Review Article

Updates on Optical Strategies of Myopia Control

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ABSTRACT

Myopia has become a pandemic disease in the past few years and its sight-threatening consequences associated with high myopia have been a challenging issue for most public health societies. Controlling myopia progression has also become a global concern for many people particularly, parents of myopic children. Accordingly, a large body of work has been devoted to considering different optical and non-optical methods to prevent or retard myopia progression. Different optical strategies such as sunder correction, monofocal spectacles or contact lenses, bifocal or progressive spectacle lenses, multifocal contact lenses, gas-permeable (GP) contact lenses, and orthokeratology (ortho-K) have been proposed to slow down the myopia progression. Although the effectiveness of these treatment strategies has been vastly studied, there are some debates concerning the most efficient method in controlling myopia progression. The present study reviewed the current optical therapies to control the progression of myopia. A literature review revealed that optical strategies, such as myopic under correction, monofocal spectacles or contact lenses, GP contact lenses, and bifocal and multifocal spectacle lenses did not provide a clinically significant reduction in myopia progression. In contrast, ortho-K and newly introduced multifocal soft contact lenses may significantly slow myopia progression.

Keywords:

Myopia control; Myopia progression; Orthokeratology (ortho-K); Multifocal spectacle lenses; Multifocal contact lenses

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1. Introduction

Myopia is one of the most common ophthalmic disorders around the world and its global incidence is increasing dramatically. It has been predicted that almost 50% of the world's population will be myopic by 2050 [1]. Higher degrees of myopia (especially over -6.00 D) are associated with an increased risk of sight-threatening ocular pathologies, such as glaucoma, cataract, and retinal detachments (RD) [2, 3]. It was shown that the risk of retinal detachments in patients with myopias greater than -6.00 Dwas 20 times higher than in normal individuals [4]. Therefore, clinicians need to understand the risk factors of myopic and control their progression. A literature review shows that the crucial risk factors of myopia progression are age, parental refractive status, near visual tasks, ethnicity, ocular biometric properties, and accommodative and binocular vision status. These factors are briefly discussed after the method section.

2. Materials and Methods

In this review article, PubMed, Science Direct, and Google Scholar search engines were searched for articles using search keywords, including "myopia control", "myopia progression", "orthokeratology", "multifocal spectacle lenses" and "multifocal contact lenses". The papers published from 2005 to June 2021 included at least one of the keywords and were relevant to the subject of this review study. More emphasis was placed on recently published articles. The selected articles and valid scientific evidence were collected, classified, evaluated, and finally summarized.

Age

The myopia age of onset is one of the critical risk factors for myopia to reach higher levels in adulthood. The younger the age of onset of myopia in children, the longer it will take for myopia to develop, and therefore myopia will be high at the end of childhood and adolescence. Children in pre-school age (between 4 and 7 years old) are more likely to have high myopia [5]. Preschool children with myopia more than -1.25 D are at risk of faster progression than myopic children at older ages [6]. Other studies have also shown that myopia progression is faster in those children with myopia incidence before school ages [7]. The rate of myopia progression after its onset is a vital factor in developing high myopia. If the progression rate of myopia is high in early childhood and the earlier years after the onset of myopia, the likelihood of high myopia in adulthood is remarkable. Thereby, after the onset of myopia, it is highly essential to control the myopic progression rate in children [8]. Previous studies have shown that the earlier the age of initiating myopia treatment, the lower the risk of developing higher levels of myopia at older ages [9]. Further studies are undergoing to investigate the effect of myopia therapy in young children recognized to be at risk of myopia.

Parental refractive status

The parental refractive status can be a precipitating factor in developing various degrees of myopia in children [10-12]. Previous studies showed that in children with one or both parents having high myopia, the myopia age of onset and its progression rate increases [13].

