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MYOPIA: MORPHOLOGICAL CHANGES OF THE RETINA

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Annotation

Myopia is often associated with changes in the fundus that confirm the increase in the length of the anteroposterior axis of the eye and subsequent mechanical stretching, as well as thinning of the retinal pigment epithelium and choroid with accompanying vascular and dystrophic changes. Early changes in the fundus are local redistribution of pigment (parquet-type fundus) and blanching of the optic disc. Subsequent peripapillary atrophy can occur both around the optic disc and on one of its sides.

Conclusion: changes in the fundus in myopia occur over time and gradually with the development of posterior staphyloma, peripapillary atrophy and myopic macular degeneration, which in some patients can lead to a significant decrease in visual acuity.

Keywords: myopia, macular degeneration, visual acuity, retina

Аннотация

При миопии часто наблюдаются изменения глазного дна, подтверждающие увеличение длины переднезадней оси глаза и последующее механическое растяжение, а также истончение ретинального пигментного эпителия и сосудистой оболочки с сопутствующими сосудистыми и дистрофическими изменениями. Ранние изменения глазного дна заключаются в локальном перераспределении пигмента (паркетное глазное дно) и побледнении диска зрительного нерва. Последующая перипапиллярная атрофия может возникать как вокруг диска зрительного нерва, так и с одной из его сторон.

Заключение: изменения глазного дна при миопии происходят с течением времени и постепенно с развитием задней стафиломы, перипапиллярной атрофии и миопической макулярной дегенерации, что у некоторых пациентов может приводить к значительному снижению остроты зрения.

Ключевые слова: миопия, макулярная дегенерация, острота зрения, сетчатка.

Annotatsiya

Miopiya ko'pincha fundusdagi o'zgarishlar bilan bog'liq bo'lib, bu ko'zning anteroposterior o'qi uzunligining oshishi va keyinchalik mexanik cho'zilishi, shuningdek, tomir va distrofik o'zgarishlar bilan birga retinal pigment epiteliysi va xoroidning yupqalanishi. Fundusdagi dastlabki o'zgarishlar pigmentning mahalliy qayta taqsimlanishi (parket tipidagi fundus) va optik diskning oqartirilishidir.

Keyinchalik peripapiller atrofiya ham optik disk atrofida, ham uning bir tomonida paydo bo'lishi mumkin. Xulosa: miopiyadagi fundusdagi o'zgarishlar vaqt o'tishi bilan va asta-sekin posterior stafiloma, peripapiller atrofiya va miyopik makula degeneratsiyasi rivojlanishi bilan sodir bo'ladi, bu ba'zi bemorlarda ko'rish keskinligining sezilarli darajada pasayishiga olib kelishi mumkin. Kalit so'zlar: miopiya, makula degeneratsiyasi, ko'rish keskinligi, to'r parda.

Myopia is often associated with changes in the fundus that confirm the increase in the length of the anteroposterior axis of the eye and subsequent mechanical stretching, as well as thinning of the retinal pigment epithelium and choroid with accompanying vascular and dystrophic changes. Early changes in the fundus are local redistribution of pigment (parquet-type fundus) and blanching of the optic disc. Subsequent peripapillary atrophy can occur both around the optic disc and on one of its sides. Further chorioretinal dystrophic changes usually appear as a crescent on the temporal side of the disc. The area of these changes and the size of the staphyloma correspond to the area of thinning of the retinal pigment epithelium. At the same time, the mechanical aspects of the progression of myopia are due to further stretching of the fundus structures, which become increasingly pronounced. Late changes of axial myopia include decreased choroidal blood supply and increased chorioretinal degeneration. These retinal changes in myopia have been studied in detail. However, it remains unclear whether eye elongation has any effect on retinal function.

Beginning with the publication of G. Karpe in 1945 [1], in which he noted a decrease in the amplitude of the b-wave in eyes with myopia, in subsequent publications, authors have noted contradictory data on their changes on electroretinography (ERG) in myopia [2, 3]. With regard to changes in the a-wave, publications are also contradictory [3, 4].

In this review, we summarized the data from foreign literature on the effect of myopia on the functioning of various retinal components, including photoreceptors, bipolar cells, and inner parts of the retina, in children and adults.There are several types of electroretinography, but we will focus only on Ganzfeld ERG and multifocal ERG as the most commonly used to assess retinal function in eyes with myopia [5, 6].

