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How to effectively manage myopia

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Abstract:

Myopia has become epidemic in the world. Without effective control, the progression may lead to excessive myopia with severe complications affecting vision and ocular alignment. The genetic factors and environmental factors of myopia are closely interrelated to each other. Asian ethnicity and parental myopia, among other genetic factors, influence the refractive outcome dramatically when environmental risk factors such as hours of near work and reading distance are analyzed. Outdoor activities are protective measures that retard myopia progression. Total time under the sun and not the specific outdoor activities are contributing factors. Current effective treatments for myopia include atropine of high, moderate, and low doses, relative peripheral myopia-inducing devices, and bifocal spectacles including prism bifocal spectacle lenses. Although atropine is considered highly effective in randomized controlled trials, it is not well tolerated in a clinical setting, especially in high dosage. Since the severity of rebound effect of atropine after cessation of usage and the side effects are directly related to the concentration of the medication, it is recommended that low-dose atropine is used in the initial attempt. Higher concentration for better control can be considered when compliance is observed. Devices that induce relative peripheral myopia such as orthokeratology are moderately effective interventions that are well accepted by children who wish to be spectacle free. Bifocal spectacles generally have low effect in myopia control. Prism bifocal spectacle lenses may have a special niche in myopia retardation for patients with low lags of accommodation.

Keywords:

Atropine, myopia, near work, orthokeratology, outdoor activities

Introduction

Myopia is one of the most common Ophthalmological diseases in the world. The prevalence has almost doubled worldwide within the past two decades, and the age of onset is decreasing at an alarming rate.^[1,2] It is well known that the younger a patient acquires myopia, the faster the progression is. In some patients, the progression can be unrelenting, leading to excessive myopia and inevitable consequences such as retinal detachment, macular hemorrhage and scarring, glaucoma, and myopic strabismus fixus. In Asia, myopia maculopathy has become one of the leading causes of low vision.^[3] Myopic strabismus fixus, a disfiguring condition that is irresponsive to traditional strabismus surgery, is directly related to the extent of

axial length elongation and the severity of refractive error.^[4] With the advent of electronic era and early education, extended near work is started at early childhood. Without effective myopia control and preventive measures, excessive myopia and its vision-impairing consequences are expected to affect more patients in the near future.

Inciting Factors of Myopia

The formation and progression of myopia are multifactorial. It is suggested that genetic and environmental influences have intricate interrelation and each category of factors should not be discussed alone.^[5]

Ethnicity

In Asia-Pacific region, depending on the age group of the studies, the ratio of myopic prevalence between European Caucasians and Asians ranges from 1:3 to 1:8.^[5,6]

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However, Asians tend to have far less outdoor activities than Caucasians and spend more time performing near works.^[6] Moreover, in a population-based eye study in Germany, the discrepancy among the different ethnicity was not observed.^[7]

Parental myopia

Parental myopia not only increases the incidence of myopia but also plays a significant role in the progression in myopia. In the age group of 6–14 years, the incidence of myopia in those with both myopic parents is nearly six times those with none or one myopic parent.^[8] The progression of myopia is much faster if both parents are myopic, especially if both parents are highly myopic. In Singapore, the annual myopic progression doubles if both parents are highly myopic ($< -6.0D$).^[9]

Refractive errors at age 6 years

According to Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error, cycloplegic refraction at the age of 6 years can be a predictive measure of possible myopia in later school years. Preventive measures should be suggested to the parents should the child's cycloplegic refraction fall below $+ 0.75D$ any time before the age of 6 years.^[8,10]

Duration of reading/near tasks

Disregard of ethnicity and parental influence, near work is an independent cause of myopia. The duration is more of a determining factor than the total time of near tasks.^[11] In 12-year-old Australian school children, significant differences in refraction are observed when the duration of continuous reading is taken into consideration.^[11] The difference becomes evident after 16 min of continuous reading.

Seven to nine-year-old Singaporean children become significantly more myopic when reading more than two books per week. This difference is accentuated when both parents are myopic.^[12]

Near-work distance

Aside from the duration of near work, the distance also plays a significant role in myopia. Reading or performing near tasks closer than 30 cm is associated with significant myopia, especially when one or both parents are myopic. This holds true even after the data are adjusted for age, sex, ethnicity, and school type.^[11]

Lack of outdoor activities

Children of any ethnicity are more prone to become less hyperopic or more myopic when less time is spent outdoors.^[6,13] While the refraction in children with no myopic parent is not related to the hours spent outside, that in those with myopic parents is significantly related to the outdoor hours.^[6] This perhaps could provide

myopic parents with some incentives to maximize their outdoor time spent with their children. The refractive status is related to outdoor hours in bright light condition rather than specific physical activities.^[14] Once it is adjusted to the outdoor activity time, near-work hours and activities become insignificant factors for myopia.^[13]

Relative Peripheral hyperopia

Animal studies show that postnatal visual stimulation determines the refraction, and the control is at the level of retina and central nervous system. The responsible area for the refractive outcome is the nonfoveal areas instead of the fovea. Hyperopic defocus beyond 10° of fovea can result in myopia.^[15] In human, relative peripheral myopia is found in hyperopic and emmetropic patients, and relative peripheral hyperopia is observed in myopic patients. Hyperopic peripheral refraction becomes evident as early as 2 years before the onset of myopia.^[16] Relative peripheral hyperopia is now considered as a risk factor for myopia formation and progression.

