https://doi.org/10.17116/oftalma201913504160

Influence of various means of correcting myopia on peripheral refraction depending on the direction of gaze

© E.P. TARUTTA, N.A. S. V. Tarasova MILASH, O. V. PROSKURINA, G.A. MARKOSYAN

FSBI "Moscow Research Institute of Eye Diseases named after Helmholtz "Ministry of Health of Russia, st. Sadovaya-Chernogryazskaya, 14/19, Moscow, 105062, Russian Federation

SUMMARY

Introduction. Experimental peripheral defocus controls refractogenesis.**Purpose of the study** - to evaluate the peripheral refraction (PR) of myopic eyes in different means of correction and indifferent direction of gaze.**Material and methods.** Examined 128 patients (256 eyes) aged 8-14 years with myopia from (-) 1.0 to (-) 7.0. PR was measured without correction, in perifocal (PFD), monofocal (MFO), progressive glasses (PO), monofocal soft contact lenses (MCL) and after orthokeratological exposure (OCL) with dosed gaze deviation or turning the head outward, inward , up and down with an "open field" binocular autorefkeratometer.**Results.** The PR profile without correction and with contact (OKL, MCL) correction does not depend on the direction of gaze. With glassesperipheral defocus is different when looking straight ahead and when looking away. Against the background of OCL, a significant myopic defocus is formed along the entire periphery of the retina. In the MCL, in all zones, except for the extreme temporal zone, hypermetropic defocus is enhanced. In the MFO, hyperopic defocus is formed and intensified in all zones, which is greater when the gaze is diverted than when looking straight ahead. In PO, myopic defocus is formed when looking up and down, as well as on the extreme temporal periphery of the retina when looking straight ahead. In all other zones, hyperopic defocus is increasing. In the PFD, myopic defocus is formed in most peripheral zones in all directions of gaze. The annual gradient of progression was the smallest in OCL (0.28 diopters / year) and PFO (0.26 diopters / year).**Conclusions.** Unlike contact correction, PR in glasses depends on the direction of the gaze. Inhibitory effect of opticalmeans correlates with the correction of hyperopic defocus existing in myopic eyes.

Keywords: *myopia, defocus, peripheral refraction, perifocal glasses, progressive glasses, orthokerato-logical lenses, soft contact lenses, monofocal glasses.*

INFORMATION ABOUT THE AUTHORS:

Tarutta E.P. - Doctor of Medical Sciences, Prof., Head of the Department of Refraction Pathology, Binocular Vision and Ophthalmoergonomics; https: // orcid. org / 0000-0002-8864-4518

Tarasova N.A. - Candidate of Medical Sciences, Senior Researcher of the Department of Refraction Pathology, Binocular Vision and Ophthalmoergonomics; https://orcid.org/0000-0002-3164-4306

Milash S.V. - Researcher of the Department of Refraction Pathology, Binocular Vision and Ophthalmoergonomics; https://orcid.org/ 0000-0002-3553-9896

O. V. Proskurina - Doctor of Medical Sciences, Leading Researcher of the Department of Refraction Pathology, Binocular Vision and Ophthalmoergonomics; https://orcid.org/0000-0002-2496-2533

Markosyan G.A. - Doctor of Medical Sciences, Leading Researcher of the Department of Refraction Pathology, Binocular Vision and Ophthalmoergonomics; https://orcid.org/0000-0002-2841-6396

Corresponding author: Tarasova Natalya Alekseevna - Candidate of Medical Sciences, Senior Researcher of the Department of Refraction Pathology,binocular vision and ophthalmoergonomics; https://orcid.org/0000-0002-3164-4306; e-mail: tar221@yandex.ru

The influence of different means of myopia correction on peripheral refraction depending on the direction of gaze

© EP TARUTTA, NA TARASOVA, SV MILASH, OV PROSKURINA, GA MARKOSIAN

Helmholtz Moscow Research Institute of Eye Diseases, 14/19 Sadovaya-Chernogryazskaya St., Moscow, Russian Federation, 105062

ABSTRACT

Introduction. Peripheral defocus was experimentally found to control the development of refraction.**Purpose** - to evaluate peripheral refraction (PR) of myopic eyes in terms of different means of correction and the direction of gaze.**Material and methods.** The study examined 128 patients (256 eyes) aged 8-14 years (average 11.07 ± 0.39 years) with myopia from –1.0 to –7.0 (average –3.57 ± 0.27 D). PR was measured without correction, in perifocal (PF), monofocal (MF), progressive glasses (PAL), monofocal soft contact lenses (MCL) and after orthokeratological (OCL) correction with the gaze directed straightforward or head angled outward, inward, upward and downward; all measurements were performed using binocular open-field auto ref / keratometer.

Results. PR profile without correction and with contact (OCL, MCL) correction does not depend on the direction of the gaze. In glasses, peripheral defocus is different with straightforward and skewed gaze directions. OCL forms a significant myopic defocus throughout the periphery of the retina. When using MCL, hyperopic defocus increases in all zones except the extreme temporal. In MF glasses, hyperopic defocus is formed and enhanced in all areas, significantly greater with skewed gaze than with straightforward. In PALs, myopic defocus is formed with gaze directed upward and downward, as well as at the extreme temporal periphery of the retina with straightforward gaze. In all other zones, hypermetropic defocus increases. In PF, in most zones myopic de-

focus is formed with all gaze directions. The greatest inhibitory effect on myopia progression is provided by OCL (YPR = 0.28 D / year) and PF glasses (YPR = 0.26 D / year).
Conclusion. In contrast to correction with contact lenses, PR in glasses does depend on the direction of gaze. The inhibitory effect of the optics correlates with correction of hypermetropic defocus in myopic eyes.

