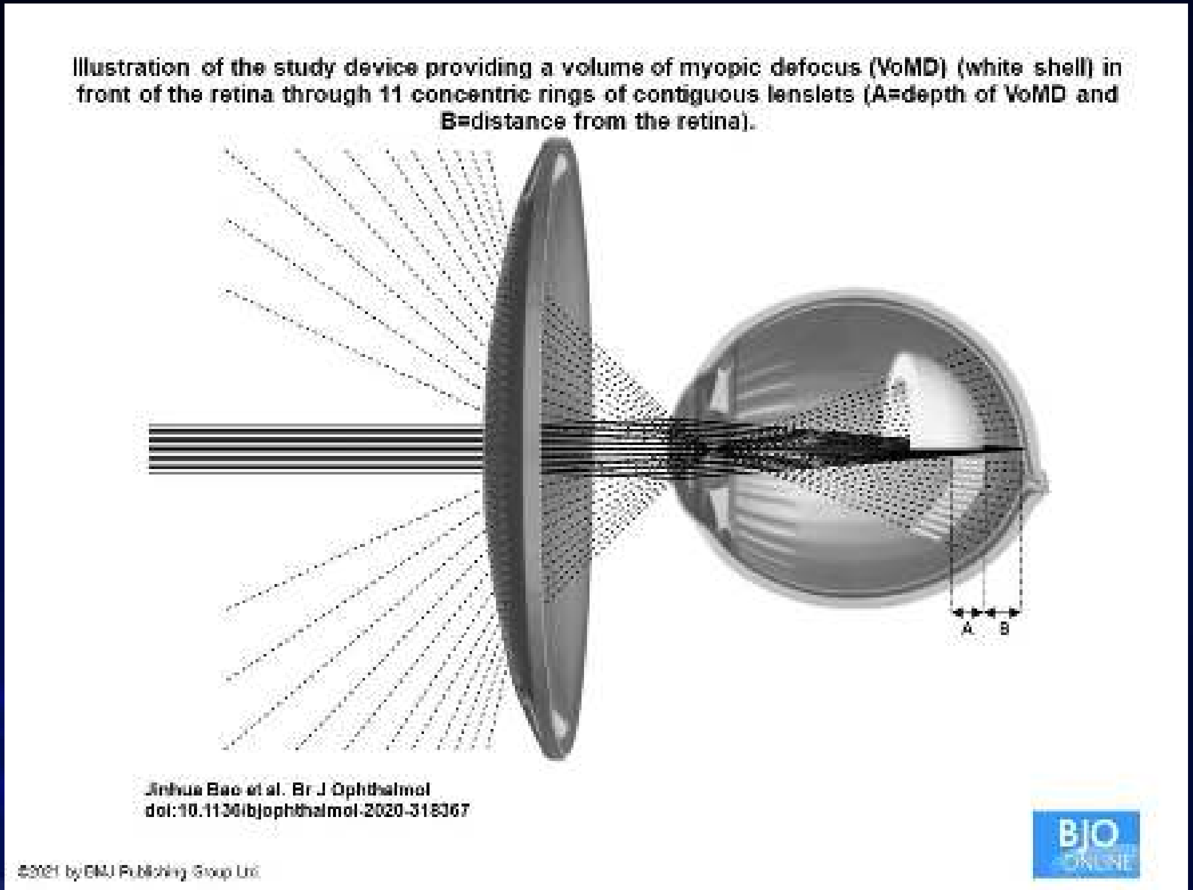
Soft contact lenses for MC

	Extended Depth Of Focus Contact Lens	Dual-focus Contact Lens	Centre Distance Contact Lens
Rationale	Global Retinal Image Quality that degrades rapidly for all points behind the retina	Simultaneous Defocus	Peripheral Defocus
Design	Optimisation of higher-order aberrations to extend the Depth of Focus	Central correction zone and concentric treatment zones (+2 addition)	Three zones: far, intermediate and near
Replacement	Monthly	Daily	Daily/Monthly
Type	Soft Contact Lens	Soft Contact Lens	Soft Contact Lens
Images (Colours represent the power profile)			

In general, they are designed with a central zone for correcting distance myopia, surrounded by one or more concentric rings with less negative power (+ add).

Highly Aspherical Lenslet Target or H.A.L.T. technology



Are spectacle lenses having "a spherical front surface with 11 concentric rings formed by contiguous aspherical lenslets (diameter of 1.1 mm). The area of the lens without lenslets provides distance correction. The geometry of aspherical lenslets has been calculated to generate a VoMD in front of the retina at any eccentricity, serving as a myopia control signal

MiYOSMART Spectacle Lenses

Eight years of wearing **Defocus Incorporated Multiple Segments** (DIMS) Spectacle Lenses: User Experience and myopia control outcomes

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ORTHOKERATOLOGY

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Ophthalmic Technology Assessment

Use of Orthokeratology for the Prevention of Myopic Progression in Children

A Report by the American Academy of Ophthalmology

Deborah K. VanderVeen, MD,[1] Raymond T. Kraker, MSPH,[2] Stacy L. Pineles, MD,[3] Amy K. Hutchinson, MD,[4] Lorri B. Wilson, MD,[5] Jennifer A. Galvin, MD,[6] Scott R. Lambert, MD[7]

