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Epidemiology of myopia and the effect of orthokeratology on controlling the disease
Epidemiologia krótkowzroczności oraz wpływ ortokeratologii na kontrolę schorzenia

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Abstrakt

Wprowadzenie i cel

Krótkowzroczność (miopia) jest wadą wzroku, która uniemożliwia wyraźne widzenie przedmiotów znajdujących się w oddali. Może również prowadzić do innych chorób narządu wzroku. Chorobą tą dotknięte jest obecnie około 30% populacji światowej, a według szacunków, odsetek ten wzrośnie do 50% w ciągu najbliższych 30 lat. Ortokeratologia jest stosunkowo nową metodą niechirurgicznej, odwracalnej korekcji krótkowzroczności. Specjalnie zaprojektowane soczewki, noszone w nocy, modyfikują kształt rogówki, co pozwala na prawidłowe widzenie w ciągu dnia.

Metody przeglądu

Celem pracy była ocena efektywności soczewek ortokeratologicznych na podstawie przeglądu literatury medycznej opublikowanej w bazie PubMed w ciągu ostatnich 5 lat.

Opis stanu wiedzy

Dokonany przegląd literatury wskazuje na korzystne efekty stosowania soczewek ortokeratologicznych. Zaobserwowano redukcję długości osiowej gałki ocznej oraz zmianę krzywizny rogówki. Progresja krótkowzroczności u dzieci stosujących opisywane soczewki była pięć razy, a u dorosłych trzy razy wolniejsza niż w odpowiednich grupach kontrolnych. Wykazano, ze korzystne efekty utrzymują się przez pierwsze 8 lat leczenia. Z powodu ograniczonej podatności rogówki, w ciągu kolejnych lat dochodzi do spadku efektywności. Zazwyczaj nie obserwuje się działań niepożądanych lub są to łagodne i przemijające skutki uboczne.

Podsumowanie

Zgodnie z wynikami najnowszych badań można stwierdzić, ze ortokeratologia jest skuteczną i bezpieczną metodą hamowania progresji miopii. Metoda ta może być rekomendowana zwłaszcza dzieciom oraz osobom, którym warunki pracy uniemożliwiają stosowanie standardowych soczewek kontaktowych lub którzy nie kwalifikują się do zabiegu laserowej lub chirurgicznej korekcji krótkowzroczności.

Słowa kluczowe: ortokeratologia, krótkowzroczność, kontrola krótkowzroczności, soczewki kontaktowe

Abstract

Introduction and objective

Myopia is a defect of vision, which makes it impossible to see remote objects clearly. The disease can also lead to serious ocular problems. Myopia affects about 30% of the world population and -according to the estimates- that percentage is about to increase up to 50% within the next 30 years. Orthokeratology is a relatively new method on non-surgical, reversible correction of myopia. Specially designed lenses, worn at night, affects the shape of the cornea, which results in proper vision during the day.

Review methods

The aim of the study was evaluation of effectiveness of wearing orthokeratology contact lenses based on a review of medical literature published on PubMed in the last 5 years.

Abbreviated description of the state of knowledge

Research results show that wearing orthokeratology lenses have beneficial effects. Reduction of axial length of the eyeball and curvature of the cornea were observed. Progression of myopia was five times slower in children study group and three times slower in adult study group compared to control groups. It was proved, that favourable health effects persist through the first eight years of treatment. Due to the fact, that cornea has a limited susceptibility, a decrease in efficiency occurs in the following years. Usually no undesirable side effects are reported, yet the possible side effects are mild and disappear after a short time.

Summary

According to the results of recent studies, we can assume that orthokeratology is a safe and effective method of inhibition of myopia progression. The method may be especially recommended to children, to people working in such conditions, that make wearing standard contact lenses impossible and to people not qualified for laser or surgical vision correction.

Key words: orthokeratology; myopia; myopia control; contact lenses

Introduction

Myopia, also called short-sightedness, is a defect of vision. The myopic eyeball is slightly elongated, so light focuses in front of the retina, instead of directly on it. It leads to blurry distance vision - the more remote an object, the worse view. When refraction is equal or greater than -6 dioptres, we classify the disease as high myopia. It can also be defined as having axial length of the eyeball >= 24 mm [1].