Keywords: *myopia, defocus, peripheral refraction, perifocal glasses, progressive glasses, orthokeratological contact lenses, soft contact lenses, monofocal glasses.*

INFORMATION ABOUT THE AUTHORS:
Tarutta EP - https://orcid.org/0000-0002-8864-4518 Tarasova NA - https://orcid.org/0000-0002-3164-4306
Milash SV - https://orcid.org/0000-0002 -3553-9896 Proskurina OV - https://orcid.org/0000-0002-2496-2533
Markosian GA - https://orcid.org/0000-0002-2841-6396**Corresponding author:** Tarasova NA - https://orcid.org/0000-0002-3164-4306; e-mail: tar221@yandex.ru

Fundamental studies in animal models have provided compelling evidence for the important role of the retinal periphery in refractogenesis [1]. The possibility has been revealed with the help of the optical defocus of the retina, induced in the peripheral regions, to influence the growth of the eye, including the local one [2-5]. Negative lenses induced hyperopic defocus and accelerated eye growth. In contrast, collecting lenses induced myopic defocus and retarded eye growth. The exact mechanisms of the eye's reaction to optical defocus are not fully understood.

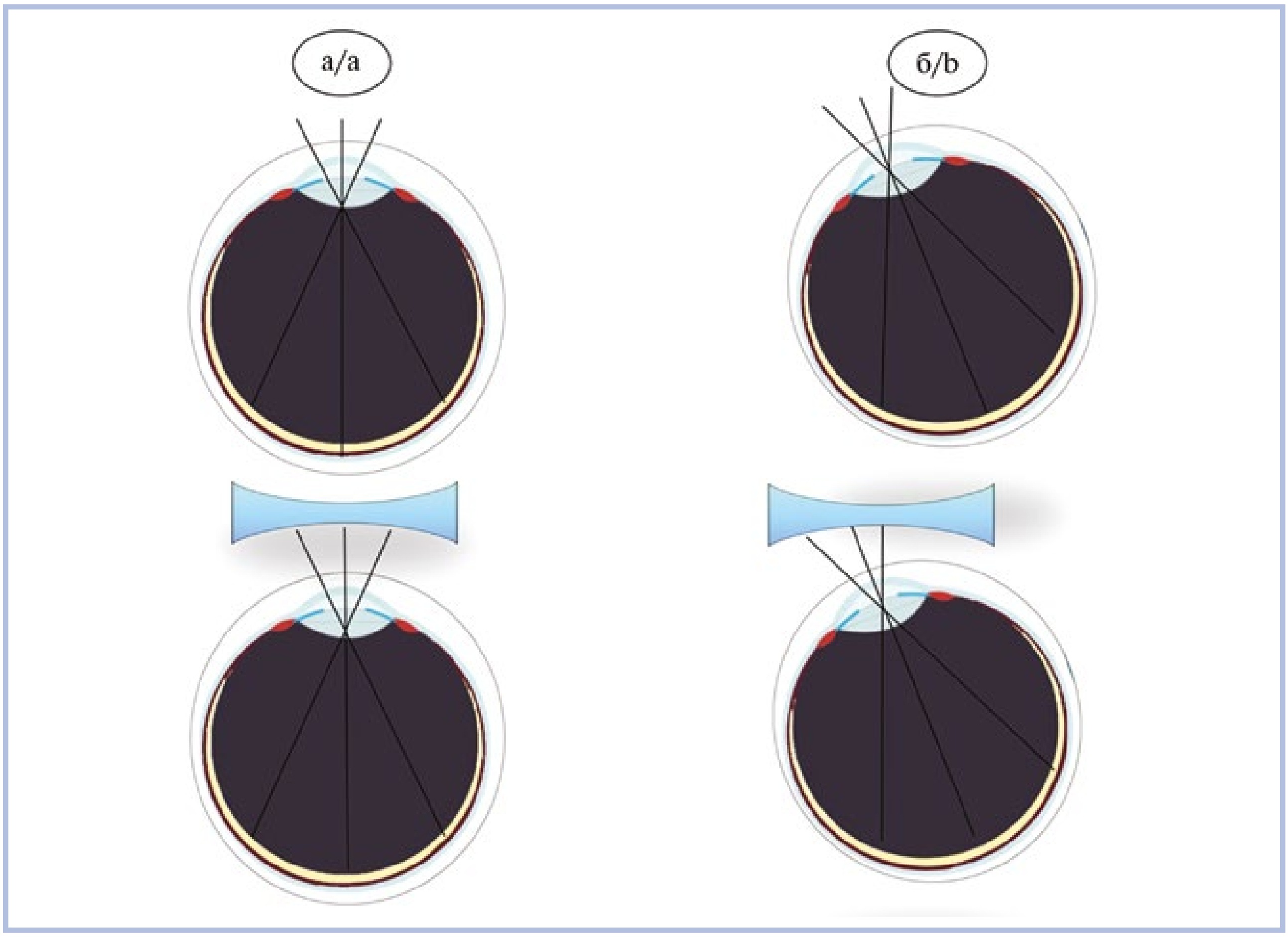
In clinical practice, no correlation has been found between natural (a consequence of the shape of the eye) peripheral refraction (PR) and eye growth. Both longitudinal [6-8] and transverse [9] studies have demonstrated that natural peripheral defocus is a consequence of eye growth, not its cause. Domestic and foreign researchers emphasize that only an induced (induced by various devices, influences, optical methods) defocus of the desired sign and magnitude is capable of inhibiting or accelerating the growth of the eye [8-10]. It is the optical strategies for preventing the progression of myopia (both in spectacle format and in the format of contact correction) that can modify PR by reducing peripheral hyperopic defocus or inducing peripheral myopia that have shown their effectiveness [11-13].

Most of the modern methods for measuring PR involves the use of an “open field” binocular autorefkeratometer. "Open field" allows you to measure PR on a narrow and wide pupil, in the horizontal plane [14], in the vertical [15] and oblique [16], including glasses and contact lenses. The measurement process consists in sequential fixation of marks or light diodes located at different distances in real space from the nasal, temporal, upper or lower sides from the center, the position of the gaze fixation mark is dosed based on the known distance to the fixation object in the center and the desired deflection angle. To fix the marks, 3 different methods are used: 1) with a dosed deviation of the gaze; 2) with an appropriate turn of the head, so as to fix the mark in the direct gaze position; 3) with the rotation of the device with the immobility of the head and eyes of the subject. In some works it was noted that when the eye is deviated, especially up to 40 °, and during long-term observation of the object, the peripheral refraction due to the pressure of the eyelids and extraocular muscles has a shift towards myopia in comparison with the measurement under the conditions of turning the head or the device [17]. In a comparative study carried out by H. Radhakrishnan and W. Charman in 2008, no significant difference was found in the results of measuring PR in intact eyes when fixing the mark with eye turn or head turn at least for a deflection angle of up to 30 ° and fixation duration less than 2.5 min [eighteen]. A completely different situation can arise when measuring under conditions of optical correction. Different parts of the spectacle lens can fall into the measurement area, depending on the chosen method.**(rice. 1)**in turn, eye movements can cause displacement (decentration) of the contact lens.

