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Myopia as a problem of the modern world. Methods of treatment and prevention

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Abstract

Introduction and objective

Sight is one of the most important human senses, which enables proper coordination of the entire body. Short-sightedness is increasingly being called the “scourge” of our time. Prognosis in early 2024 predict that people with myopia problems may represent as much as 35% of humanity. In the research, we want to present the possibilities of treating and preventing short-sightedness, collect those that seem most relevant and effective against the background of today's knowledge.

Abbreviated description of the state of knowledge

Short-sightedness (myopia) is a visual defect in which light rays do not focus properly on the retina, but in front of it. Among the methods of treating and slowing down the progression of myopia, we can identify environmental, pharmacological, optical and surgical methods. Intracular lenses and soft contact lenses are the most frequently used forms of correction. However, at high values of the defect, they may not be effective enough. The choice in such situation is hard contact lenses, which are not always well tolerated by patients. Among the methods confirmed by numerous studies of slowing the progression of myopia still include atropine and orthocorrection. More innovative techniques include DIMS lenses, HAL and red-light therapy. However, they require more research to confirm their long-term effectiveness and safety.

Summary

In recent years, myopia has become a worldwide problem. Promising results are provided by recent studies on HAL spectacle lenses, DIMS, MiSight contact lenses and RLRL. Thanks to the large number of treatment methods, the doctor can adjust the treatment that seems to be best for the patient. The development of current therapies, as well as an appropriate lifestyle, are important aspects for the treatment of myopia.

Keywords: Myopia; environment; treatment; atropine; contact lenses; health education

Introduction

Medicine faces new challenges every day. Each field requires attention and preparedness for the threats and surprises the future may bring. The pandemic period remains fresh in our collective consciousness. There are also longstanding problems and issues that have consistently occupied significant attention among physicians and researchers. One of these challenges is the effort to minimize, limit, or slow down myopia in ophthalmology. Today, it would not be an exaggeration to refer to myopia as a “plague of our times” or the “epidemic of the 21st century”. The increasing number of patients across all age groups, particularly the alarming rise in myopia among children, is a source of concern within the medical community.

Forecasts from early 2024 estimate that individuals affected by myopia could constitute as much as 35% of the global population. This issue is particularly pronounced in Asia, but Europe and the United States are not immune, as the scale of the problem in these regions is comparable. In Poland, individuals with myopia represent approximately 28-29% of the population aged 35 to 39, which equates to an estimated 9-10 million people. However, it is worth noting the severity of the issue: only 40% of these individuals have their visual impairments adequately corrected [1].

Vision is one of the most crucial human senses. It enables individuals to acquire information about their surroundings, control movements and behaviors, and coordinate the body's overall function with other senses. The visual system allows humans to perceive visible stimuli from the external environment. This is made possible by the electromagnetic radiation present in the environment, commonly known as visible light [2].

Objective of the Study

This review aims to analyze and systematize knowledge regarding available methods for treating and preventing myopia, compare emerging technologies, and encourage discussion about their effectiveness.

State of Knowledge

Myopia, also known as nearsightedness, is a visual impairment where individuals have difficulty seeing distant objects clearly while maintaining good near vision. This condition occurs when light rays entering the eye do not focus correctly on the retina but in front of it. Myopia can result from excessive refractive power of the eye's optical system (with anatomically normal eyeball length), referred to as refractive myopia, or from increased eyeball length (with refractive power within normal range), known as axial myopia. Refractive changes may also occur due to excessive accommodation or alterations in the lens's refractive index, as seen in conditions like diabetes.

Progressive elongation of the eyeball leads to changes caused by the stretching of the choroid and retina, potentially resulting in retinal detachment or degeneration. The most significant progression of myopia is typically observed during adolescence, coinciding with rapid and abrupt growth spurts. Other conditions associated with myopia include an increased prevalence of glaucoma and cataracts.

