Review Article

Myopia: Can Its Progression Be Controlled?

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ABSTRACT

Myopia is considered to be a leading cause of visual impairment. Furthermore, the prevalence of myopia in young adolescents has increased substantially over the past few decades. Although myopia was identified more than two thousand years ago, a consistently effective approach to myopia control for all patients still eludes clinicians.

Among all the treatments mentioned in this review, the most promising ones are muscarinic receptor antagonists, including atropine and pirenzepine. Bifocal and progressive lenses can be effective in the control of myopia and have greater effectiveness for subjects with nearpoint esophoria and a high lag of accommodation. The treatment outcomes of gas permeable contact lenses have been confirmed to be effective but with questionable overall clinical effect. Other treatments including the under correction of myopia have been shown to be ineffective while traditional Chinese interventions for myopia prevention need further study to access their efficacy.

KEY WORDS
myopia, near work, esophoria, accommodation, muscarinic receptor antagonists, progressive lenses

Myopia is considered to be a leading cause of visual impairment with those having a high magnitude of myopia being susceptible to a range of potentially serious ocular pathologies.1 The prevalence of myopia in young adolescence has increased substantially over the past few decades affecting 25% of the adult population in the United States and 70-90% in various Asian countries.1,2 The mechanism of development and the treatment of myopia has been a major research topic for decades.

Despite the heritability of high magnitude myopia, environmental factors including the level of education, urbanization, and intensity of near work play an important role in the development of mild and moderate myopia.3 There are several theories about the mechanisms of myopia development. Given the clear association between myopia and near work, excessive accommodation has been proposed to be the cause of myopia.4 Recent animal studies suggest myopia can be caused by hyperopic and myopic retinal defocus,5,6 high lag of accommodation,7 and near-work induced transient myopia.8,9 Chemicals such as dopamine, various growth factors, and muscarinic antagonists are proposed to be involved in the local retinal effects and resultant scleral growth.10-12

Although myopia was identified by Aristotle more than 2300 years ago, an effective therapy for all patients still eludes clinicians. Several treatments towards slowing myopia progression have been suggested by recent animal studies. The outcomes from research with humans are not quite as straightforward because of the difficulties associated with isolating specific environmental variables. This review summarized the
effects and potential adverse side effects of current treatments aimed at slowing down myopia progression.

**Bifocal and progressive addition spectacle lenses**

The rationale for using positive lens additions in myopia control is to optimize accommodative accuracy for near tasks and minimize the retinal blur. Despite the clear effect of positive lens additions in animal studies, the results of clinical trials are inconsistent. Goss examined longitudinal records from three optometry practices, comparing 52 subjects with single vision lenses (SVL) to 60 subjects with bifocal lenses. He reported that esophores wearing bifocals had lower progression rates than those wearing SVL (-0.32 diopters (D) vs. -0.54 D), and exophores wearing bifocals had similar progression rates as those wearing SVL (-0.45 vs. -0.43). No effect on myopic progression was noted in other randomized clinical trials where the nearpoint phoria was not taken into consideration. Another study by Goss confirmed that bifocal wearers with nearpoint esophoria had progression rates of only -0.33 D/year compared with -0.59 D/year for those of age-matched children who wore single vision lenses. Full study 82 myopic children with esophoria at near and reported that myopia progression averaged -0.99 D for bifocals and -1.24 D for SVL over 30 months. Those studies suggest that the effectiveness of bifocals in slowing myopia progression may depend on the nearpoint phoria. Bifocals seem to slow the myopia progression in children with nearpoint esophoria, but not necessarily in children with exophoria.

Progressive addition lenses (PAL) are often more cosmetically acceptable than bifocal lenses. Furthermore, children may not always use the lower segment of the bifocal for reading. Thus, several clinical trials with PALs have been conducted. Leung and Brown examined 32 Chinese children (9 to 12 years old) with SVL and 36 children with PAL. They reported that the rates of myopia progression over 2 years in PAL and SVL groups were -0.76 D and -1.23 D respectively with statistical significance. Another masked and randomized study with 254 Chinese myopic children (7 to 9 years old) by Edwards and Lam noted less of a difference between PAL and SVL groups (-1.12 D vs. -1.26 D over 2 year) (not statistically significant). They found that PALs had a greater preventative effect on those with myopia and esophoria at near (-0.89 D in PAL vs. -1.26 D in SVL) (not statistically significant). Edwards suggested that age differences in myopic children may partially explain the different findings between the two studies. The Correction of Myopia Evaluation Trial (COMET) was a multi-center randomized clinical trial, involving 469 ethnically diversified subjects. This study found that mean three-year increases in myopia were -1.28 D in the PAL group and -1.48 in the SVL group, which was statistically significant. The mean myopic progression in the PAL group with nearpoint esophoria was -1.18 D compared to -1.39 D in SVL group. Children with nearpoint exophoria had a myopia increase of -1.43 D in PAL group and -1.38 D in SVL group, which was consistent with other similar studies. In summary, clinical trials indicate that bifocal and progressive lenses can be effective in control of myopia and show greater effectiveness for subjects with nearpoint esophoria.