Conclusions: Orthokeratology may be effective in slowing myopic progression for children and adolescents, with a potentially greater effect when initiated at an early age (6–8 years). Safety remains a concern because of the risk of potentially blinding microbial keratitis from contact lens wear. *Ophthalmology 2018;■:1–14 © 2018 by the American Academy of Ophthalmology*

Microbial Keratitis with Myopia Control

Daily Wear Soft Lenses

- 3 per 10,000 years
- 95% CI: 1 – 19

Overnight Ortho-K

- 5 per 10,000 years
- 95% CI: 2 – 12

Table 4. Crude Incidence Rates by Lens Type for All Presumed Microbial Keratitis, "Severe" Keratitis and for Keratitis Causing 2 Lines of Vision Loss

Lens Type	Any Presumed Microbial Keratitis (95% CI)	"Severe" Microbial Keratitis (95% CI)	Microbial Keratitis With >2 Lines Vision Loss (95% CI)
Daily wear RGP	1.2 (1.1–1.5)	1.2 (1.1–1.5)	0 (0.0–0.0)
Pure DW soft	1.9 (1.8–2.0)	1.1 (1.1–1.2)	0.4 (0.4–0.4)
Pure DW DD soft	2.0 (1.7–2.4)	0.5 (0.5–0.6)	0 (0.0–0.0)
Pure DW SH	11.9 (10.0–14.6)	8.0 (6.7–9.8)	1.1 (0.9–1.4)
Occ O/N soft	2.2 (2.0–2.5)	1.8 (1.6–2.0)	0.2 (0.2–0.2)
Occ O/N DD soft	4.2 (3.1–6.6)	2.4 (1.7–3.7)	0 (0.0–0.0)
Occ O/N SH	5.5 (4.5–7.2)	5.3 (4.3–6.9)	1.6 (1.2–2.1)
Overnight wear soft*	19.5 (14.6–29.5)	13.3 (10.0–20.1)	4.0 (2.9–6.6)
Overnight wear SH	25.4 (21.2–31.5)	16.9 (14.1–20.9)	2.8 (2.3–3.5)
Any lens type	4.2 (3.4–5.5)	2.7 (2.2–3.5)	0.6 (0.5–0.7)

CI = confidence interval; DD = daily disposable; Occ O/N = occasional overnight use; Overnight wear = regular overnight use; RGP = rigid gas permeable; "Severe" microbial keratitis = all cases excluding mild; SH = silicone hydrogel.
*Conventional soft contact lenses and planned replacement soft.

From Stapleton et al. (2008)

- A report of American Academy of Ophthalmology concluded that ortho-K may be effective in slowing myopic progression for children and adolescents, safety remains a concern because of the risk of potentially blinding microbial keratitis from contact lens wear
- *Ophthalmology 2020*

Ophthalmol Ther (2024) 13:1453–1477
https://doi.org/10.1007/s40123-024-00951-w

Check for updates

REVIEW

Myopia Control: Are We Ready for an Evidence Based Approach?

Leila Sara Eppenberger · Andrzej Grzybowski · Leopold Schmetterer · Marcus Ang

Received: February 19, 2024 / Accepted: April 11, 2024 / Published online: May 7, 2024

ABSTRACT

Introduction: Myopia and its vision-threatening complications present a significant public health problem. This review aims to provide an updated overview of the multitude of known and emerging interventions to control myopia, including their potential effect, safety, and costs.
Methods: A systematic literature search of three databases was conducted. Interventions were grouped into four categories: environmental/behavioral (outdoor time, near work), pharmacological (e.g., atropine), optical interventions (spectacles and contact lenses), and novel approaches such as red-light (RLRL) therapies. Review articles and original articles on randomized controlled trials (RCT) were selected.
Results: From the initial 3224 retrieved records, 18 reviews and 41 original articles reporting results from RCTs were included. While there is more evidence supporting the efficacy of low-dose atropine and certain myopia-controlling contact lenses in slowing myopia progression, the evidence about the efficacy of