The global prevalence of myopia has rapidly increased in the last decades and is still increasing. It has now became a public health problem. The greatest extent of myopia is observed in East Asia, where its level – reaching up to 90% of young adults [2] - is now

determined as ‘epidemic’ [3]. In Europe and United States, myopia affects about 20-50% of the population [3]. According to World Health Organisation, its worldwide prevalence is around 33% [4]. Approximately from 12% [4] to 24% [2] of all cases is high myopia. It is estimated, that in 2050 half of the world population would by myopic, which gives a total number of 5 billion cases – one fifth of those would be high-myopic [2,4].

One of the causes of short-sightedness are genetic predispositions. By some estimates, the likelihood of becoming myopic is six times higher in children whose both parents have the disease, comparing to children who have one or no myopic parents [3]. Inheritance was the main causative factor in the past, when myopia was not such common a disease. Currently, other factors, rather environmental, are taken into consideration. Ongoing industrialisation, urban environment, change of working models have all affected the occurrence and development of myopia [5]. Too much time spend reading, using computer or other electronic devices as well as staying indoors increase the risk [3,5,6]. On the contrary, outdoor activity is considered to be a protective factor– the eye is forced to focus on both near and distance objects [2,3,6]. The protective mechanism also involves higher illuminance, reduced peripheral defocus, exposure to vitamin D, increased physical activity and lower body mass index [5]. Researchers measured that an average teenager in Shanghai spends 15 hours per week doing homework, while their peer in United Kingdom studies at home for about 5 hours weekly, which corresponds to higher myopia prevalence in Asia [6]. Similar results were found in a polish study involving 5601 children, conducted between 2000 and 2009. It was observed, that reading and writing led to significantly higher prevalence of myopia, as well as working on a computer. Outdoor activity, however, was associated with lower occurrence of the disease [7]. In other study, it was observed that people with higher education degree are more likely to have myopia [5]. It corresponds with greater amount of time spend on near distance work, which increases the risk of short-sightedness. Educational stress may also have a negative impact on children’s sight [2].

The Covid-19, which started in 2019 in China, eventually spread all over the world. The global pandemic, apart from the negative impact on our health caused by the virus infection itself, has led to considerable changes in our lifestyle and well-being. In Poland, the whole education between March and July 2020 and October and May 2021 was held online, which caused prolonged usage of digital devices, substantial reduction of the time spent outside and the increased stress level in both children and adults. A consequence of this issue can be the development and/or the worsening of myopia [8,9]. In one of the studies it was observed, that the prevalence of myopia in 2020 was higher than in the previous years in children between 6 and 8 years old and is suggested to be associated with Covid-19 pandemic and its impact on education model [9].

The prevention of myopia development and progression should be of great importance for patients, doctors and the authorities. Myopia increases the risk of other ocular diseases such as myopic maculopathy, retinal detachment, glaucoma, cataract [2,3,6] and in most serious cases the risk of macular atrophy due to degeneration of choroid and retina [2]. Moreover, progressive elongation of the eyeball results in thinning of ocular tissue, which can even lead

to blindness [2,5]. The risk of all those undesirable effects increases with each dioptre, so they are specifically dangerous for patients with high myopia.

By estimates, the earlier in childhood symptoms occur, the faster myopia progresses. The most rapid growth in visual acuity decline is observed in school-aged children, then it slows down in adulthood [2]. There is a strong association between early onset of myopia and developing high myopia in the future [10]. The risk of complications rises when myopia affects young children and the complications get more serious as the times passes, thereby reducing myopia progression as soon as possible should be of great importance for all practitioners, patients and their parents.

The aim of the study was to evaluate the newest data about epidemiology of myopia and to estimate the efficacy and safety of orthoketatological lenses based on the latest research studies.

Material and method

Review of medical journal literature published on PubMed in the last 5 years was made. We included both short- and long-term studies referring to orthokeratology in children and adults, that were performed in different continents The review also contains most recent studies that focused on the impact of Covid-19 pandemic on people's sight.