Ganzfeld or general electroretinography has proven itself as a useful and noninvasive tool for objectively assessing retinal function. The ERG response is a set of retinal electrical potentials from different retinal cell types whose interrelated contributions depend on the properties of the stimuli and the background adaptation conditions. Thus, under dark adaptation conditions, the ERG responds to bright flashes with a- and b-waves, which initially reflect, respectively, the activity of the photoreceptors (cones and rods taken together) and the depolarization of bipolar cells.

The ERG response to bright flashes under light adaptation conditions reflects the activity of only the cones and the bipolar cells extending from them [7, 8].

The standard protocol for the study of the general ERG, developed by the International Society of Clinical Electrophysiology of Vision (ISCEV), includes five types of response: scotopic response (rod response in the dark-adapted eye), maximal or mixed response (obtained from rods and cones and postreceptor pathways), oscillatory (oscillatory) potentials (OP) obtained from the inner layers of the retina and amacrine cells, photopic signal to a flash (from cones and postreceptor pathways) and flickering (rhythmic) ERG - flicker response to a flickering stimulus with a frequency of 30 Hz (function of rod bipolar cells) [9].

Thus, the functions of different retinal layers can be assessed by the level of response change and the configuration of these five response types, which allows identifying areas of retinal damage. Since ERG records multiple retinal potentials, its capabilities are useful in diseases that affect the retina as a whole (e.g., retinitis pigmentosa). However, total ERG is not sensitive enough to detect diseases associated with subtle or local functional changes within the retina (e.g., macular degeneration).

Multifocal ERG (mfERG) is a mathematical model of the topography of retinal bioelectrical activity in the central visual field of 60° of the visual angle [2, 15, 38]. Unlike total ERG, mfERG can record responses from more than 100 different areas of the retina simultaneously and provides detailed functional topography of the retina. mfERG is more sensitive than total ERG in identifying the area of retinal dysfunction.

The response signal (wave) to mfERG consists of three main components called N1 (first negative deflection), P1 (first positive peak) and N2 (second negative deflection). The N1 response includes responses from the same structures that generate the a-wave of Ganzfeld ERG, and the P1 response includes the b-wave of photopic ERG and OP. The use of mfERG in the clinic has found wide application [10] and it has proven its sensitivity in the early detection of retinal dysfunction in various pathologies, including diabetic retinopathy [9, 10], toxic retinopathy, retinal abiotrophy [2]. However, there are many limitations to the use of mfERG, since the recorded potentials at each point under study do not always correspond to the localization of the process and the degree of pathological changes for many reasons [8]. Thus, by applying knowledge of the electroretinographic response of each of the many components, it is possible to assess the impact of myopia on different layers of the retina and its areas as a whole.

Thus, in adult patients with myopia, a decrease in the amplitude of the a-wave on the ERG was found [7, 11], which indicates the presence of abnormal functioning of the outer (photoreceptor) layer of the retina. The relationship between the ERG amplitude and the magnitude of myopia is best expressed by a linear function. It was also found that the amplitude of the a-wave on the ERG is directly proportional to the

magnitude of myopia [9] and inversely proportional to the length of the anterior-posterior axis of the eye [10, 11].

In 1960, G.E. Jayle [8] reported a violation of the function of cones in eyes with myopia.

Currently, three types of cones are distinguished by sensitivity to different wavelengths of light (colors). S-type cones (S stands for Short) are sensitive to the violet-blue part of the spectrum (443 nm), M-type (M stands for Medium) to the green-yellow part (544 nm), and L-type (L stands for Long) to the yellow-red part (570 nm). The presence of these three types of cones (and rods sensitive to the emerald-green part of the spectrum) gives a person color vision. Long-wave and medium-wave cones (with peaks in blue-green and yellow-green) have wide sensitivity zones with significant overlap, so cones of a certain type react not only to their own color – they just react to it more intensely than others [1].

The effect of myopia on the functioning of each type of cone was studied by Yamamoto S. et al. [11] using a special ERG technique. In these studies, ERG was recorded after the presentation of color stimuli obtained using different color filters. The results of the studies showed that the amplitudes of cone responses to short-, medium-, and long-wave stimuli decrease with increasing myopia, but a more significant correlation was found between the amplitude of the L, M-cone response and the magnitude of myopia [12]. These findings allowed the authors to assume that L, M-cones are affected by myopia more than S-cones.