Prolonged near visual tasks

The load of the child's visual activities, especially at near (40 cm) is an environmental factor affecting the onset and progression of myopia in children [14]. It has been shown that appropriate visual habits, such as reading at very close distances and without breaks have a more significant effect on the severity of myopia than total time spent on near visual tasks. Although near activities can also cause and increase the rate of myopia progression at older ages, its effect is more remarkable in children under 6 years old [14, 15]. In contrast, a study by Jones-Jordan et al., on 1318 myopic and emmetropic children revealed no significant difference in near visual activities between the two groups of participants [16]. Further support was given by Lu et al., which more generally asserted that there may be no relationship between near visual activities and myopia development and progression [17]. The amount of indoor activities, independent of the type of activity performed, is another risk factor for myopia progression. A review of the literature shows that spending more time in an outdoor environment can reduce myopia development in children [5, 18]. A study conducted in Taiwan found that children who spend outdoors for 11 hours or more per week are 54% less likely to have myopia progression compared to subjects with less outdoor activity [19]. This could be due to increased bright light perception, raised vitamin D uptake, decreased close work, increased physical activity, the various color spectrum of sunlight, and higher spatial frequencies in the outdoor environment [20].

Ocular biometric properties

Biometric properties of the eye can also be effective in the development and progression rate of myopia [21]. Previous studies showed that the eyes with longer axial length and thinner crystalline lenses were more prone to myopia (known as pre-myopic eyes) [21].

Ethnicity

Ethnicity also affects the prevalence and progression rate of myopia. It has been reported that the prevalence of myopia in the East Asian population is approximately 80% which is remarkably higher than its prevalence in the Caucasian population [22]. In contrast, less than 10% of myopia prevalence has been reported in the African population [1]. According to a study by Donovan et al., the progression rate of myopia is slower in European children than in Asian children (0.55 D/y versus 0.82 D/y; the average age of 9.3 years) [23].

Accommodative and binocular vision status

Conflicting results are reported regarding the effects of lag of accommodation on myopia progression. While some studies have found that the presence of higher values of accommodative lag and near esophoria are underlying factors in boosting the rate of myopia progression, other reports indicated that these two factors are ineffective in the onset and progression of myopia [24]. According to a study conducted by Pan et al. on 2346 Chinese children, the use of LED (Light-Emitting Diode) lamps while reading tasks increases the chance of myopia, as well as increasing the axial length, compared to the children who use incandescent and fluorescent lamps [25]. Inadequate sleep could also be a risk factor in the development and progression of myopia. According to the study by Gong et al., sleep duration of 7 hours or less is considered a crucial risk factor for the onset and progression of myopia in students aged 12 to 15 years [26].

Two major challenges in implementing myopia control strategies are the lack of screening programs in schools and the inadequate and inaccurate statistical information regarding the prevalence of myopia. The main suggestions for decreasing the risk of myopia development and progression are as follows [27]:

1. Cycloplegic refraction in epidemiological studies in individuals under 18 years of age.

2. Increasing the awareness of teachers and parents concerning the high risk of myopia in developing ocular pathologies that can be sight-threatening).

3. Encouraging the students to spend outdoors at least 2 to 3 hours (as an effective intervention in preventing the development and progression of myopia).

4. Encouraging governmental and non-governmental organizations (such as the Ministry of Health and Medical Education) to collaborate on developing a national program to prevent myopia and define myopia as a public health issue that needs to be addressed.

5. The World Health Organization (WHO) has added easier access to the glasses (as an effective and safe method to correct myopia) to the Priority Assistive Products List.

Myopia control includes two major concerns, such as controlling the rate of myopia progression and the initial prevention of myopia development. The present review article summarizes previous studies on optical treatment strategies for myopia progression.

The theory of peripheral defocus

The routine refraction examinations are being performed along with the fovea in the form of on-axis refraction. In practice, the clinicians are unaware of how the rays are focused in the peripheral retina. The visual perception does not occur only in the center and when we look around, the peripheral loci of the retina also perceive the images. The common treatment modality for myopia, which is spherical lenses, is that the rays passing through the lens center fall exactly on the fovea. However, due to the non-spherical shape of the globe, the peripheral retina has different refractive status and the patient experiences a hyperopic defocus. In other words, the patient whose myopia was corrected with conventional lenses has planorefraction in the fovea, while hyperopic defocus occurs in the retinal periphery. Physiologically, this hyperopic defocus transfers abnormal visual signals to the brain, and accordingly, a compensatory response from the brain in the form of globe stretching promotes myopia [28-30]. A commercially available instrument for measuring peripheral refraction is the Shin-Nippon NV ision-K 5001 which can provide refraction data up to approximately 30 degrees off-axis [31].