Current state of knowledge

The increase in myopia prevalence and the complications the disease leads to has driven interest into restraining progression of myopia from an early age. Findings from several studies showed that orthokeratology lenses are a safe approach not only for short-sightedness correction, but more importantly – retardation of myopia progression [11-21].

Orthokeratology (OK) dates back to 1960s [12, 20] and nowadays is approved in all countries in the world for the temporary reduction of myopia [20], despite the fact that orthokeratological lenses make no more than 1% of total number of contact lenses used worldwide [3]. Specially designed contact lenses have a reverse geometry design, that results in the anatomical changes in the cornea. The middle part of the lens is responsible for flattening and thinning the centre of the cornea, while the peripheral part of the cornea is a reserve zone, which thickens, thereby enabling the lenses to reshape the corneal surface. It is presumably due to the fact, that under the influence of the hydrostatic forces of the tear film, acting under the lens, the epithelial cells are redistributed to the perimeter, which results in the corneal surface taking a flatter shape [3]. The hyperopic peripheral refractive error is reduced, and the eyeball elongation is slowed down [13]. Through the use of highly oxygen-permeable materials [13, 22], lenses can be safely worn at night and taken off during the day. Unfortunately, the effect of myopia reduction is temporary, so contact lenses must be worn regularly to continue the gains, nonetheless a patient can function without any correction during the waking day [20].

The newest study about orthokeratology and myopia progression, which results were published in April 2021, was held in Switzerland between 2012 and 2020 [21]. It involved patients up to 19 years old with myopia but no other comorbidities. The study showed a slower growth of axial length in orthokeratologicaly treated patients compared to control group with glasses. In the 21-person group, two cases of mild keratitis occurred. It supports

the view that OK was a good treatment option in myopia progression [21]. The authors emphasize, that early identification and treatment of myopia is essential to prevent serious side effects. Nowadays it is especially important, when the possible negative impact of Covid-19 pandemic on our sight remains unknown.

Ophthalmologists from Republic of Korea examined 45 children aged 7-13. Their study [14] last more than 12 months and the results were published in May 2018. Every child used an orthokeratology lens on one eye only, while no intervention was made on another eye. After a year of lens wear an elongation (0.36 mm) of the control eyeball was observed, whereas the change of another eye was four times smaller (+0.7 mm). Nine participants were also examined in two-year follow-up. There was no axial length change in orthokeratologicaly treated eye and a significant increase (0.38 mm) in a control one. Contralateral comparison study prevented the influence of any exterior factors [14].

One hundred and twenty-six participants took part in the Taiwanese study, which results were published in 2016 [15]. The youngest participant was 9, the oldest was 62 and the median age was 20.4. All the participants had myopia =< -6D and astigmatism. They wore orthokeratology lenses for at least 7 hours per night. The results were checked after 1, 2, 4, 12, 24 weeks of treatment. Beneficial effects such as a decrease of corneal curvature were observed right after the first week. The success rate increased up to week 24. No severe complications occurred [15].

One of the recent long-term study is a retrospective trial conducted in Taiwan between 1998 and 2013 and the results were published in 2017 [16]. The study included 102 school-aged children. Sixty-six of them created a research group, and the others formed a control group. There were no significant differences between both groups at the baseline. Children wore orthokeratology lenses for at least 6 hours per night. The effects were measured every 2-3 months up to 12-year follow-up, though the maximum wearing time of some patients was 16 years. At the end of clinical trial, children who used the lenses had lower refractive error change and an improved corneal shape. The myopia progression pace was slower compared to control group – 0.2-0.3 dioptres per year versus 0.4-0.5 dioptres/year respectively. However, the desirable effects increased gradually in the first few years (approximately up to 8 year of treatment) and then started to decrease afterwards. During the study period, mild superficial punctate keratopathy was noted in 8 children and mild corneal erosion in 2 representatives of the study group. The symptoms deceased after a several-day break from wearing the lenses. Re-design of the lens were necessary in one subject. No other severe complications occurred in orthokeratology lens users [16].