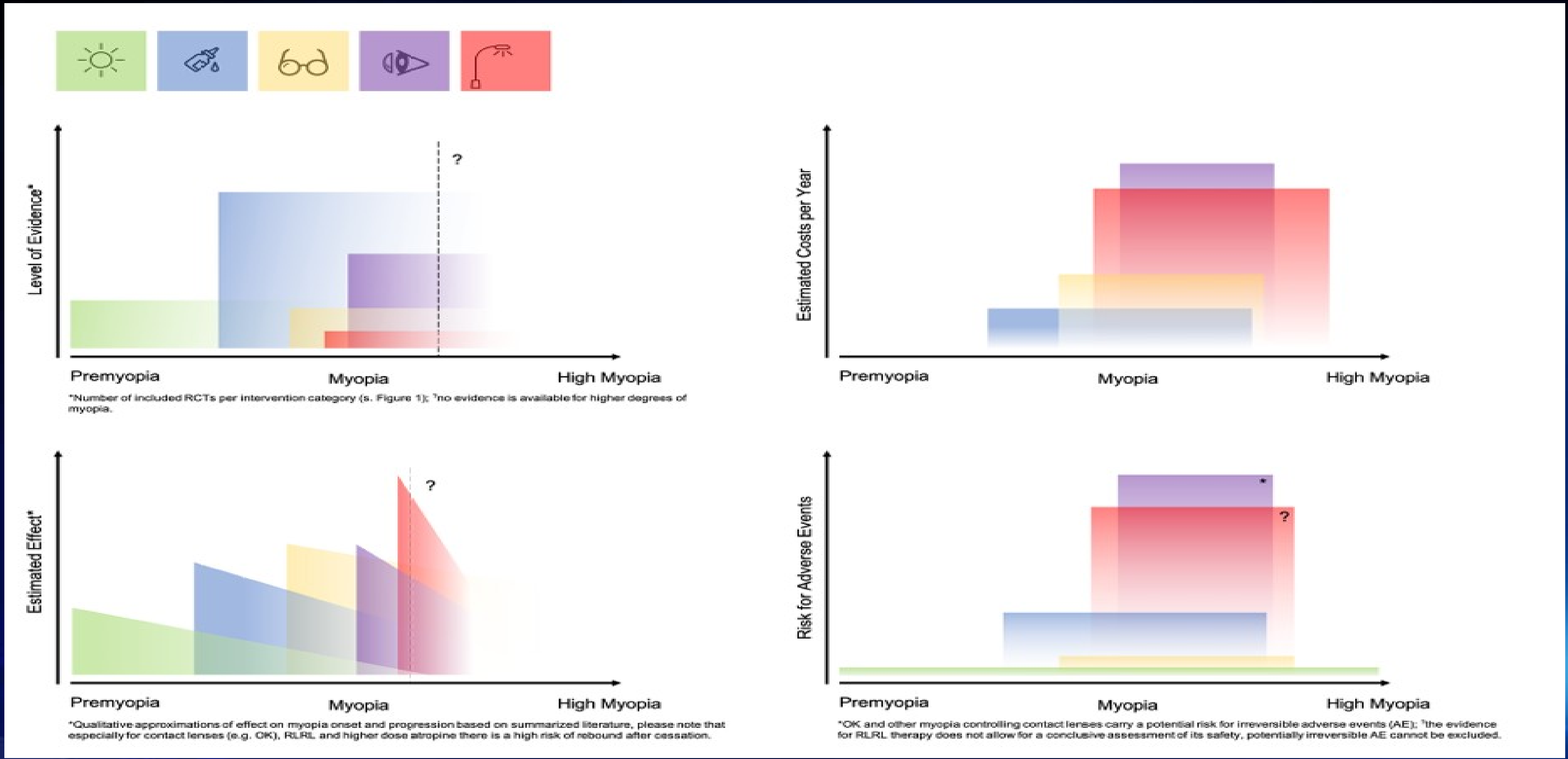
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40123-024-00951-w.

L. S. Eppenberger · L. Schmetterer · M. Ang (✉)
Singapore Eye Research Institute, Singapore
National Eye Centre, Singapore, Singapore
e-mail: Marcus.Ang@Singhealth.com.sg

L. S. Eppenberger
Health Sciences and Technology, ETH Zurich, Zurich, Switzerland

L. Schmetterer
School of Chemical and Biological Engineering, Nanyang Technological University, Singapore, Singapore

L. Schmetterer
Department of Clinical Pharmacology, Medical University Vienna, Vienna, Austria


?
Level of Evidence*
Premyopia
Myopia
High Myopia
*Number of included RCTs per intervention category (s. Figure 1); ˀno evidence is available for higher degrees of myopia.
Estimated Costs per Year
Premyopia
Myopia
High Myopia
?
Estimated Effect*
Premyopia
Myopia
High Myopia
*Qualitative approximations of effect on myopia onset and progression based on summarized literature, please note that especially for contact lenses (e.g. OK), RLRL and higher dose atropine there is a high risk of rebound after cessation.
*
?
Risk for Adverse Events
Premyopia
Myopia
High Myopia
*OK and other myopia controlling contact lenses carry a potential risk for irreversible adverse events (AE); ˀthe evidence for RLRL therapy does not allow for a conclusive assessment of its safety, potentially irreversible AE cannot be excluded.

Atropine in myopia control

- Cost-effective: No 1
- Accumulation of evidence: No 1
- Safe: No 2
- Effectiveness: 2/3 (depending on the concentration)
- Availability worldwide: Very good (compounded pharmacy)

WINNER

Early Detection and Monitoring

- Comprehensive eye examinations starting before school age
- Regular refractive assessments: Every 6-12 months for at-risk children
- Axial length monitoring: Gold standard for progression assessment
- Corneal topography and peripheral refraction mapping
- Risk assessment tools incorporating multiple factors
- Digital health platforms for continuous monitoring

Personalized Intervention Approaches

- <u>**Risk stratification based on:**</u>
  1. Age of onset (earlier = higher risk of progression)
  2. Parental myopia status Rate of progression
  3. Ethnicity and geographic factors
- <u>**Tailored intervention protocols**</u> based on risk level
- <u>**Combination therapies for high-risk individuals**</u>
- <u>**Regular reassessment and intervention adjustment**</u>