The purpose of the study is by the off-axis method (*off axis*) refractometry to evaluate the peripheral defocus of myopic eyes in different means of correction and in different directions of gaze.

Material and methods

We examined 128 patients (256 eyes) aged 8-14 years (average 11.07 ± 1.39 years) with various degrees of myopia (average (-) 3.57 ± 1.27 diopters). All patients measured PR without correction, then in perifocal glasses (PFO) (34 patients, 68 eyes), in monofocal glasses (MFO) (22 patients, 44 eyes),



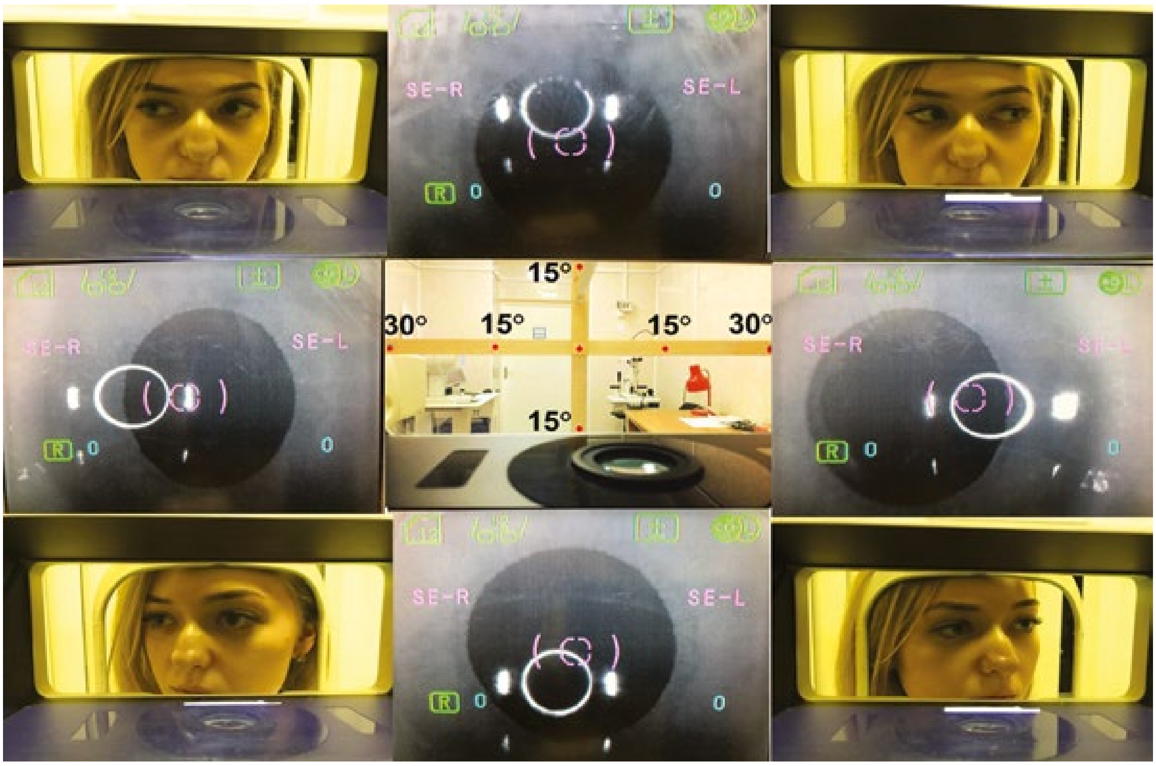
Rice. 1... **Peripheral defocusing in the forward direction (a) and with gaze deviation (b) without glasses and with glasses.**
Fig. 1.**Peripheral defocusing in the forward (a) and skewed (b) direction of gaze without glasses and with glasses.**

progressive glasses (PO) (18 patients, 36 eyes), monofocal soft contact lenses (MCL) (21 patients, 42 eyes) and after orthokeratological treatment (33 patients, 66 eyes).

Peripheral refraction (PR) was determined using an open field binocular autorefkeratometer WR-5100K (Grand Seiko Co., Ltd, Japan). For a dosed deviation of the gaze, a nozzle is designed, which is attached to the device tripod at a distance of 50 cm from the patient's eyes. The attachment has 4 marks for fixing the gaze at 15 ° and 30 ° to the nose and temple and 2 marks at 15 ° up and down from the central position**(rice. 2)**... The distance in centimeters is calculated from the Bradis tables based on the known length of one leg (50 cm) and the desired deflection angle. The study was carried out in conditions of cycloplegia. First, the refraction was determined when looking straight ahead, then sequentially when fixing each mark. When looking to the nose, refraction is measured in the nasal periphery of the retina, when looking to the temple - in the temporal. The spherical equivalent of refraction was calculated at each position. To calculate the peripheral defocus from the values of the peripheral sphere equivalent were subtracted the value of the central (axial) refraction taking into account its sign (that is, an algebraic difference was obtained, for example (-) 4.0 - (-) 5.0 = (+) 1.0 - hypermetropic defocus) ... All studies were carried out twice with a deviation of the gaze when the head was in a straight position and with a turn of the head in a direct direction of gaze (in order to preserve the situation of peripheral defocus, which existed in natural conditions when looking into the distance).

results

The research results are presented in **tab. 1-5** As seen from **tables**, without correction, in all children with moderate myopia (on average (-) 3.57 ± 0.27 diopters), hyperopic defocus was formed in all the studied areas of the retina. Its magnitude, as a rule, was greatest on the extreme nasal periphery of the retina (N30 °). In this case, it is obvious that the value of the defocus in each investigated zone was the same both when the gaze was deflected and when