The most common classification system used by specialists is based on the severity of the refractive error, measured in diopters (D). This categorization includes low myopia (up to -4,0 D), moderate myopia (-4,0 to -8,0 D), and high myopia (greater than -8,0 D) [3].

In general, methods for treating and slowing the progression of myopia can be grouped into four categories: environmental, optical, pharmacological, and surgical.

Environment

Hereditary factors, minimal or no outdoor activity, work requiring prolonged near-focus accommodation, and educational pressure are among the many causes contributing to the development of myopia. The influence of electronic devices such as mobile phones and smartphones is particularly significant. Continuous staring at small screens prevents the eyes from relaxing their accommodation. This lifestyle was exacerbated during the recent pandemic, highlighting the importance of adhering to visual hygiene principles. These include maintaining an appropriate distance and posture while reading, ensuring proper lighting, taking breaks during close-up work, and performing exercises to relax accommodation [4, 5, 6].

Some researchers suggest that increasing time spent outdoors and limiting near-work activities may not only inhibit the progression of myopia but also slow its development in already affected individuals [7, 8]. However, this topic remains under active investigation, and further results are awaited.

Pharmacology

Atropine is a natural alkaloid of the tropane class and acts as a competitive, selective antagonist of muscarinic receptors. The exact mechanism by which atropine affects myopia progression is not fully understood. It is hypothesized that reduced levels of type I collagen contribute to scleral thinning and its abnormal, progressive elongation. Atropine stimulates scleral fibroblasts to increase type I collagen production, aligning with its expected efficacy in slowing myopia progression [9, 10, 11].

Numerous studies have assessed the effects of atropine on myopia progression. In one study, participants received eye drops containing atropine at concentrations of 0,05%, 0,025%, and 0,01% or a placebo over a year. It was demonstrated that all concentrations reduced myopia progression, with the most significant effects observed in the 0,05% atropine group [12]. Another study found that 0,05% atropine was approximately twice as effective in preventing myopia progression compared to 0,01% [13]. However, Repka and colleagues, in a study conducted in the United States comparing 0,01% atropine and placebo in children, found no significant slowing of myopia progression [14].

Another debated question was whether atropine could have a preventive effect in children who had not yet developed myopia, delaying the onset of the condition. To explore this, Yam and colleagues conducted a study at the Chinese University of Hong Kong, using atropine sulfate at concentrations of 0,05% and 0,01%, as well as a placebo consisting of 0,9% sodium chloride. After two years, the incidence of myopia was 28,4% in the 0,05% atropine group, 45,9% in the 0,01% atropine group, and 53,0% in the placebo group. The findings indicate that 0,05% atropine significantly reduced the incidence of myopia compared to placebo, while no significant difference was observed between 0,01% atropine and placebo [15].

When using atropine, it is important to consider potential side effects and the so-called rebound effect upon abrupt discontinuation. Adverse effects include photophobia, blurred vision, pupil dilation, glare, local allergic reactions, loss of accommodation, and near vision impairment (cycloplegia). The higher the concentration of atropine, the greater the risk of these complications. Chia and colleagues demonstrated that after discontinuing atropine treatment, a rebound effect was observed, with myopia increasing by at least 0,5 D in 68% of participants using 0,5% atropine, 59% of those using 0,.1% atropine, and 24% of those using 0,01% atropine [16, 17].

Optics

There is no doubt that correcting vision with standard spectacle lenses is the most commonly chosen method. In the past, under-correction was a widely used technique to slow myopia progression. However, it is now known that this strategy was not only ineffective but also counterproductive [18,19]. Attempts have also been made to use bifocal and progressive lenses. The effectiveness of these methods has been primarily observed in Asian populations, while European studies do not confirm their efficacy [6,20].

The limited success of these methods has driven researchers to explore further options. Increasingly, studies are highlighting the potential of new optical correction methods, such as highly aspherical lenses (HAL) and defocus incorporated multiple segments (DIMS) lenses.