**Muscarinic receptor antagonists: atropine and pirenzepine eye drops**

The use of muscarinic antagonists has been based on the hypothesis that excessive accommodation leads to increases in myopia. Other mechanisms have been reported, including retardation of axial length elongation by affecting release of dopamine neurotransmitter and synthesis of glycosaminoglycan in the sclera. The slowing of myopia progression has been observed with atropine instillation even in high myopes (-10 to -12D), however, some of the studies were retrospective and/or had an insufficient sample size. Recently, Shih and Lin conducted a double-masked randomized clinical trial involving 227 Chinese children aged 6 to 13 years. The mean progression of myopia in the atropine with PAL group (-0.41 D) was significantly less than the PAL only group (-1.19 D) and SVL only group (-1.40 D) at the end of the 18 months follow-up period. No progression of myopia (less than 0.25 D/year) was shown in 57.6% of the children receiving 0.5% atropine vs. 4.9% in SVL group. The elongation of axial length was 0.22 mm in atropine group and 0.59 mm in SVL group.

The side effects of atropine have been frequently reported and include: mydriasis, photophobia, blurred vision, and allergic dermatitis, as well as other significant systemic effects. Thus an M1 specific muscarinic antagonist, pirenzepine, was tested both in the United States and several Asian countries. The Asian Pirenzepine Study with 353 myopic children aged 6 to 12 years showed that the rate of myopia progression was -0.47 D/year with pirenzepine (2% Gel twice a day) and -0.84 D/year in the control group. The increase in axial length was 0.20 mm/year in pirenzepine vs. 0.33 mm/year in control group. The United States Pirenzepine Study with 174 children, aged from 8 to 12 years (mixed ethnicity/73% were Caucasian), found that the mean increase in myopia was -0.26 D/year in the pirenzepine group vs. -0.53 D/year in the control group. There was a mean increase in axial length of 0.19 mm/year in the pirenzepine group and 0.23 mm/year in the control group with no statistical significance. Both studies
reported that pirenzepine had innocuous side effects compared to atropine. The efficacy of pirenzepine was greater than that reported by the use of PALs, but less than the use of atropine. This may be due to the fact that subjects in these studies were not allowed to wear bifocals or progressive lenses. A continuing second year controlled evaluation of pirenzepine now being conducted by the US Pirenzepine Study Group will provide further evidence of the efficacy of pirenzepine in myopia prevention.

Contact lenses

Soft contact lenses do not appear to affect myopia progression compared to spectacle correction. The treatment outcomes of using gas permeable (GP) contact lens are somewhat mixed. Perrigin reported that the mean increase in myopia for 56 GP-wearing myopes from 8 to 13 years of age was -0.48 D as compared with -1.53 D for spectacle wearers after three years of follow-up. Although the age and initial refractive error in the two groups were matched, this study had problems of high rates of loss to follow-up and was not a randomized design. Since myopia progression slows down as age increases, the high loss rate in young children from the GP group but not the spectacle group, may lead to the false impression that GPs significantly slow the myopic progression. A recent randomized clinical trial with 428 Chinese children by Katz and Chew show that there was no significant difference in myopia progression between GP wearers and spectacle wearers. The mean increase of myopia was -1.33 D and -1.28 D, and axial length increased by 0.84 and 0.79 mm over 2 years in GP and spectacles wearers, respectively. This trial however had a low retention rate (only 37.5% of the GP wearers and 67.8% of the spectacle wearers remained at the end of 2 year study). The latest randomized study (Contact Lens and Myopia Progression Study; CLAMP) with 84.5% Causation subjects used a better design to reduce the drawbacks of previous studies. The mean myopic increase was -1.56 D for 59 GP wearers and -2.19 D for 57 soft contact lenses wearers after a 3 year follow-up (statistically significant). The axial growth of the eyes was not significantly different between the two groups, indicating that the decreased myopia progression by GPs was likely due to corneal flattening instead of the slowing axial growth. Based on results from recent randomized clinical trials, the effects of GPs on myopia prevention are small and may have no significant clinical implications.