Rice. 2.**Study of peripheral refraction using an "open field" autorefkeratometer in horizontal and verticalthe local field at different directions of gaze.**

Fig. 2.**Examination of peripheral refraction on binocular open-field auto ref / keratometer in horizontal and vertical field with different direction of gaze.**

Table 1. **Indicators of relative peripheral refraction (in diopters) in children without correction and in monofocal glasses with different direction of gaze (*M ± m*)**

Table 1. **Indicators of relative peripheral refraction (D) in children without correction and in monofocal glasses with different direction of gaze (*M ± m*)**

Retinal zone	Index					
	T30 °	T15 °	N15 °	N30 °	15 ° superior	15 ° inferior
Without correction:						
deviation of gaze	0.3 ± 0.04	(-) 0.06 ± 0.01	0.54 ± 0.08	1.63 ± 0.2	(-) 0.19 ± 0.02	(-) 0.12 ± 0.02
look straight	0.28 ± 0.04	(-) 0.03 ± 0.01	0.56 ± 0.08	1.61 ± 0.2	-	-
With correction:						
deviation of gaze	0.8 ± 0.06	0.14 ± 0.03	0.85 ± 0.1	1.29 ± 0.15	0.45 ± 0.04	0.37 ± 0.03
look straight	0.43 ± 0.04	0.13 ± 0.01	0.27 ± 0.03	1.59 ± 0.2	-	-

looking straight with a turn of the head (*R*> 0.05) and averaged over all groups and all meridians (+) 0.64 ± 0.06 diopters.

In the MFO with full correction, hyperopic defocus was also preserved in all the studied zones, including 15 ° upward and downward, both in the direct direction of the gaze and in its deviation.**(see table 1)**... The obtained defocus values in all zones, except for T15 °, significantly differed depending on the direction of the gaze. At T30 ° and N15 ° in the MFO, the hyperopic defocus was 1.9-3 times higher when the gaze was deviated, in the N30 ° zone it was 1.2 times higher when looking straight ahead, and only in the N15 ° zone there were no differences (0.14 ± 0.03 and 0.13 ± 0.01 diopters, respectively).

When the gaze was deviated, the initial (without correction) hyperopic defocus increased by 1.6—2.7 times in the T30 ° and N15 ° zones, passed from weakly myopic to hyperopic at T15 ° and only in the N30 ° zone decreased by 1.3 times. In the direct direction of gaze, the hyperopic defocus increased by 1.4 times in the T30 ° zone, passed from weakly myopic to hyperopic at T15 °, decreased by 2 times at N15 ° and did not change at N30 °. The average defocus value for all studied meridians for all gaze directions in the MFO was (+) 0.63 ± 0.06 diopters (without correction - (+) 0.45 ± 0.05 diopters).

In software (with full distance correction), when looking to the right-to the left, the hyperopic defocus increases

table 2... **Indicators of relative peripheral refraction (in diopters) in children without correction and in progressive glasses withpersonal direction of gaze (*M ± m*)**

Table 2. **Indicators of relative peripheral refraction (D) in children without correction and in progressive glasses with different direction of gaze (*M ± m*)**

Retinal zone	Index					
	T30 °	T15 °	N15 °	N30 °	15 ° superior	15 ° inferior
Without correction:						
deviation of gaze	0.01 ± 0.01	0.09 ± 0.01	0.41 ± 0.04	1.42 ± 0.15	(-) 0.11 ± 0.02	0.01 ± 0.01
look straight	0.02 ± 0.01	0.08 ± 0.01	0.39 ± 0.04	1.4 ± 0.15	-	-
With correction:						
deviation of gaze	0.4 ± 0.03	0.28 ± 0.03	0.98 ± 0.1	1.7 ± 0.2	(-) 0.23 ± 0.02	(-) 0.64 ± 0.06
look straight	(-) 0.48 ± 0.05	0.19 ± 0.02	0.86 ± 0.09	1.56 ± 0.15	-	-

Table 3. **Indicators of relative peripheral refraction (in diopters) in children without correction and in MCL in different directions lazy gaze (*M ± m*)**

Table 3. **Indicators of relative peripheral refraction in children without correction and in soft contact lenses with different direction of gaze (*M ± m*)**

Retinal zone	Index					
	T30 °	T15 °	N15 °	N30 °	15 ° superior	15 ° inferior
Without correction:						
deviation of gaze	0.8 ± 0.07	0.13 ± 0.02	0.4 ± 0.04	1.6 ± 0.15	0.03 ± 0.02	0.04 ± 0.02
look straight	0.78 ± 0.07	0.14 ± 0.02	0.39 ± 0.04	1.63 ± 0.15	-	-
With correction:						
deviation of gaze	0.9 ± 0.09	0.8 ± 0.08	0.78 ± 0.08	2.0 ± 0.2	0.12 ± 0.02	0.9 ± 0.05
look straight	0.4 ± 0.04	0.9 ± 0.08	0.8 ± 0.08	2.1 ± 0.2	-	-

Table 4... **Indicators of relative peripheral refraction (in diopters) in children without correction and in the PFD (Perifocal-M) whenpersonal direction of gaze (*M ± m*)**

Table 4. **Indicators of relative peripheral refraction (D) in children without correction and in perifocal glasses (perifocal-M) with different direction of gaze (*M ± m*)**

Retinal zone	Index					
	T30 °	T15 °	N15 °	N30 °	15 ° superior	15 ° inferior
Without correction:						
deviation of gaze	2.01 ± 0.15	0.36 ± 0.03	0.02 ± 0.04	1.76 ± 0.12	0.24 ± 0.03	0.15 ± 0.02
look straight	2.0 ± 0.15	0.37 ± 0.03	0.03 ± 0.04	1.73 ± 0.12	-	-
With correction:						
deviation of gaze	0.44 ± 0.04 *	(-) 0.01 ± 0.01 *	(-) 0.18 ± 0.02 *	1.25 ± 0.2	(-) 0.31 ± 0.03	(-) 0.41 ± 0.04
look straight	(-) 0.44 ± 0.03 *	(-) 0.05 ± 0.01 *	(-) 0.25 ± 0.04 *	0.38 ± 0.03 *	-	-

Note... * -*R*≤0.05 - statistically significant relative to indicators without correction.