Public Health Strategies

- School-based screening and intervention programs
- Built environment modifications promoting outdoor activity
- Public awareness campaigns targeting parents and educators
- Integration of eye health into primary healthcare systems
- Policy recommendations for screen time and educational practices
- Urban planning considerations for visual environment

Global Initiatives and Case Studies

- Singapore's outdoor program: Mandatory outdoor time in schools
- Taiwan's prevention program: 120 minutes outdoor time daily
- China's myopia prevention policy: National strategy limiting homework and screen time
- Australia's light exposure programs: Utilizing natural light in classrooms
- European comprehensive eye care integration models

Research Frontiers

- Wearable technology for real-time visual behavior monitoring
- Novel pharmaceutical delivery systems: Microneedles, sustained-release implants
- Gene therapy approaches targeting key pathways
- Artificial intelligence for risk prediction and intervention optimization
- Advanced imaging modalities for earlier detection
- Microbiome influences on eye development

Challenges in Implementation

- Access and affordability of interventions
- Adherence to long-term prevention strategies
- Cultural and educational system barriers
- Balancing digital learning needs with eye health
- Provider education and awareness
- Regulatory approval for novel interventions

Practical Recommendations for Clinicians

- <u>Implement</u> comprehensive myopia screening protocols
- <u>Discuss</u> myopia management options with parents early
- <u>Consider</u> progressive intervention based on risk factors
- <u>Monitor</u> axial length when possible, not just refraction
- <u>Stay</u> updated on IMI guidelines and emerging evidence
- <u>Educate</u> families about environmental modifications

Future Directions

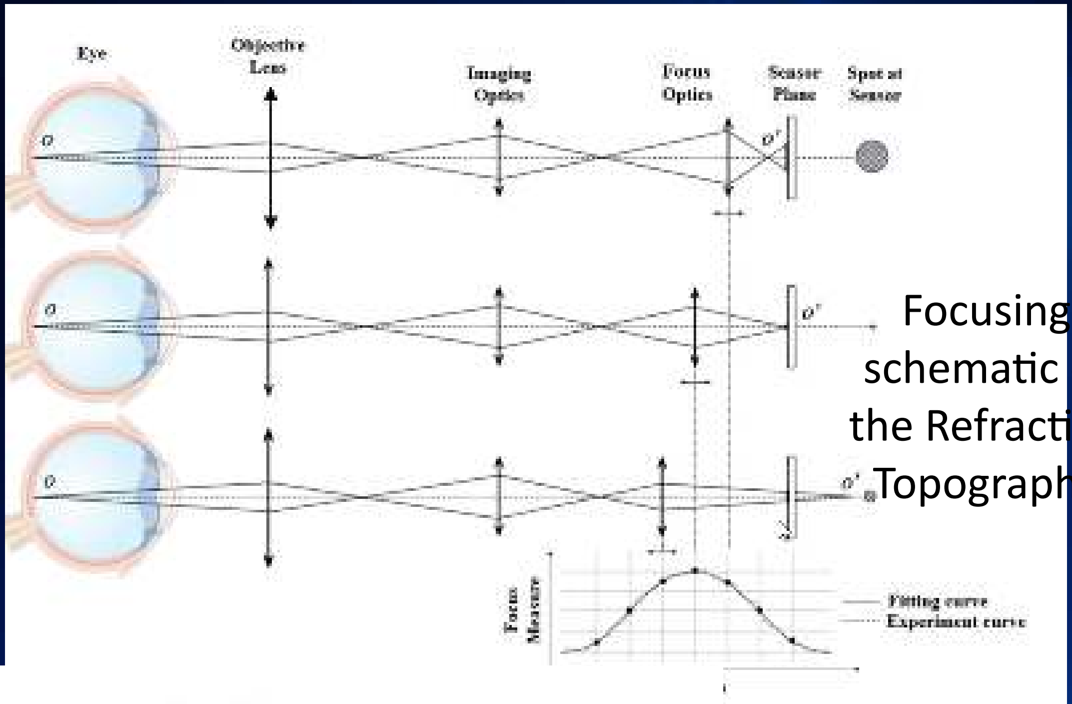
- Global collaboration for standardized protocols
- Integration of genetic risk assessment in clinical practice
- Development of targeted biologics for high-risk individuals
- Implementation science for effective prevention strategies
- Longitudinal studies on long-term outcomes of interventions
- Economic analyses to support policy changes