Treatment for Myopia

According to the meta-analysis conducted by Huang *et al.*, effective interventions for myopia include atropine eye drops of high, moderate, and low dose, pirenzepine, cyclopentolate, peripheral defocus modifying contact lenses, peripheral defocus modifying spectacle lenses, orthokeratology, progressive addition spectacle lens, prism bifocal spectacle lenses, bifocal spectacle lenses, and more outdoor activities.^[17] In the setting of randomized controlled trial, atropine is the only treatment that manifests strong effect. Interventions that alter relative peripheral refraction tend to achieve moderate effect. Bifocal spectacles and outdoor time tend to provide low myopia control effect.^[17]

Thoughts on atropine

The effect of atropine eye drop has always been validated in clinical trials. It is by far the most effective treatment for myopia, and its effect correlates with the concentration of the medication. In Atropine for the Treatment of Myopia 1 (ATOM-1), atropine with 1% concentration retarded 0.92D of myopia progression within 2 years.^[18] In ATOM-2, 0.5%, 0.1%, and 0.01% atropine retarded 0.30D, 0.38D, and 0.49D, respectively, within 2 years.^[19] However, compliance with atropine has always been an issue in clinical setting due to its side effects such as photophobia, blurred vision, loss of accommodation, and possible solar damage to the lens and retina. A downside of atropine less known to the patients is the rebound effect after cessation of the medication. In ATOM-1 phase 2, there was a 1.14D of myopia progression 1 year after 1% atropine was stopped.^[20] Similarly, there was a 0.87D, 0.68D, and 0.28D myopia progression 1 year after 0.5%, 0.1%, and 0.01% atropine, respectively, was

stopped.^[21] The rebound effects are directly related to the concentration of atropine. At the end of 3 years of study, patients in 1% atropine group had the most myopic progression, whereas those in 0.01% atropine group had the least. It is not clear if the rate of rebound would have continued into the 4th year since ATOM-2 patients received 0.01% atropine after 1 year of cessation.^[22] Even though the mean final refractive error in patients receiving 1% atropine was still less than the placebo group at the end of the 3-year study,^[21] one may predict that if myopic progression continues at the same rate as that of the 3rd year, the final refractive error may eventually exceed that of the placebo group.

In real life, a great proportion of patients are noncompliant with atropine. Rebound effect is a common observation in the clinical setting. Hence, atropine may not be beneficial for those who choose not to continue with the treatment. Information about the side effects and rebound effect should be fully discussed with the patients and the parents before the treatment is initiated.

What dosage of atropine should be used? Since the effect of myopia control is observed in concentration as low as 0.01%, it may be sufficient to use 0.01% concentration as the initial dose of treatment. Higher compliance is expected since there are fewer side effects associated with a lower dosage. If there is inadequate myopia control and the patient is proven to be compliant, a higher concentration can be considered.

Interventions related to altering peripheral refraction

Clinically, human eyes respond with peripheral myopic defocus with retardation of axial length growth. This is evident with clinical trials on daytime-use peripheral defocus modifying devices and night-wear orthokeratology.^[17] High cost and risks of infection may be of concern with contact lenses. It is not clear whether there is similar rebound effect after cessation of wear, but the condition of being spectacle free is an additional incentive for patients to be compliant.

Prism bifocal spectacle lenses

Prism bifocal spectacle lenses are bifocal spectacles with 3-Δ base-in prism in near addition of + 1.50D. With this device, the effort for convergence and accommodation during near work can be attenuated. It appears to work best for myopic children with low lags of accommodation. In these patients, 0.99D/year of myopia retardation as compared with control was observed.^[23]

Conclusion

Parental myopia may be both hereditary and environmental cause for myopia. Children with myopic parents tend to

spend less time outdoors and perform more near tasks. However, myopia progression can be significantly decreased if children with both myopic parents spend more time outside. Longer total hours under the sun are protective measures, and the short distance for near work and the duration for reading are worsening factors for myopia. While atropine is a strongly effective treatment for myopia in randomized control trials, it is not well tolerated in clinical setting due to its prominent side effects, especially with high dosage. Rebound effect may mitigate and even reverse its myopia control effect. Low-dose atropine is perhaps more well accepted and has proven to be highly effective in myopia control. Peripheral refraction altering products such as orthokeratology are effective options for myopic patients both in retardation of myopia and elimination of spectacles.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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