Table 5. **Indicators of relative peripheral refraction (in diopters) in children without correction and against the background of OCL with different direction of gaze (*M ± m*)**

Table 5. **Relative peripheral refractive index (D) in children without correction and in orthokeratological contact lenses with different gaze direction (*M±m*)**

Retinal zone	Index					
	T30 °	T15 °	N15 °	N30 °	15 ° superior	15 ° inferior
Without correction:						
deviation of gaze	1.75 ± 0.2	0.4 ± 0.04	0.3 ± 0.03	1.9 ± 0.2	0.21 ± 0.03	0.17 ± 0.03
look straight	1.73 ± 0.2	0.39 ± 0.04	0.31 ± 0.03	1.87 ± 0.2	-	-
With correction:						
deviation of gaze	(-) 3.15 ± 0.3	(-) 5.75 ± 0.6	(-) 6.1 ± 0.6	(-) 3.7 ± 0.4	(-) 6.3 ± 0.7	(-) 6.3 ± 0.7
look straight	(-) 2.75 ± 0.3	(-) 5.8 ± 0.6	(-) 6.8 ± 0.7	(-) 3.3 ± 0.3	-	-

in all zones: in N15 ° - 2.4 times, in T15 ° - 3 times, in T30 ° - 40 times, in N30 ° - 1.2 times **(see table. 2)**...

When looking directly in the T15 °, N15 ° and N30 ° zones, the hyperopic defocus increased to a lesser extent than when the gaze was deviated (by 2.1, 2.1 and 1.3 times, respectively), and on the extreme temporal lobe Ripheria (T30 °), a significant myopic defocus was formed, on average (-) 0.48 ± 0.05 diopters. Myopic defocus was also formed in the vertical meridian: when looking upwards (-) 0.23 ± 0.02 diopters, when looking downwards - (-) 0.64 ± 0.06 diopters. Difference in defocus indices for different gaze directions in software turned out to be not as significant as in MFIs. On average for all zones, the hyperopic defocus in the PO was 1.6 times higher when the gaze was deviated than when looking straight ahead (0.84 ± 0.08 and 0.53 ± 0.05 diopters, respectively). The average defocus value along all meridians and directions of gaze was 0.46 ± 0.05 diopters in PO (without correction - (+) 0.37 ± 0.04 diopters).

In monofocal MCLs, hyperopic defocus is present in all studied zones of the horizontal and vertical meridians**(see table 3)**...

When the gaze was deviated, it increased in comparison with the initial (i.e., without correction) more significantly in the near periphery (6.1 times at T15 ° and at 1.9 times at N15 °) than at the far (1.1 times at T30 ° and at 1.2 times in N30 °). When looking directly at the near periphery, the hyperopic defocus also increased (at T15 ° by 3 times, at N15 ° by 2 times), in the N30 zone - insignificantly (by 1.3 times), and in the T30 ° zone it decreased by on average, 2 times. This effect was obtained due to significant myopic astigmatism that forms in many patients in the extreme temporal half of the retina, apparently due to the action of the MCL edge, as well as its displacement. With the exception of this zone (T30 °), the defocus value in conventional MCLs practically did not change when the direction of gaze was changed.**(see table. 3)**... The average value of the hyperopic defocus in the MCL along all the studied meridians and in all directions of gaze was 0.97 ± 0.11 diopters (without correction - (+) 0.6 ± 0.06 diopters).

In the Volga Federal District (Perifocal-M) **(see table. 4)** in all used the following zones, the initial hyperopic defocus decreased or turned into myopic.

Thus, when the gaze deviates to the temple at T15 °, a weak myopic defocus ((-) 0.01 ± 0.01 diopters) occurs, at T30 ° the hyperopic defocus decreases by 4.6 times. When looking to the nose at N15 °, myopic defocus is formed ((-) 0.18 ± 0.02 diopters), and at N30 °, the hyperopic defocus decreases by 1.4 times. When looking up and down, a noticeable myopic defocus is formed ((-) 0.31 ± 0.03 and (-) 0.41 ± 0.04 diopters, respectively). In the direct direction of gaze, myopic defocus is formed in all zones (in T30 ° (-) 0.44 ± 0.03, in T15 ° (-) 0.05 ± 0.01, in N15 ° - 0.25 ± 0 , 04 diopters), except for N30, where the value of the initial hyperopic defocus decreases by 4.6 times. Thus, in any direction of gaze, the claimed design features of Perifocal-M spectacle lenses reduce hyperopic defocus and form peripheral myopia in 7 out of 10 studied zones. This effect was greater when looking straight ahead than to the sides: the average value of the residual induced defocus in the VFD in the first case was (-) 0.09 ± 0.02 diopters, in the second - (+) 0.37 ± 0.04 diopters. The average defocus value in the VFD in all meridians and in all directions of gaze was (+) 0.04 ± 0.01 diopters, i.e. was practically emmetrophic (without correction - (+) 0.87 ± 0.08 diopters).

An even more pronounced effect of correction of peripheral hyperopia was noted in those who used night orthokeratological lenses (OK lenses) **(see table. 5)**...

Against the background of OCL, a significant myopic defocus was formed along the entire horizontal and vertical meridian at any direction of gaze. Its value is greater at 15 ° from the center ((-) 5.75 ± 0.6 diopters at T15 °, (-) 6.1 ± 0.6 diopters at N15 °, (-) 6.3 diopters at the top and (-) 6.3 diopters at the bottom with gaze deviation; (-) 5.8 ± 0.6 diopters at T15 ° and (-) 6.8 ± 0.7 diopters at N15 ° when looking straight ahead) and decreased towards the periphery: (-) 3.15 ± 0.3 diopters at T30 ° and (-) 3.7 ± 0.4 diopters at N30 ° when looking to the sides and (-) 2.75 ± 0.3 diopters at T30 ° and (-) 3.3 ± 0.3 diopters at N30 ° when looking straight ahead. At the same time, the value of defocus in the horizontal meridian did not differ at different gaze directions and averaged (-) 4.7 ± 0.51 diopters when looking to the sides and (-) 4.7 ± 0.52 diopters when looking directly. The averaged value of the defocus induced by OK lenses along all the studied meridians and directions of gaze was (-) 5.0 ± 0,

It seems to us interesting to compare the magnitude of defocus induced by various optical means and the rate of progression of myopia while wearing them.

