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Myopia, an underrated global challenge to vision: where the current data takes us on myopia control

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Abstract

Myopia is the most frequent cause of distance impairment in the world and is creating an alarming global epidemic with deleterious ramifications for the quality of life and economic health of individuals and nations as a whole. In addition to being immediately disadvantageous, myopia increases the risk of serious disorders such as myopic macular degeneration, retinal detachment, glaucoma, and cataract and is a leading cause of visual impairment and blindness across many countries. The reduction in age of onset of myopia is of great concern since the earlier the onset, the more myopic the individual will become, with all the attendant increased risks of accompanying debilitating eye conditions. The economic burden is great; both in consequences of uncorrected refractive error and also in the provision of devices for correcting visual acuity. Earlier onset of myopia increases the lifetime economic burden related to loss of productivity and independence, leading to a reduced quality of life. Recent data suggest addressing accommodation *per se* has little direct amelioration of myopia progression. Pharmacological interventions that effect changes in the sclera show promising efficacy, whereas optical interventions based on a myopic shift in the retinal image are proving to effect up to 55% reduction in the rate of progression of myopia. Early contact lens and spectacle interventions that reduce the rate of progression of myopia are able to significantly reduce the burden of myopia. These non-pharmacological interventions show profound promise in reducing the overall associated morbidity of myopia.

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Prevalence of myopia and high myopia

On the basis of world-wide prevalence of myopia, it can be estimated that over 22% of the current world population, that is, 1.5 billion people are myopic, and although myopia has often been referred to as a 'simple' refractive error, even in lower amounts it enhances the risk of serious eye disorders such as retinal detachment, cataract, and glaucoma. More urgently perhaps, high myopia is emerging as the major cause of blindness in some Asian countries. For example, myopic macular degeneration (MMD) is now the major cause of permanent monocular blindness in Japan and of new cases of blindness in Shanghai.[1,2] On a wider front affecting over 100 million children, adults and elderly people with massive socio-economic consequences, uncorrected myopia is the most frequent cause of distance visual impairment in the world.[3]

The prevalence of myopia is rising dramatically, reaching 70–80% in many East Asian countries and $\sim$25–40% in Western countries;[4–11] and high myopia (defined as greater than -6.00D) ranges from 6.8 to 38% in Asia.[8,12–15] In the United States, myopia has doubled in the last 30 years[6] and the prevalence of myopia over 8.00D has risen eightfold. In China where there are $\sim$216 million individuals in the age range of 15–24 years[16] and with a prevalence of myopia in young adults aged

15–25 years of over 75%, it is estimated that there are at least 160 million young myopes and 16 million with myopia over −6.0D. The shift to a younger onset of myopia is especially worrying as younger eyes experience more rapid progression of myopia which could lead to even greater levels of high myopia than those currently being reported.

Blindness due to myopia

The retinal abnormalities identified and associated with myopia include chorioretinal atrophy, lattice degeneration, pigmentary degeneration, lacquer cracks, posterior staphyloma, Fuch's spot, macular degeneration, retinal breaks and detachment, and posterior vitreous detachment.[17–20] These degenerative changes substantially increase the risk of loss of vision and indeed in countries where the prevalence of myopia is high, MMD has been identified as one of the leading causes of visual impairment and blindness. MMD was the most frequent cause of visual impairment and blindness in a population of elderly Chinese in Taiwan[21] and a pilot assessment of Hong Kong Chinese residents aged 40 and over found myopic choroidal degeneration to be the leading cause for impaired vision (<20/60 visual acuity).[22] Similarly, in a cross-sectional study conducted in Tajimi City, Japan, the primary cause for blindness was MMD.[1] Interestingly, even in western populations wherein the prevalence of myopia is less, MMD was frequently found to be a significant cause of visual impairment and blindness. The Copenhagen study found myopia-related retinal disorders to be the most common cause of impaired vision with MMD being the third most common cause of blindness.[23] The Rotterdam eye study[24] found that in persons younger than 75 years, myopic degeneration was the most important cause of impaired vision.[24] And in a more recently conducted, Los Angeles Latino Eye Study, myopic degeneration was the third most major cause of blindness.[25]

In addition to retinopathy, increasing levels of myopia is said to increase the risk of a number of other ocular pathologies. The association between glaucoma and myopia has been reported across multiple, large, population-based studies involving many ethnicities with the odds of developing glaucoma rising with increasing myopia. The Blue Mountains Eye Study reported an odds ratio of 2.3 for low myopia and 3.3 for moderate-to-high myopia (≥ −3.0D).[26] A systematic review of 11 population-based cross-sectional studies found the pooled odds ratio of the association between low myopia (up to −3.0D) and glaucoma to be 1.65 and for myopia > −3.0D to be 2.46.[27] As with glaucoma, the link between cataract and myopia has been reported across many studies. A meta-analysis of large, population-based studies found myopia to be associated with nuclear as well as posterior subcapsular cataracts.[28] Also, it has been reported that myopic eyes have an increase in optic disc abnormalities such as optic nerve crescents, tilted discs, and larger disc areas.[17,29]

Economic burden

For each and every individual with myopia, there are the economic or financial considerations with both uncorrected refractive error and the cost of treatment of the condition with optical devices or other refractive modalities and the need for frequent and long-term management of the condition by the eye-care practitioner. The earlier the onset of myopia, the greater is this burden extending over many years and possibly over the lifetime of the individual. The long-term management not only includes the need to monitor the eye for any refractive error change but to also monitor the eye for risks associated with high levels of myopia. At a stage where myopia progresses and is categorised to be high myopia, additional economic and health burdens are imposed due to more frequent visits and complex corrective strategies. In addition, in highly myopic eyes, even in the absence of retinal pathology or degeneration, visual performance is frequently found to be reduced and imposes a burden not dissimilar to those seen in eyes with significant visual impairment resulting in loss of productivity, quality of life, and independence.