In a clinical study comparing single-vision lenses (SVL), slightly aspherical lenses (SAL), and highly aspherical lenses (HAL), the average 2-year myopia progression in diopters was 1,46 D for SVL, 1,04 D for SAL, and 0,66 D for HAL. The average axial elongation over two years was 0,34 mm, 0,51 mm, and 0,69 mm for HAL, SAL, and SVL, respectively. In summary, both HAL and SAL reduced the rate of myopia progression and axial elongation over two years, proving more effective than single-vision lenses [21].

Defocus Incorporated Multiple Segments (DIMS) lenses consist of a central optical zone for refractive error correction and an annular focal zone with multiple positive power segments arranged in a honeycomb-like structure. This design provides clear vision at all distances. In a two-year randomized, double-blind controlled study with 183 Chinese children, Lam et al. demonstrated that myopia progression was 52% slower among children using DIMS lenses compared to those using single-vision lenses. Axial elongation was also reduced and reached 62% in the DIMS group compared to the SVL group. Moreover, 21.5% of children wearing DIMS lenses showed no myopia progression over two years, compared to only 7.4% in the SVL group [22].

Guo et al. also compared the effectiveness of HAL and DIMS lenses. They found that children wearing HAL lenses exhibited less myopia progression than those using DIMS lenses [23].

Nucci et al. conducted a European study in a pediatric ophthalmology clinic, showing that both DIMS lenses and 0.01% atropine slowed myopia progression compared to the control group. The best results were achieved by combining both methods. In the atropine group, the reduction in myopia progression was 57% in spherical equivalent refraction (SER) and 62% in axial elongation (AL). In the DIMS group, the reduction was also 57% in both SER and AL, while the combined group achieved reductions of 70% in SER and 77% in AL [24].

Contact lenses hold a special place in myopia treatment. Based on their material, they are categorized into soft (hydrogel or silicone hydrogel), rigid gas-permeable (corneal, scleral, and semi-scleral), and hybrid lenses (combining rigid and soft materials) [25].

A 2023 report published in Contact Lens Spectrum indicated that soft contact lenses account for 90% of all prescribed lenses. Silicone hydrogel lenses represent over 75%, with spherical lenses at 50%, toric lenses at 28%, multifocal lenses at 17%, and myopia control lenses at 3% [26]. Rigid lenses are typically chosen when soft lenses fail to provide optimal correction. However, their rigidity can cause discomfort for some individuals. High levels of myopia often warrant their use. Hybrid lenses, combining a rigid central lens with a soft peripheral section, allow correction up to -40 D [27,28,29].

Each method has its pros and cons. Contact lenses offer several advantages over glasses, such as an unrestricted field of vision, reduced spherical and chromatic aberrations, no fogging, and a natural image size without magnification or reduction. These benefits are especially important for athletes or individuals whose work prevents them from wearing glasses. They also provide psychological comfort for those who find glasses cumbersome or embarrassing. In cases of high myopia, contact lenses are often the first choice since glasses with high power have thick, heavy lenses that can be uncomfortable and visually unappealing. Additionally, glasses can distort images and cause other vision disturbances. In certain cases (e.g., anisometropia), lenses are recommended primarily for medical reasons, as they may be the only option for developing proper vision in young children.

The disadvantages of contact lenses include the need for meticulous hygiene. Neglecting regular lens replacement or proper maintenance can lead to ocular complications. Additionally, some individuals find the process of inserting lenses to be a significant barrier, as they cannot tolerate contact with their eyes [2].

There are also contraindications to wearing contact lenses, both ocular and systemic. Ocular contraindications include active microbial infections, chronic inflammation, severe allergic reactions, dry eye syndrome, and recurrent corneal erosions. Systemic contraindications include upper respiratory tract infections, severe allergies, uncontrolled diabetes, alcoholism, and certain mental health conditions [2].