For this purpose, we carried out a comparative analysis of the progression of myopia in MCL, MFO, PO, PFD and against the background of OCL according to the literature of recent years. The collected data are presented in**tab. 6** [13, 19-23]. Taking into account the fact that the progression of myopia in those using OK lenses can be assessed only by the dynamics of the length of the anteroposterior axis (PZO), the results of wearing all the listed correction means were assessed by two indicators - the dynamics of refraction and the length of the PZO (the latter in**tab. 6** marked with).

When analyzing **tab. 6** draws attention discrepancy between the dynamics of refraction according to refractometry data and in terms of the length of the PZO (based on the calculation of 1 mm of the length of the PZO = 3.0 diopters). In almost all authors, the increase in PZO, to one degree or another, outstrips the increase in refraction. In our opinion, this is due to the fact that the growth of the eye in children is partly compensated by the action of the so-called emmetropizing factors: flattening of the lens, deepening of the anterior chamber, moving the irido-lens diaphragm posteriorly, which ultimately brings the focal point closer to the retina and reduces myo - peak refraction error [24]. Over time, when the above compensatory mechanisms are exhausted, the progression of myopia becomes more pronounced, and there may even be a "jump in refraction". Obviously, for a more objective and accurate assessment of the rate of progression of myopic

Table 6. **Progression of myopia in children against the background of the use of various means of correction (summary data)**

Table 6. **Progression of myopia in children using different methods of correction (summary data)**

Term observation	OKL	MCL		Monofocal glasses		Progressive glasses		Perifocal glasses		Control group	
For 2 years, diopters	0.87 $*_1$ 0.87 $*_2$	0.53	1.23 *	1.6$_3$ 1.6$_4$ 1.95$_2$	2.4 $*_3$ 2.3 $*_4$ 1.62 $*_2$	1.35	1.8 *	0.7	0.66 *	1.4$_2$ 1.18$_6$	0.78 $*_2$ 1.5 $*_6$
For 5 years, diopters	1.71 $*_1$ 1.4 $*_2$	1,2	2.19 *	2.38$_2$	3.12 $*_2$	-	-	1.16	1.38 *	1.87$_2$ 1.95$_6$	1.71 $*_2$ 2.13$_6$
GGP, diopters / year	0.23 $*_1$ 0.28 $*_2$	0.24	0.44 *	0.48$_2$	0.62 $*_2$	0.67	0.9	0.23	0.26 *	0.37$_2$ 0.44$_6$	0.34 $*_2$ 0.47$_6$
Notes: * - calculated from ΔPZO	$_2$E.P. Tarutta, T.Yu. Verzhanskaya, 2017 [19]; $_2$MM. Sitka et al., 2018 [20]	$_2$MM. Sitka et al., 2018 [twenty]		$_3$COMET study, 2003 [21]; $_4$T. Hiraoka et al., 2012 [22]; $_2$MM. Sitka et al., 2018 [20]		$_3$COMET study, 2003 [21]		$_5$ E.P. Tarutta et al., 2015 [13]; $_6$R.A. Ibatulin et al., 2018 [23]		$_2$Sitka M.M. et al., 2018 [20]; $_6$R.A. Ibatulin et al., 2018 [23]	

Table 7. **Peripheral defocus and the rate of progression of myopia against the background of various means of correction (summary data)**

Table 7. **Peripheral defocus and rate of myopia progression per different methods of correction (summary data)**

Index	OKL	Perifocal glasses	Progressive glasses	Monofocal glasses	MCL	No correction
Defocus, diopters	(-) 5.0 ± 0.58	0.04 ± 0.01	0.46 ± 0.05	0.63 ± 0.06	0.97 ± 0.11	0.64 ± 0.06
GGP, diopters / year	0.23[19]-0.28[twenty]	0.26[13, 23]	0.9[21]	1,2[21, 22]-0.62[20, 21]	0.44[twenty]	0.47[23]

control of the PZO is optimal.

V **tab. 7** we present selected from **tab. 6**ve- the average annual gradient of myopia progression (HGP), calculated from the dynamics of the PZO length, against the background of different means of correction and in the control group, according to different authors. In the column "control group" we also placed the average value of the defocus in the uncorrected eyes of children with myopia from (-) 1.0 to (-) 7.0 (on average (-) 3.57 ± 1.27 diopters).

As follows from **tab. 7**, the greatest myopic a distal defocus on the retinal periphery (in the zone 15-30 ° from the center of the fovea) is directed by OK-lenses (on average (-) 5.0 ± 0.58 diopters). Further, according to the degree of correction of the initial hyperopic defocus, follow the PFO**(see table 7)**... The peripheral refraction induced by them corresponds to relative emmetropia. The GHP value for 5 years of follow-up in patients of these groups was minimal and practically the same: 0.23–0.28 diopters / year in patients from the OCL group and 0.26 diopters / year in patients from the PFO group. In all other cases: without correction, in MCL, MFO and PO - hypermetropic defocus was observed on the retinal periphery, the mean values of which ranged from 0.46 diopters to 1.0 diopters. The rate of myopia progression in these groups varied from 0.4 to 1.2 diopters / year.

The data presented, in our opinion, confirm the favorable effect of the elimination of the hypermetropic and the guidance of the myopic peripheral defocus on the course of myopia in children. Semi- The total emmetropic defocus in the VFD, which we have obtained, in combination with a low rate of progression of myopia, deserves a separate comment. First, as shown in**tab. 4**, in the majority (7 out of 10) of the examined zones, myopic defocus is noted, which, when calculating the average value, was leveled out mainly due to the N30 ° zone. Second, our results are in good agreement with the opinion of D. Atchison and co-authors, who believe that stabilization of myopia requires the formation of emmetropia or very weak hypermetropia at the periphery of the retina [8].