Effect of single vision lenses on peripheral refraction

Lin et al., carried out a study on myopic children to determine the peripheral refraction following myopia correction with single vision lenses. The participants were divided into two categories, low myopia, and moderate myopia. They found that after correcting myopia with single vision lenses, the amount of hyperopic defocus was significantly higher in children with moderate myopia than in children with low myopia [32]. Recent studies have tried to find a method to revert hyperopic defocus toward myopic defocus. In this situation, reverse feedback is induced, and the brain is prevented from sending signals to increase the axial length and subsequent myopic progression. Although creating myopic defocus in myopic individuals does not change the optical quality of the perceived image, it can slow down the rate of myopia progression [32].

Optical strategies in myopia progression control

Current optically-based methods in preventing and halting myopia progression include single vision spectacles and contact lenses, myopia under-correction, bifocal and progressive spectacles, multifocal contact lenses, and othokeratology (ortho-K) [33].

Single vision spectacles and contact lenses

Single vision spectacles and contact lenses are commonly prescribed as the first treatment plan for myopia correction. Some studies have suggested using gas-permeable (GP) lenses to prevent the progression of myopia. CLAMP (Contact Lens and Myopia Progression) study compared myopic children wearing GP lenses with soft contact lens wearers. The authors found that after three years, the rate of myopia progression with GP lenses was less than the soft contact lenses but the axial length elongation was the same. At earlier stages of the study, they proposed that GP lenses, due to their corneal flattening effects, could reduce the rate of myopia progression; however, after discontinuing the use of GP lenses, the corneal curvatures returned to their initial state [34, 35]. In another study on myopic children aged 6-12 years in Singapore, the authors found that GP lenses did not affect axial length elongation and myopia progression compared to single vision eyeglasses [36].

Myopia under-correction

Previous studies assumed that myopia under-correction prevents myopia progression due to imposing myopic defocus and less accommodative effort during near visual tasks [37]. Chung and his colleagues conducted a clinical trial on two groups of myopic children treated with myopia under-correction(by 0.75 D) and full-correction for two years [38]. They observed that the myopia degree of the under-correction and the full-correction treated groups progressed by -1.00 D and -0.77 D, respectively. Their results confirmed that myopia under-correction could accelerate myopia progression. Other studies on myopia under-correction have shown the triggering effect of this treatment plan on myopia progression [38-40]. Therefore, it is recommended to correct the full amount of myopia to reduce the risk of myopia progression.

Bifocal and progressive spectacles

It is hypothesized that plus addition lenses in two forms of bifocal and progressive spectacle lenses can effectively prevent or halt the myopia progression by two mechanisms; decreasing effect on accommodative demand in near viewing distances and decreasing peripheral defocus [41]. Studies have shown that myopic children have higher amounts of accommodative lag than metropic children [42]. On the other hand, some studies have found that higher amounts of accommodative lag may contribute to faster myopia progression [41, 43]. In the COMET (The Correction of Myopia Evaluation Trial) study, myopic children were divided into two groups and monitored for two years [41]. The first group was treated with single vision lenses and the second group was treated with progressive addition lenses. At the end of the first year, the authors found that myopia progression was 0.20 D less in the group treated with progressive lenses than that in the group treated with single vision lenses. During the second and third years of the study, the myopia progression was the same between the two groups. They concluded that although progressive spectacle lenses showed superior results than regular single vision spectacles in the first year of the study, using progressive spectacle lenses as a treatment modality to decrease myopia progression rate would not provide clinical benefits for myopic patients during subsequent years. Therefore, the prescription of progressive lenses was not recommended by the authors. The second phase of the COMET study, known as COMET2 was performed on myopic patients who had esophoria at near vision [44]. The authors found some improvements in myopia progression during three-year follow-ups. However, at the end of three years, the progression rate in esophoric patients was 0.28 D less than in the control group. They noted that this difference was not clinically significant.

Cheng et al. conducted a study on three myopic groups, including myopic patients prescribed single vision glasses, executive bifocal spectacles with +1.50 D addition power, and executive bifocal spectacles with the combination of +1.50 D addition power and 3Δbase-in. After a three-year follow-up, they observed that myopia progression was 50% lower in the third group than in the first group [45]. Berntsen et al., assumed that the possible reason for decreasing myopia progression rate with progressive addition lenses could be the imposition of myopic defocus, especially in superior loci of the retina [46].