A number of researchers note that on ERG, the amplitude of the b-wave is similar to the amplitude of the a-wave and decreases in direct proportion to the increase in myopia and inversely proportional to the length of the eye axis [7,10,12]. However, it should be noted that the interpretation of the decrease in b-wave amplitude in myopia is not as simple as in the case of the a-wave. Although studies by a number of authors report a decrease in b-wave amplitude in myopic eyes, this does not necessarily indicate the presence of a disturbance in the transmission of impulses between the outer and middle layers of the retina and post-receptor dysfunction. Most often, this occurs because the decrease in a-wave amplitude is accompanied by a directly proportional decrease in b-wave amplitud.

In the foreign literature of recent years, there are contradictory data on retinal conductivity disorders in myopia. Thus, some researchers suggest that normal signal transmission in the retina occurs in myopic eyes [10]. Perlman I. et al. reported that in all myopic eyes, a subnormal b-wave amplitude was recorded, but a normal b-/a-wave amplitude ratio. However, other researchers report that with high myopia, a decrease in the b-/a-wave amplitude ratio is noted, although its value remains within the normal range. Pallin E. et al. [12,13] believe that signal transmission in the retina has a slight tendency to decrease with high myopia.

Consequently, the ambiguity of the obtained results on retinal conductivity disorders in myopia requires further research.

In the foreign literature, there are isolated works on abnormal OP and retinal adaptation in myopic eyes [9, 10, 13]. Thus, Chen et al. [9], having studied retinal adaptation in myopic eyes using a type of mfERG with a bright flash, showed that retinal adaptation varies depending on the magnitude of myopia. Abnormal OP and retinal adaptation are possibly related to the hypothesis that dopamine may play a role in the development of myopia.

It is known that dopamine is an important chemical messenger (transmitter) for processes in amacrine and ganglion cells of the retina and is involved in light adaptation processes [14]. A number of authors have shown on experimental models that dopamine, a neurotransmitter produced by the inner layer of the retina, is associated with the development of myopia [8, 14]. It has also been established that amacrine cells of the retina play an important role in the processes of modulation and control of eyeball growth [6,10, 15].

Considering that retinal OP ERG reflects the function of amacrine cells, it can be assumed that the registration of abnormal OP in myopia indicates changes in the level of dopamine in the inner layers of the retina.

Since myopic eyes typically show dysfunction of the outer retinal layers, this may presumably cause abnormal changes in ERG parameters (including OP) in the inner retinal layers as well.

There is reason to believe that the relationship between abnormal OP and myopia should be interpreted with caution, since it is possible that abnormal OP may be caused by dysfunction of the outer retinal layers.

Macular functions in myopic eyes have been studied using mfERG by several research groups [16,17]. A statistically significant correlation was found between the first-order mfERG response and the magnitude of myopia. It was also found that the mfERG amplitude decreases with increasing its magnitude. The amplitude of the P1 parameter on mfERG is inversely proportional to the length of the anterior-posterior axis of the eye, and the time indices of the P1 peak on mfERG increase with an increase in both the length of the anterior-posterior axis of the eye and the magnitude of myopia.

Historically tested first in the 19th century, subsequently losing popularity until the 1960s and renewed interest today, at least abroad [11, 18], atropine is considered one of the effective local medications in the treatment of progressive myopia in children.

Despite the therapeutic effect of atropine, which consists in slowing down the progression of myopia, most ophthalmologists do not use atropine to treat progressive myopia. This is due to the side effects caused by prolonged local use of atropine in the

form of retinal intoxication, light retinopathy, effects on the fovea and eye accommodation, as well as the systemic effect.

Lu C.D. et al. [19] recorded mfERG responses in children who received instillations of atropine drops once a day for two years. The authors did not establish a significant effect of atropine use on retinal functioning.

Chen J.C. et al. [20] studied the changes in the OP of mfERG in emmetropia, stationary and progressive myopia. The authors found that with progressive myopia, the time indices of mfERG are significantly shorter compared to eyes with emmetropia and stationary myopia. However, no statistically significant difference was found between the groups in OP amplitudes.

Thus, based on the data reviewed in the presented foreign literature, it can be concluded that studies that included Ganzfeld ERG revealed a progressive decrease in the responses of both the a-wave (photoreceptors) and b-wave (bipolar cells) in individuals with progressive myopia and a decrease in the b-/a-wave amplitude ratio in individuals with very high myopia. Changes in the fundus in myopia occur over time and gradually with the development of posterior staphyloma, peripapillary atrophy and myopic macular degeneration, which in some patients can lead to a significant decrease in visual acuity.

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