Undercorrection of distance spectacles

Myopia is proposed as an adaptive response to the accommodative demand during near work. It has been suggested that myopia correction by minus lenses requires subjects to accommodate for the near demand and leads to hyperopic retinal defocus. This would then stimulate the compensative ocular elongation. This theory is supported by animal studies which show that the increase in axial length can be inhibited by plus lens. In a human study, Tokoro found that the mean change in myopia is significantly reduced in the under corrected group as compared to the fully corrected group. However, this study did not match subjects for age and had a very small sample size. Recently Chung and O’Leary carried out a single masked randomized clinical trial with 94 myopes aged 9-14 years. Forty seven myopes were under corrected by +0.75 D while 47 subjects were fully corrected. At the end of the 24 month period, the mean progression in the under corrected group was -1.00 D versus -0.77 D in fully corrected group. A greater axial length elongation was also found in the under corrected group. This study indicated that under correction of distance spectacles enhances rather than prevents myopia progression. Hung and Ciuffreda explained this new finding using their proposed Incremental Retinal-Defocus theory. They stated that with myopia under correction focusing from far-to-near results in reduction of retinal image defocus, which decreases the rate of retinal neuromodulator release. This in turn decreases the rate of proteoglycan synthesis and adversely affects scleral structural integrity, resulting in axial elongation.

Traditional Chinese interventions

China, one of several countries with high rates of myopia, has a myopia prevalence of 20.23% in primary school, 48.18% in middle school, 71.29% in high school, and 73.01% of college students (reported by the Chinese National Teaching Institute). A great deal of time and effort has been utilized to study myopic progression. Many traditional Chinese interventions have been tried in China and other countries. These include Chinese eye excises, acupuncture, Qi-gong ocular exercises, electrophotomagnitostimulation, and eye massage. Those interventions are based on the theory of Jing-Luo. Jing represents channels which connect the interior and the exterior as well as the upper and lower parts of the human body. Luo represents the collaterals which connect these channels and are distributed all over the body surface. Acupuncture, as well as several other interventions, have claimed to influence circulation of blood and Qi, reduce eyestrain, and improve the neural nutrition of the eyes leading to prevention of myopia. Although the Chinese believe these therapies are effective, there has been little scientific support.
Chinese eye excises originally created by the Jing-Luo school of acupuncture approximately 4000 years ago are a part of the school routine and are regularly performed by Chinese children 5 to 15 years of age. It is a massage and pressure exercise on selected acupuncture pressure points around the eye. A pilot study with 10 subjects found that the Chinese eye excises did not have any effect on accommodation or critical flicker fusion. Shih reported that Qi-Qong ocular exercise, another popular Chinese myopia intervention, improved accommodative amplitude and accelerated the accommodative response, however, this study had only 17 subjects. Shakola used acupuncture and electrophotomagnitostimulation to treat 98 patients, 5 to 45 years, and reported a decreased myopic progression for 91.5% of the subjects. Since this was an abstract and there was no further report, the details of the study were unavailable. In summary, although traditional Chinese methods of intervention have been available for thousands years and are generally believed by the Chinese to be effective for the control of myopia, further studies and clinical trials are needed to demonstrate the efficacy of these forms of treatment.

Summary

Despite extensive research efforts in the area of myopia prevention/progression control, a consistently effective treatment for all patients has still not been firmly established. Researchers would prefer to have large scale, high quality, masked, and randomized, double blind clinical trials to assess the efficacy of any treatment. Although the research community is investigating all aspects of myopia development and its progression, many questions remain unanswered.

At this time we recommend that patients prone towards myopia development should use an appropriate near working distance (Harmon distance), adequate lighting, and take frequent breaks from demanding nearpoint tasks. Among all the approaches mentioned in this review, some of the most promising ones appear to be the use of muscarinic receptor antagonists (such as atropine and pirenzepine). Further studies about the efficacy and side effects of using pharmaceuticals will provide additional evidence for clinical treatments. Bifocal and progressive lenses have been shown to be effective in control of myopia and have a greater effectiveness for subjects with nearpoint esophoria. The treatment outcomes of gas permeable contact lenses have been confirmed to be effective but with little clinical implication. Other treatments including the under correction of myopia appear to be ineffective while traditional Chinese interventions for myopia prevention need further study to access their efficacy. We suggest that in order to slow myopic progression, clinicians should consider the following:

1. Fully correct all myopia present.
2. Consider using pharmacological intervention (atropine and pirenzepine) in conjunction with progressive multifocal lenses.
3. Use progressive multifocal lenses for those individuals with esophoria/and or a high lag of accommodation at near.

It is time for optometrists to use all the resources available to decrease myopic progression by using those mechanisms most suitable for the individual patients we diagnose and treat. All too often eye and vision care professionals do not use these appropriate therapies either because they choose to ignore their existence or have not kept up to date on the very latest approaches to vision care in this area. We can reduce the impact myopia has on the child and later the adult, if we treat it now.

REFERENCES