In addition to vision correction, contact lenses can be used to slow the progression of existing myopia. Daily disposable lenses such as MiSight operate on the principle of peripheral defocus. Their effectiveness was confirmed in a three-year study on children, showing reduced myopia progression. Children using MiSight lenses exhibited a spherical equivalent that was 0,73 D ± 0,61 lower and axial elongation that was 32 mm ± 0.27 shorter than the control group [30].

Orthokeratology (OK) lenses, which belong to rigid gas-permeable lenses, hold a special place in myopia management. This method involves wearing lenses overnight to reshape the cornea, allowing clear vision during the day. The design of OK lenses ensures optimal correction in both the central and peripheral retina, transforming peripheral refraction from hyperopic to relative myopic defocus. However, the main drawback is the return to the original state after discontinuing lens use, along with the risk of complications such as allergic reactions or inflammation [31].

To evaluate the effectiveness of orthokeratology, Santodomingo-Rubido et al. conducted a seven-year clinical study involving European children. The study found that children wearing OK lenses experienced a 33% reduction in the rate of axial elongation compared to the control group [32].

Surgery

Surgical methods of vision correction include intraocular and corneal procedures, commonly referred to as refractive surgery.

An increase in intraocular interventions is being observed worldwide, primarily performed on individuals who do not qualify for corneal methods. These procedures include the implantation of a phakic intraocular lens (a reversible intervention) or the replacement of the natural lens with an artificial one.

Laser refractive surgery predominantly utilizes two types of lasers: excimer and femtosecond. In myopia correction, these lasers work by reducing the central thickness of the cornea. Corneal procedures can be divided into surface treatments using excimer lasers and deeper treatments performed with excimer and femtosecond lasers. One of the more recent methods, ReLEx SMILE, exclusively relies on a single laser - the femtosecond one.

Each surgical intervention has its advantages and disadvantages. Before deciding on a particular method, the physician should assess which option is most suitable for the individual patient. It is also important to note that surface treatments are associated with a longer rehabilitation period, a higher likelihood of haze formation, significant pain, and an increased risk of refractive regression compared to deeper methods [33].

Light Therapy

An emerging and promising method for slowing myopia progression is low-intensity red light therapy (RLRL). This is a relatively new treatment approach, with efficacy primarily demonstrated in Asian countries.

In one clinical study, the average refractive change over six months was 0,06 ± 0,30 D in the RLRL group compared to -0,11 ± 0,33 D in the sham device control group. Additionally, the average axial elongation was 0,02 ± 0,11 mm in the RLRL group versus 0,13 ± 0,10 mm in the control group [34]. Xiong et al. showed that the combination of orthokeratology (OK) lenses and low-frequency light therapy more effectively slowed myopia progression compared to single-vision distance glasses. Furthermore, they suggested that RLRL might better control axial elongation (AL) and slow myopia progression than OK lenses alone [35]. However, further research is needed to assess the long-term effects and safety of this method.

Summary

In recent years, myopia has become a global issue. Medicine continues to refine existing approaches and explores new methods for managing this condition.

Among the treatments and strategies for slowing myopia progression are spectacle lenses, contact lenses, pharmacological interventions, and surgical procedures. Promising results have been observed with newer therapies, such as DIMS and HAL spectacle lenses, MiSight contact lenses, and red-light therapy. However, these approaches require further clinical research. Despite decades of use, atropine and orthokeratology remain popular and effective methods for myopia management, with the majority of scientific studies confirming their efficacy.

The variety of available treatment options allows for individualized approaches to each patient. The continuous advancement of both established and newer methods offers an encouraging outlook for the future of myopia management.

Environmental factors also play a significant role in myopia prevention. Key elements include adequate time spent outdoors, reducing accommodative strain, and maintaining proper visual hygiene. These environmental influences are likely to intensify over time, making health education equally important. Such education holds the potential to improve both prevention and control rates for myopia. The more widespread the condition, the greater the need for effective interventions. It is recommended to limit the root causes rather than merely combat the consequences.

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