Even without obvious retinal pathology, and in spite of attempts to fully correct the condition, the quality of vision as indicated by best-corrected visual acuity is compromised in highly myopic eyes. One reason for reduced vision is spectacle minification resulting in loss of resolution. Other reports have proposed that increased eye length contributing to retinal stretching and spacing of the cone mosaic, morphologic changes in the photoreceptor outer segment,[30–32] and decreased subfoveal choroidal thickness delivering less oxygen and nutrients to outer retina may have a role.[33] Also, it was reported that there appeared to be a correlation between degree of myopia at age 14 and subsequent visual loss.[34]

Clearly either loss of functional vision associated with uncorrected refractive error or permanent vision loss significantly affect all aspects of the individual's life. And at a stage where myopia causes significant visual impairment and blindness, the constraints experienced by affected individuals are likely to be different to those with functional vision, and is likely to further limit their choices in life and pose additional monetary and physical burden.[35] In addition to direct costs, there are a significant burdens imposed due to the decrease in productivity, loss of quality of life, and independence among those affected that translates to a significant health and socio-economic burden for the society.

Given the evidence that the number of eyes destined to become highly myopic is increasing along with the substantial burdens associated with the condition, the need to reduce the number of eyes becoming highly myopic is urgent.

Current data on myopia control and where it takes us

Pharmacological, environmental, and optical interventions have been used to try to slow the progress of myopia. Often these have been aimed at controlling accommodative responses, however, accommodation appears to have a very minor role, if any, in the induction of myopia.

Recent evidence suggests that atropine, a most effective pharmacological agent, slows the progress of myopia through non-accommodative mechanisms, acting directly on receptors in the sclera.[36] More recently the pharmacological agent, 7-methylxanthine (7MX), has been reported to be able to reduce the rate of progress of myopia in compliant children by 66% with a daily 400 mg capsule and is said to act by causing scleral collagen thickening and proliferation without side effects.[37]

Optical intervention

A most promising method of myopia control is the animal and human optical intervention clinical trials based on creating a myopic shift in the retinal image in the peripheral retina that slows the development and progress of myopia. Many forms of optical intervention, sometimes combined with temporary reductions in myopia due to altering corneal shape such as with orthokeratology, are aimed at slowing myopia by reducing relative peripheral hyperopia. Such a simple, non-invasive intervention that acts merely by changing the image profile provides a ‘natural’ stimulus which seems not to create rebound effects unlike pharmacological agents that act directly on tissue systems. These optical strategies appear to slow the progression of myopia by ~30–55% and without adverse effects.[38–42] It has been suggested that reducing the progression of myopia by as little as 33% would reduce the number of highly myopic eyes (> −5.00 D) by as many as 75%.[43] Data from a longer term clinical study, involving the use of contact lenses to reduce the hyperopic defocus at the peripheral retina, showed that the ability of these lenses to slow the progression of myopia was a consistent 40% per year over the study period of 43 months.[44]

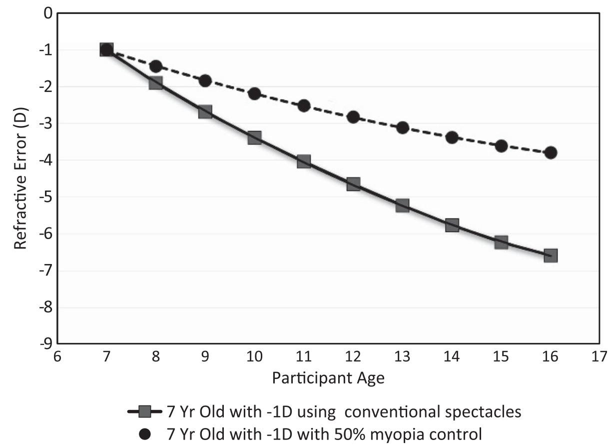

Figure 1 Myopia progression for a 7-year-old child with conventional correction based on experimental data and progress with a myopia control contact lens that slows the rate of myopia increase by 50% per year.

Summary

One new therapeutic preparation (7MX) is interesting, although it needs a long-term clinical trial concentrating on efficacy over time and possible side effects. Orthokeratolgy has been shown to produce an average reduction in the rate of progress of myopia of 30% by inducing a flat-centre, steeper periphery hyperopia-reducing corneal shape in a 5-year study with a decreased effect during the fourth and fifth year. Optical intervention with strategies focussed on reducing peripheral hyperopia, has proven in its many forms from executive bifocal spectacles to peripheral plus soft contact lenses, to be capable of 30–55% reductions in the rate of progress of myopia and in one study with a consistent reduction of ~40% each year over 3.5 years.

If the rate of increase of myopia could be consistently reduced by 50% per year, then using the Sankaridurg and Holden evidence-based model for rate of myopia increase for an Asian population (see publication by Sankaridurg and Holden in the same issue), as shown in Figure 1, the effect on high myopia prevalence and its associated morbidity could be profound. Clearly one way forward is the large-scale implementation of optical intervention strategies that create an effective myopia-controlling relative image profile. The refinement, adoption, and widespread use of contact lens, spectacle-based and selective pharmacological myopia control strategies could have massive beneficial outcomes for hundreds of millions of future myopes.

Conflict of interest

The authors have patents on myopia control strategies.

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