Progressive myopia: Exploring new technologies

A focusing method on refraction topography measurement

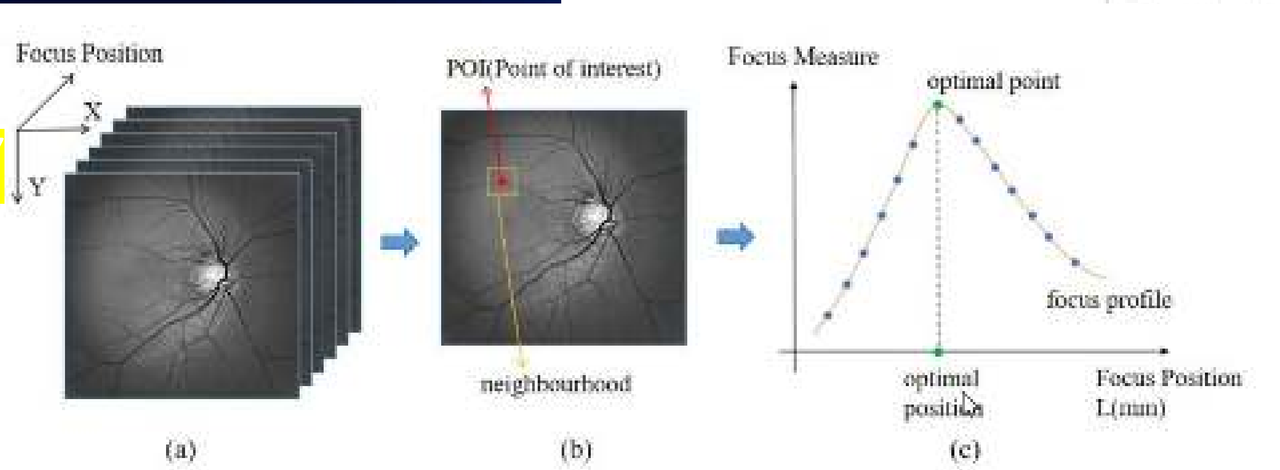
Huang Yequan[1], Guo Jingyun[2], Guo Yu[1], Cui Yan[1], Li Zhechuang[1], Dong Xuechuan[2] & Ning Xiaolin[1]

This paper introduces a novel focusing method Refraction Topography (RT) for wide-angle refraction measurement. The agreement of the test results obtained using RT is evaluated against simulation results and expected refraction. RT develops a refraction algorithm on fundus images at various focusing statuses. Unlike conventional techniques for peripheral refraction measurement, RT requires the subject to stare at a stationary fixation target. The refraction algorithm calculates the focus measure for multiple images at the Point of Interest and formulates them into a focus profile. The maximum focus measure correlates with the optimal focus position. Refraction Characterization Function (RCF) is proposed to translate the focus position into refraction determination, thus forming the refraction topography. The refraction characterization of RT optical system is performed using Isabel schematic eye. Three test eyes of −15 D, 0 D, and +15 D are defined, and expected refraction is obtained through simulation on an independent test schematic eye. Both simulation results and experimental results are obtained by combining the test eyes and RT system. Test results are compared with simulation results and expected refraction. The study demonstrates agreement among the test results, simulation results, and expected refraction on three test eyes.



Focusing schematic of the Refraction Topography

REFRACTION TOPOGRAPHY



Determination of optimal position from image stack.

Progressive myopia: Exploring new technologies

RESEARCH ARTICLE Open Access

Axial length growth difference between eyes after monocular laser refractive surgery: eight patients who underwent myopic laser ablation for both eyes at intervals of several years

Chenghai Weng[1†], Fei Xia[2,3,4†], Dang Xu[1], Xingtao Zhou[2,3,4] and Liangcheng Wu[1*]

Table 2 SE and AL in ablated eyes and nonablated eyes

	Ablated eyes	Nonablated eyes
Age (yrs)	17.63±0.52	
Follow-time (yrs)	3.79±0.80	
SE1 (D)	0.47±0.16	-0.71±0.13
Initial AL (mm)	24.52±0.96	23.73±0.91
SE increase (D)	-0.59±0.21*	-0.97±0.36*※
AL elongation (mm)	0.16±0.30	0.53±0.32*※

SE spherical equivalent, SE1 spherical equivalent at 3 month after myopic ablation in first eye, AL axial length,

* P<0.05, ※comparison between ablated eyes and nonablated eyes

Since laser refractive surgery works in a similar way to orthokeratology, producing the same corneal shape, it can be speculated that laser surgery can produce the same effects on axial elongation, that is myopic corneal ablation may help to control myopia progression BUT it is hard to prove that myopia refractive corneal ablation can control myopia progression because refractive surgery patients have more or less stable refraction.

Refractive surgery and progressive myopia: What is known

Myopia progression over a 4-year period after laser-assisted refractive surgery in patients in their 20s and 30s

Miho Sasaki[1,2] · Osamu Hieda[1,2] · Koichi Wakimasu[2] · Kiyoshi Yamamura[2] · Shigeru Kinoshita[2,3] · Chie Sotozono[1]

Received: 4 July 2019 / Accepted: 22 February 2020

No significant difference in myopia progression during a 4 year period after LASIK/EpiLASIK.

Refractive surgery and progressive myopia: What is known

- **Without axial length measurements** it is challenging to determine whether the refractive changes represent real myopic progression or post-surgical regression due to corneal alterations (and even then, few studies can be found in literature!)