Further research will help shed light on this burning and not completely clear problem.

conclusions

1. For the first time, a comparative study was carried out. improvement of peripheral refraction in different means of correction with different directions of gaze.

2. Profile of peripheral refraction at con- tactical (orthokeratological lenses, soft contact lenses) correction, as well as in intact eyes, does not depend on the direction of gaze. With spectacle correction, the magnitude of the relative peripheral defocus is different when looking straight ahead and when looking away.

3. Orthokeratological correction forms significant myopic defocus in all areas of the retina: nasal, temporal, superior and inferior.

4. When correcting with soft contact lenses In addition, hypermetropic defocus is formed in all of the above zones, and at 15 ° to the nose and to the temple, it increases 2–3 times in comparison with the state without correction.

Only with high myopia at the extreme temporal periphery (T30 °) in soft contact lenses does myopic defocus occur on average - due to significant myopic astigmatism induced by the lens.

5. In monofocal glasses in all zones, the There is a hyperopic defocus. Its value is greater when the gaze is diverted, when the defocus increases several times compared to the initial one, and somewhat less when looking straight ahead. In the latter case, in the nasal half of the retina (N15 °), the magnitude of the hypermetropic defocus is 2 times less than the initial value.

6.Wearing progressive glasses with deviating gaze both to the temple and to the nose in all zones a hypermetropic defocus is formed, which is much larger than without correction, in magnitude. Only when looking up and especially downward is a myopic defocus formed. When looking directly at the extreme temporal periphery of the retina (T30 °), a myopic defocus occurs, in all other zones - a hyperopic one of a larger size than without glasses.

7. In perifocal glasses when looking directly into all zones, except for N 30 °, a myopic defocus; in N30 ° the hyperopic remains, but its value is 4.6 times less than before the correction. When the gaze is deviated on the middle nasal, temporal, as well as the upper and lower periphery, a myopic defocus is formed. In the T30 ° and N30 ° zones, the hyperopic remains, but its value is 1.5-3 times less than without glasses.

8. Elimination by optical means of hypermetropical and the formation of myopic defocus is consistent with the lowest rates of myopia progression. The greatest inhibitory effect on progression is exerted by orthokeratological lenses (the annual gradient of progression is 0.28 diopters / year) and perifocal glasses (the annual gradient of progression is 0.28 diopters / year), which correlates with the most pronounced correction that exists in myopic eyes with hypermetropic defocus.

Contribution of authors:
Study concept and design: E.T.
Collection and processing of material: N.T., S.M., G.M., O.P.
Statistical data processing: N.T., S.M. Text writing: N.T., S.M.
Editing: E.T.
The authors declare no conflicts of interest. The authors declare no conflicts of interest.

REFERENCES / REFERENCES

1. Smith EL 3rd, Hung LF, Huang J, Blasdel TL, Humbird TL, Bockhorst KH. Effects of Optical Defocus on Refractive Development in Monkeys: Evidence for Local, Regionally Selective Mechanisms.*Investigative Ophthalmology and Visual Science.* 2010; 51 (8): 3864-3873. https://doi.org/10.1167/iovs.09-4969

2. Smith EL, Kee CS, Ramamirtham R, Qiao-Grider Y, Hung LF. Peripheral vision can influence eye growth and refractive development in infant monkeys. *Investigative Ophthalmology and Visual Science.* 2005; 46 (11): 3965- 3972.

3. Smith EL, Hung LF, Huang J. Relative peripheral hyperopic defocus alters central refractive development in infant monkeys. *Vision Research.* 2009; 49 (19): 2386-2392.

4. Stone RA, Pendrak K, Sugimoto R, Lin T, Gill AS, Capehart C, Liu J. Local patterns of image degradation differentially affect refraction and eye shape in chick. *Current Eye Research.* 2006; 31: 90-105.

5. Smith EL 3rd, Huang J, Hung LF, Blasdel TL, Humbird TL, Bockhorst KH. Hemi-Retinal Form Deprivation: Evidence for Local Control of Eye Growth and Refractive Development in Infant Monkeys.*Investigative Ophthalmology and Visual Science.* 2009; 50 (11): 5057-5069. https://doi.org/10.1167/iovs.08-3232

6. Sng CC, Lin XY, Gazzard G, Chang B, Dirani M, Lim L, Selvaraj P, Ian K, Drobe B, Wong TY, Saw SM. Change in peripheral refraction over time in Singapore Chinese children.*Investigative Ophthalmology and Visual Science.*2011; 52 (11): 7880-7887.
https://doi.org/10.1167/iovs.11-7290

7. Lee TT, Cho P. Relative peripheral refraction in children: twelve month changes in eyes with different ametropias. *Ophthalmic and Physiological Optics.* 2013; 33 (3): 283-293. https://doi.org/10.1111/opo.12057

8. Atchison DA, Li SM, Li H, Li SY, Liu LR, Kang MT, Meng B, Sun YY, Zhan SY, Mitchell P, Wang N. Relative peripheral hyperopia does not predict development and progression of myopia in children. *Investigative Oph thalmology and Visual Science.* 2015; 56 (10): 6162-6170. https://doi.org/10.1167/iovs.15-17200

9. Tarutta EP, Iomdina EN, Kvaratskhelia NG, Milash SV, Kruzhkova GV. Peripheral refraction and refractogenesis: cause or effect?*Bulletin of Ophthalmology.* 2017; 133 (1): 70-74.
Tarutta EP, Iomdina EN, Kvaratschelija NG, Milash SV, Kruzhkova GV. Peripheral refraction: cause or effect of refraction development?*Vestnik oftal'mologii.* 2017; 133 (1): 70-74. (In Russ.). https://doi.org/10.17116/oftalma2017133170-74

10. Smith EL 3rd. Optical treatment strategies to slow myopia progression: effects of the visual extent of the optical treatment zone.*Experimental Eye Research.* 2013; 114: 77-88.
https://doi.org/10.1016%2Fj.exer.2012.11.019