In American research, 10 young people with mean age 25.9+/-3,9 years were included in 60-day treatment with orthokeratology lenses [13]. Eight of them completed the study. By the end of first week, a significant improvement in vision acuity was observed. Refraction and subjective refraction at the day 60^{th} were lower comparing with the first day of treatment. Moreover, the central cornea was thinner and flatter.

Researchers from Hong-Kong recruited 16 young people for their study from 2018 [23]. On one eye, an orthokeratology lens was used, while another was a control one that wore a standard soft lens. Participants were divided into two groups. One group wore the lenses for

30 minutes and the other for 60 minutes. They had their eyes closed to imitate night-wear. One overnight wearing was arranged and lasted 7-9 hours. All measurements were done immediately after the lens removal. Statistically significant corneal flattening was observed in treatment eyes, just as short as after 30 minutes of orthokeratology (−0.19D, $p < 0.01$). It was accompanied by myopia reduction and increased with a longer wear time, so did myopia reduction. After overnight orthokeratology, the average myopia reduction was 1.18D ($p < 0.01$), though it was not associated with corneal flattening ($p = 0.393$) [23].

Any side effects reported by the patients in described studies, such as corneal staining, reduced tear secretion [19], were rather insignificant and typical for any other types of lenses [22]. All these events recovered completely after clinical action was taken, discontinuation of lens wear for several days was ordered, or they were resolved in another way e.g. lens re-design [16,22]. None of those complications had a negative impact on vision. However, the occurrence of microbial keratitis is worth pointing out. It is a serious condition induced by bacterial or, rarely, fungal pathogens. According to The College of Optometrists the condition is usually associated with contact lens wear, especially lenses worn overnight, when the incidence is up to 5 times higher comparing to daily use [24]. Other main predisposing factors for contact lens-related microbial keratitis are male gender and smoking. It may also be a consequence of increased wear time, using contact lenses despite discomfort and poor hygiene [22,24,25,26].

The total price of orthokeratology therapy is high. Starting with an eye exam, through the cost of lenses to the follow-up care it reaches 1500-2500$ [27].

Summary

Myopia is a common ophthalmic disease. It not only disturbs the quality of vision, but can also lead to serious eyesight problems, even including blindness. Especially dangerous is high myopia, so early identification of risk factors in children of developing high myopia is a key task for health practitioners. Changes in lifestyle should be actively encouraged, especially now, when the possible increase of myopia occurrence secondary to Covid-19 is yet to become clear.

The principle of orthokeratology is to reduce, or even eliminate, the refractive error so the patient do not need to use any correction (spectacles or contact lenses) for most of the time. Its advantages in correcting eyesight are significant, though temporary, so the lenses need to be worn on a nightly basis to continue the improvement. What is more important, orthokeratology lenses have also a proven effect in slowing down and preventing myopia progression. The method is the most effective among patients with mild to moderate myopia. Avoiding the development of high myopia in children can lead to a reduced risk of serious, sight-threatening disorders in later life and this is a major goal of myopia control.

As any other treatment, orthokeratology lenses may also carry risk. Most of the studies reported only non-significant side-effects that disappeared after a short time. However, proper education guidelines are essential in order to avoid unhygienic practices among patients. Still, further clinical trials are still needed to provide a better knowledge of changes along a longer-term follow-up.

Despite its undisputable advantages, especially after a relatively short period of treatment, orthokeratological lenses still constitute no more than 1% of contact lenses, because the majority of doctors prescribe glasses or contact lenses as the first option of correcting myopia. One of the reasons is probably a high cost of orthokeratology.

Nonetheless, the method can be recommended for children, in whom the slowing down myopia progression is especially important, and for people for whom using standard contact lenses is not advisable for example due to the fact of working in dry or dusty rooms. It may also be a solution for patients disqualified for laser or surgical correction of vision. Moreover, all patients, especially school-aged children, should be advised to spend more time outdoors, because bigger distances diminish the need of the eye to accommodate and reduce the pupil diameter, which can slow down myopia progression.

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