Twenty-Year Follow-Up of a Randomized Prospective Clinical Trial of Excimer Laser Photorefractive Keratectomy

DAVID P.S. O'BRART, ZAID SHALCHI, ROBERT J. MCDONALD, PARUL PATEL, TIMOTHY J. ARCHER, AND JOHN MARSHALL

Slight increase in myopic SE after PRK between 1 and 20 years BUT axial length pre-operatively measured with ultrasound while post-operatively with optical biometry.

Refractive surgery and progressive myopia: …. For treatment??

RESEARCH ARTICLE

Changes in relative peripheral refraction and optical quality in Chinese myopic patients after small incision lenticule extraction surgery

Yuqin Du[1,2], Yuehua Zhou[1,2]*, Mingwei Ding[1,2], Mingxu Zhang[1,2], Yujuan Guo[1,2]

1 Eye School of Chengdu University of TCM, In eye Hospital of Chengdu University of TCM, Chengdu, China,
2 Beijing Ming Vision and Ophthalmology, Dongcheng District, Beijing, China

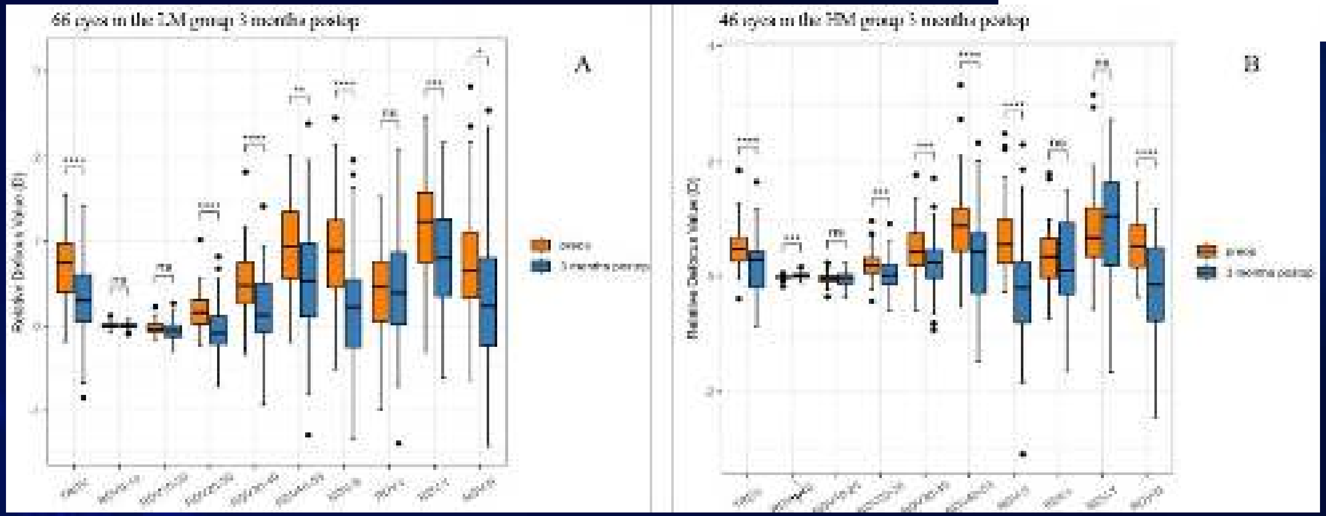
* YH06236677@163.com, 1060897890@qq.com

Purpose

To observe changes in retinal refraction difference values (RDV) and aberrations after small incision lenticule extraction (SMILE) surgery and evaluate their correlations.

Conclusions

Our findings suggest that SMILE reduces retinal peripheral hyperopic defocus but introduces some higher-order aberrations, especially in people with high myopia refractive



Reduction in peripheral defocus after SMILE surgery in both low and high myopic eyes … just like myopia control lenses and ortho-K contact lenses.

Refractive surgery and progressive myopia: What is known

- Stability is commonly defined as less than 0.50D change over 1 year (or even more), a value that some regard as far from stable, but can be vague (**stability criteria not standardized**).

- **Since refractive surgery is usually done on "stable" myopia, it is still nor clear whether the surgery has any incidence on myopia progression.**

Generative AI for Childhood Myopia-SNEC/SERI

- Education
- Triaging
- Conversational AI Chatbot

AI and DL for Myopia

- Epidemiological evidence has shown that the age of onset and rate of myopia progression in children varies considerably.
- There is a need to develop better predictive models to identify children who are most likely to progress rapidly and will therefore potentially derive most benefit from treatment.
- The absence of long term data provides little evidence as to when myopia control interventions can be stopped or modified during treatment.

Review › Curr Opin Ophthalmol. 2021 Sep 1;32(5):413-424. doi: 10.1097/ICU.0000000000000791.