11. Sun Y, Xu F, Zhang T, Liu M, Wang D, Chen Y, Liu Q. Orthokeratology to Control Myopia Progression: A Meta-Analysis. *PLoS ONE.* 2015; 10 (4): e0124535. https://doi.org/10.1371/journal.pone.0124535

12.Li SM, Kang MT, Wu SS, Meng B, Sun YY, Wei SF, Liu L, Peng X, Chen Z, Zhang F, Wang N. Studies using concentric ring bifocal and peripheral add multifocal contact lenses to slow myopia progression in school aged children: a metaanalysis. *Ophthalmic and Physiological Optics.* 2017; 37: 51-59. https://doi.org/10.1111/opo.12332

13. Tarutta E.P., Proskurina O.V., Milash S.V., Ibatulin R.A., Tarasova N.A., Kovychev A.S., Smirnova T.S., Markosyan G.A. ., Khodzhabekyan N.V., Maksimova M.V., Penkina A.V. Peripheral defocus and progression of myopia in children induced by Perifocal-M glasses.*Russian Pediatric Ophthalmology.* 2015; 2: 33-37. Tarutta EP, Proskurina OV, Milash SV, Ibatulin RA, Tarasova NA, Kovychev AS, Smirnova TS, Markosyan GA, Khodzhabekyan NV, Maksimova MV, Penkina AV. Peripheral defocus induced by "Perifocal-M" spectacles and myopia progression in children.*Rossijskaya pediatricheskaya oftalmologiya.* 2015; 2: 33-37. (In Russ.).

14. Tarutta E.P., Milash S.V., Tarasova N.A., Romanova L.I., Markosyan G.A., Epishina M.V. Peripheral refraction and retinal contour in children with myopia according to the results of refractometry and partially coherent interferometry. *Bulletin of Ophthalmology.* 2014; 130 (6): 44-49. Tarutta EP, Milash SV, Tarasova NA, Romanova LI, Markosyan GA, Epishina MV. Peripheral refraction and retinal contour in children with myopia by results of refractometry and partial coherence interferometry. *Vestnik oftal'mologii.* 2014; 130 (6): 44-49. (In Russ.).

15. Verkicharla PK, Suheimat M, Schmid KL, Atchison DA Differences in retinal shape between East Asian and Caucasian eyes. *Ophthalmic and Physiological Optics.* 2017; 37: 275-283. https://doi.org/10.1111/opo.12359

16. Queirós A, Amorim-de-Sousa A, Lopes-Ferreira D, Villa-Collar C, Gutiérrez ÁR, González-Méijome JM. Relative peripheral refraction across 4 meridians after orthokeratology and LASIK surgery. *Eye and Vision.* 2018; 5:12. https://doi.org/10.1186%2Fs40662-018-0106-1

17. Seidemann A, Schaeffel F, Guirao A, Lopez-Gil N, Artal P. Peripheral refractive errors in myopic, emmetropic, and hyperopic young subjects. Journal of the Optical Society of America. *A, Optics, Image Science, and Vision.* 2002; 19 (12): 2363-2373.

18. Radhakrishnan H, Charman WN. Peripheral refraction measurement: does it matter if one turns the eye or the head? *Ophthalmic and Physiological Optics.* 2008; 28 (1): 73-82. https://doi.org/10.1111/j.1475-1313.2007.00521.x

19. Tarutta E.P., Verzhanskaya T.Yu. Stabilizing effect of orthokeratological correction of myopia (results of a ten-year follow-up). *Bulletin of Ophthalmology.* 2017; 133 (1): 49-54. Tarutta EP, Verzhanskaya TYu. Stabilizing effect of orthokeratology lenses (tenyear follow-up results). *Vestnik oftal'mologii.* 2017: 133 (1): 49-54. (In Russ.). https://doi.org/10.17116/oftalma2017133149-54

20. Sitka M.M., Bodrova S.G., Pozdeeva N.A. The effectiveness of various methods of optical correction of progressive myopia in children and adolescents based on a comparative assessment of the study of accommodation and eye length. *Ophthalmology.* 2018; 15 (2): 65-72. Sitka MM, Bodrova SG, Pozdeeva NA. The effectiveness of various methods of optical correction of progressive myopia in children and adolescents on the basis of comparative evaluation of the study of accommodation and eye length. *Oftalmologiya.* 2018; 15 (2): 65-72. (In Russ.). https://doi.org/10.18008/1816-5095-2018-2S-65-72

21. Gwiazda J, Hyman L, Hussein M, Everett D, Norton TT, Kurtz D, Leske MC, Manny R, Marsh-Tootle W, Scheiman M. A randomized clinical trial of progressive addition lenses versus single vision lenses on the progression of myopia in children. *Investigative Ophthalmology and Visual Sci ence.* 2003; 44 (4): 1492-1500. https://doi.org/10.1167/iovs.02-0816.

22. Hiraoka T, Kakita T, Okamoto F, Takahashi H, Oshika T. Long-Term Effect of Overnight Orthokeratology on Axial Length Elongation in Childhood Myopia: A 5-Year Follow-Up Study. *Investigative Ophthalmology and Visual Science.* 2012; 53 (7): 3913-3919. https://doi.org/10.1167/iovs.11-8453

23. Ibatulin R.A., Proskurina O.V., Tarutta E.P. Multifactorial mechanisms of the therapeutic effect of perifocal glasses (Perifocal-M) on the progression of myopia in children. *Ophthalmology.* 2018; 15 (4): 433-438.

Ibatullin RA, Proskurina OV, Tarutta EP. Multifactorial mechanisms of therapeutic effects of perifocal glasses (Perifocal-M) on the progression of myopia in children. *Oftalmologiya.* 2018; 15 (4): 433-438. (In Russ.). https://doi.org/10.18008/1816-5095-2018-4-433-438

24. Mutti DO, Zadnik K, Fusaro RE, Friedman NE, Sholtz RI, Adams AJ. Optical and structural development of the crystalline lens in childhood. *Investigative Ophthalmology and Visual Science.* 1998; 39 (1): 120-133.

Received 02/09/19
Received 02/09/19
Accepted for publication 04/02/19
Accepted 04/02/19