The findings of these studies contributed to designing spectacle lenses that were specialized to neutralize central myopic defocus and peripheral hyperopic defocus [30]. Although these spectacle lenses initially successfully controlled myopia progression, their effectivity is still under investigation.

Multifocal contact lenses

As mentioned, abnormal focusing of the light rays in the peripheral retinal loci plays a vital role in progressing myopia and increasing axial length. Previous studies on the effects of multifocal contact lenses (Concentric and aspheric) on controlling myopia progression showed that using such contact lenses can induce myopic defocus in the peripheral retinal areas [33, 47].

Walline et al., conducted a study comparing the effects of high addition (+2.50 D) versus moderate addition (+1.50) powers of multifocal contact lenses on myopia progression. After a three-year follow-up, they observed that myopia progression in the group wearing high addition power, low addition power, and monofocal contact lenses were 0.60 D, 0.89 D, and 1.05 D, respectively [48]. Another study, CONTROL (The Control of Nearsightedness-Trial of Lenses), was performed on children aged 18-8 years who had near eso-fixation disparity (FD) and were fitted with center-distance concentric contact lenses [49]. The amount of addition power in these children was chosen as the lowest power that neutralized the near eso-FD. After 12 months, there was a 72% reduction in myopia progression and an 80% reduction in axial length compared to children who wore monocular spectacle lenses [49].

The first specialized contact lens to controlmyopia progression, labeled as MiSight, achieved FD approval in 2019 [50]. This contact lens has a dual-focus design attempting to simultaneously provide myopic correction as well as control myopia progression by neutralizing peripheral hyperopic defocus of the eye [51]. Previous studies have shown that MiSight contact lenses have significantly higher effects on controlling myopia progression and retarding the rate of axial length elongation compared to conventional multifocal contact lenses [52]. However, further longitudinal studies are needed to prove the effectiveness and safety of this novel contact lens.

Orthokeratology (Ortho-K)

Ortho-K lens is a type of GP lens specially designed for overnight wear. These lenses change the corneal topography into a flatter and more oblate surface and accordingly, decrease the corneal power to correct mild to moderate amounts of myopia. Therefore, during awakening times, the patient can see clearly without lenses [53]. In recent years, ortho-K lenses have also been investigated as a treatment modality in controlling myopia progression. Significant and positive effects have been reported [54, 55]. The ability of these lenses to control myopia has been attributed to the creation of peripheral myopic defocus in both the horizontal and vertical directions of the retina [56, 57]. Cho et al. conducted a prospective cohort study on children aged 7-12 years old for two years. They found that the axial length elongation and myopia progression were about 50% lower in the ortho-K group than in the group wearing single-vision spectacles [55]. Hiraoka et al. also conducted a study on children aged 8-12 years for 5 years. They observed a significant difference in myopia progression between the group that fitted with ortho-K and the group that wore single-vision spectacles in the first two years, while after three years, no significant difference was found between the two groups [58].

In essence, studies on ortho-K reported a 36%-63% reduction in myopia progression rate and axial length elongation [54-57]. The primary advantage of this method is that the patient does not need to wear the lenses during the daytime. Notwithstanding, the main disadvantages of this method include the cost, risk of microbial infection, inconvenience of putting and removing the lenses, and decreased visual acuity at the end of the day [59, 60].

3. Conclusions

Most treatment modalities currently under investigation to prevent myopia progression attempt to neutralize the effect of peripheral hyperopic defocus. Despite achieving a high success rate of some non-optical plans in myopia control, optical strategies are non-invasive and can effectively prevent myopia progression. However, several optical methods, such as different types of contact lenses and spectacle lenses, cannot adequately control myopia progression. According to the literature review, Ortho-K and newly introduced multifocal soft contact lenses are the most effective optical strategies to control myopia progression. From a clinical perspective, a successful strategy should be able to significantly prevent the progression of myopia. This outcome cannot be achieved by most optical methods as a sole treatment strategy. Therefore, due to its cumulative effect, combination therapy may be more effective in controlling myopia. Finally, it is noteworthy that the best myopia control strategy with the highest effectivity and the least adverse effects is already under contention.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of Interest

The authors declared no conflict of interest.

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