Artificial intelligence in myopia: current and future trends

Li Lian Foo [1, 2], Wei Yan Ng [1, 2], Gilbert Yong San Lim [1], Tien-En Tan [1], Marcus Ang [1, 2], Daniel Shu Wei Ting [1, 2]

Affiliations + expand

PMID: 34310401 DOI: 10.1097/ICU.0000000000000791

Fundus to predict High Myopia

npj | digital medicine

www.nature.com/npjdigitalmed

ARTICLE OPEN

Deep learning system to predict the 5-year risk of high myopia using fundus imaging in children

Li Lian Foo, Gilbert Yong San Lim, Carla Lanca, Chee Wai Wong, Quan V. Hoang, Xiu Juan Zhang, Jason C. Yam, Leopold Schmetterer, Audrey Chia, Tien Yin Wong, Daniel S. W. Ting, Seang-Mei Saw and Marcus Ang

Our study aims to identify children at risk of developing high myopia for timely assessment and intervention, preventing myopia progression and complications in adulthood through the development of a deep learning system (DLS). Using a school-based cohort in Singapore comprising of 998 children (aged 6–12 years old), we train and perform primary validation of the DLS using 7456 baseline fundus images of 1878 eyes; with external validation using an independent test dataset of 821 baseline fundus images of 189 eyes together with clinical data (age, gender, race, parental myopia, and baseline spherical equivalent (SE)). We derive three distinct algorithms – image, clinical and mix (image + clinical) models to predict high myopia development (SE ≤ −6.00 diopter) during teenage years (5 years later, age 11–17). Model performance is evaluated using area under the receiver operating curve (AUC). Our image models (Primary dataset AUC 0.93–0.95; Test dataset 0.91–0.93), clinical models (Primary dataset AUC 0.90–0.97; Test dataset 0.93–0.94) and mixed (image + clinical) models (Primary dataset AUC 0.97; Test dataset 0.97–0.98) achieve clinically acceptable performance. The addition of 1 year SE progression variable has minimal impact on the DLS performance (clinical model AUC 0.98 versus 0.97 in primary dataset, 0.97 versus 0.94 in test dataset; mixed model AUC 0.99 versus 0.97 in primary dataset, 0.95 versus 0.98 in test dataset). Thus, our DLS allows prediction of the development of high myopia by teenage years amongst school-going children. This has potential utility as a clinical-decision support tool to identify "at-risk" children for early intervention.

npj Digital Medicine (2023)6:10 ; https://doi.org/10.1038/s41746-023-00752-8

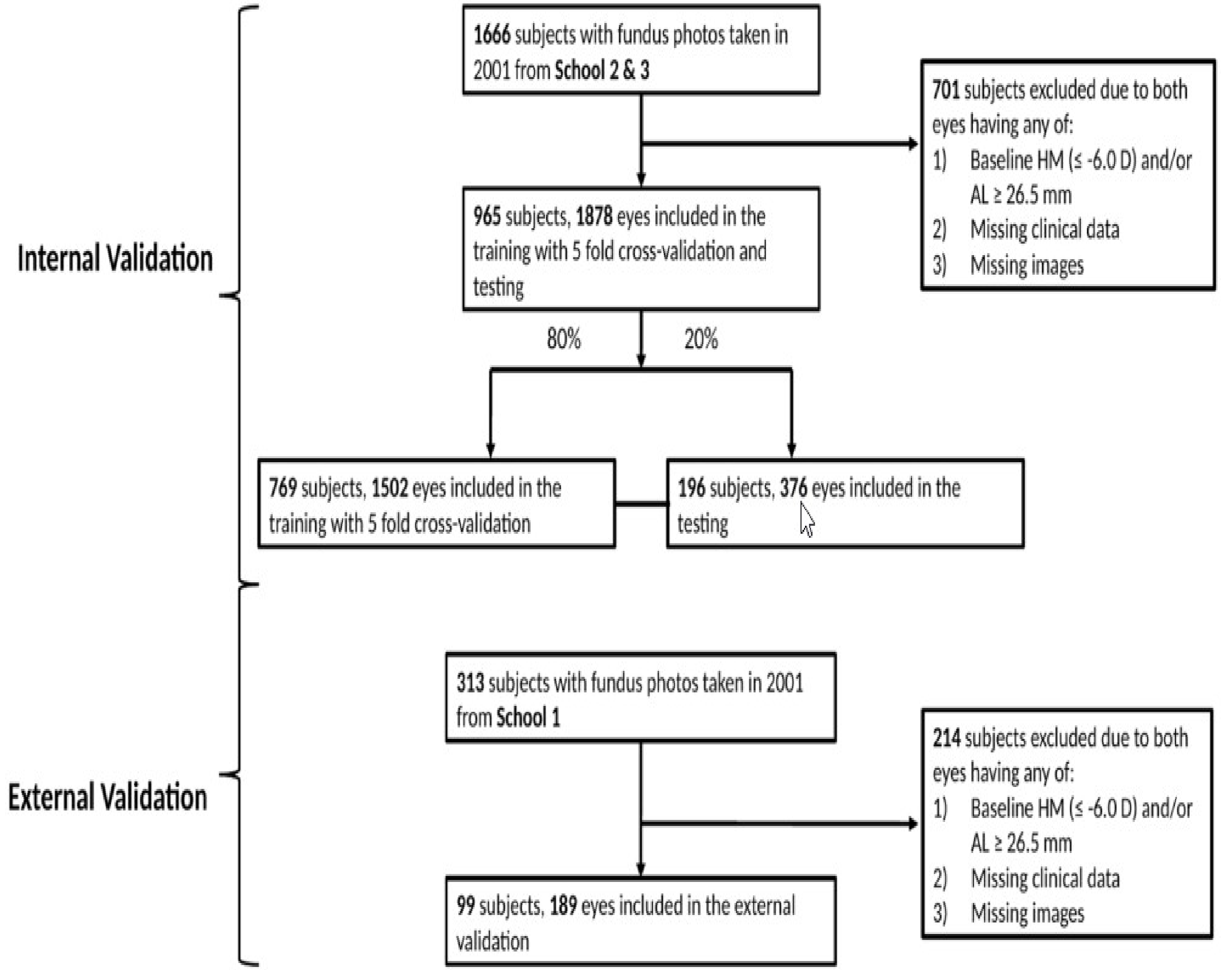


Fig. 5 Flowchart of dataset. Singapore Cohort of Risk factors for Myopia was used in Deep Learning System training/internal validation (School 2 and 3) and external validation (School 1).

Conclusion

- Myopia: From refractive error to global public health priority
- Prevention requires multi-faceted approach:
  1. Environmental modifications
  2. Optical and pharmacological interventions
  3. Public health strategies
  4. Individual risk management
- Coordinated efforts between eye care providers, researchers, public health officials, and educators essential
- Significant opportunity to reduce future burden of vision impairment globally

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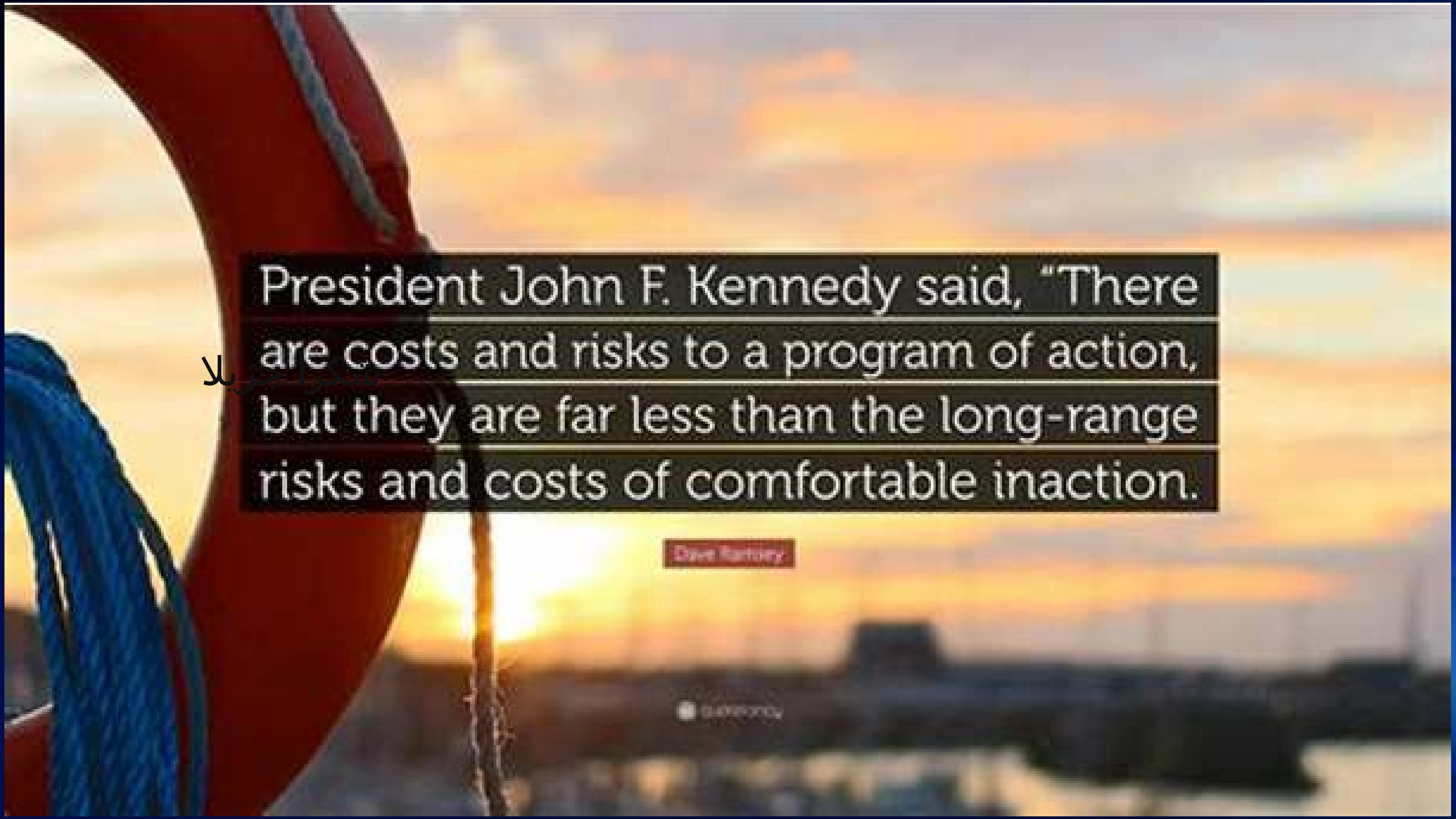

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