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Correcting progressive myopia with bifocal contact lenses with central zone for distant vision: changes in accommodation and axial length (a preliminary report)

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Purpose — to assess the state of accommodation and the dynamics of changes of ocular axial length in patients with progressive myopia who use bifocal soft contact lenses (BFSCLs). **Material and methods.** The main and control groups consisted of 50 children (100 eyes) each. Patients of the main group used BFSCLs with distance-oriented central zone and added power of 4 D on the periphery. Patients of the control group were corrected with spherical soft contact lenses (SSCLs). Baseline measurements included amplitude of accommodation (AA), positive relative accommodation (PRA) and the length of anterior-posterior axis of the eye. All patients were examined before wearing SCLs and every 3 months during the entire period of observation lasting 9 to 12 months. **Results.** Correction of myopia with contact lenses is accompanied by the increase of AA and RPA. The users of BFSCLs with distance-oriented central zone and added power of 4 D on the periphery, which induces myopic peripheral defocus, had their accommodative function normalize much faster than the patients wearing SSCLs. The average increase in the ocular axial length in the BFSCLs group appeared to be significantly smaller than in the SSCLs group (0.11 and 0.58 D, respectively), which can be attributed to the simultaneous formation of the central focus and induced peripheral myopic defocus.

Keywords: *progressive myopia, bifocal contact lenses, accommodation, axial length of the eye, peripheral myopic defocus.*

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Myopia is the most common refractive error in the world. Its potential complications (central and peripheral retinal dystrophy, retinal detachment, glaucoma, etc.) had been found to correlate with significant increase of eye dimensions and the myopia level: lengthening of the anterior-posterior (A-P) axis of the eye from 24–26 to 30 mm and more correlated with 6-fold increased risks of complications [1]. This makes the search for effective non-invasive methods of prevention (control) of myopia progression a highly relevant task.

In recent years, attempts to stabilize axial length (and, consequently, the level of myopia) involved various methods of manipulating peripheral defocus and accommodation. For example, the stabilizing effect of orthokeratology correction is associated mainly with induction of peripheral myopic defocus on the retina, which can slow its growth [2].

Another factor that can influence myopia progression is the accommodation apparatus or, more precisely, its various disorders accompanied by decrease in the amplitude of accommodation (AA) and positive relative accommodation (PRA), delay in accommodation response, concomitant esophoria [3].

Recently obtained data suggests the possibility of using soft contact lenses (SCLs) of bi- and multifocal design with peripheral add power of 2.5 Diopters and higher for management of myopia [4–7]. However, the mechanism by which this method provides stabilization has not been sufficiently studied. Considering the optical design of these contact lenses (simultaneous presence of specific zones for near and distant vision), it may be possible that the stabilizing effect of correction is realized through action on the accommodation apparatus.

The purpose of the present study is to assess the state of accommodation and the changes of axial length of the eye in patients who use bifocal SCLs (BFSCLs).

Material and methods

The study included 100 patients (200 eyes) with bilateral progressing myopia (yearly gradient of progression was between 0.74 and 0.92 Diopters per year) – the main and the control groups each consisting of 50 patients (100 eyes) with mean age of 10.24±1.92 and 13.56±1.26 years, respectively. Additionally, each group was subdivided into two subgroups including patients with low and moderate myopia (M1 and C1; M2 and C2, respectively). Presence of astigmatism or anisometropia of 1.0 Diopters and higher in refraction was the criteria for exclusion from the study.

Correction of myopia in the main group was done with BFSCLs with central area designed for distant vision and add power of 4 Diopters for periphery (Russian patent no. 2657854 “Method of treating progressing myopia and lenses for treating progressive myopia” registered on 13.01.2017). Contact lenses of this design have central optical zone that provides correction of central defocus, while their periphery is meant to change peripheral refraction

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and induce peripheral myopic defocus. This study used BFSCLs PimaBIO Bi-focal (Okay Vision Retail, Russia) made from hioxifilcon B material with base curvature of 8.4 and diameter of 14.0 mm. The lenses are intended for day wearing and are changed monthly according to the planned schedule. In the control group, myopia correction was done using spherical soft contact lenses (SSCLs) by the same manufacturer and made of similar material. Selection of lenses was done according to conventional practice and with consideration of contraindication against soft CLs. Full correction of myopia for distance was the aim of the selection process.

Spherical equivalent of clinical refraction was determined by the objective and subjective methods before and after cycloplegia. Visometry was performed without correction, then with glasses, and with contact lenses. Assessment of accommodation involved measuring AA and PRA. Objective measurement of AA was done using Auto Ref/Keratometer Tonoref (Nidek Co. Ltd., Japan) capable of determining reserves of accommodation. Axial length of the eye was assessed by optical biometry on Lenstar LS 900 (Haag-Streit AG, Koeniz, Switzerland) device.

All parameters were studied before prescribing SCLs and then every 3 months during the whole period of observation lasting 9 to 12 months. Statistical analysis was done using BM SPSS Statistics 23 software.

Results and discussion

All subgroups showed improvement of AA (i.e. regardless of myopia level), which depended on the duration of use and design of the contact lenses (**Fig. 1, a**). Group M1 had AA of 2.75±0.16 Diopters before correction, which significantly ($p<0.05$) increased after 3 months – to 8.24±0.19 Diopters ($p<0.05$), and in the next 3 months almost achieved the age norm amounting to 9.67±0.26 Diopters, staying at that level for the duration of the follow-up. In O2 subgroup, the values have also significantly ($p<0.05$) improved amounting to 1.54±0.15, 7.98±0.21 and 8.45±0.23 Diopters, respectively. Participants of the control subgroups wearing SSCLs, despite similar dynamics, had AA stay lower than the age norm by 1–2 Diopters. Baseline mean AA in subgroup C1 was 2.78±0.16 Diopters, in subgroup C2 – 1.75±0.15 Diopters, increasing by the end of the follow-up period to 8.54±0.90 and 7.17±0.18 Diopters, respectively ($p<0.05$).

Similar pattern was observed with PRA (see **Fig. 1, b**). Patients of both main groups M1 and M2 had a spike increase of PRA in the first 3 months of the follow-up: in average from 1.37±0.11 to 4.64±0.17 Diopters and from 0.99±0.11 to 4.75±0.25 Diopters, respectively ($p<0.05$), with its subsequent stabilization. Despite similar tendency in the control groups, PRA improvement there was 25% less potent.

Therefore, a reliable tendency for improvement of AA and PRA was noted in both main and control groups regardless of the initial myopia level. Prescription of BFSCLs quickened normalization of the initially reduced accommodative function compared with SSCLs. The results obtained in the course of the present study support the data published earlier concerning the beneficial effects of various contact lenses on accommodation [8]. Improvement of AA and PRA, we believe, is driven by "emmetropization" of central refraction resulting from elimination of myopic defocus, which increases range of accommodation by transferring the far point of clear vision into infinity. With spectacle lenses, this effect is less pronounced and has a tendency to decrease – often due to insufficient correction (hypocorrection) [8]. The increase in AA and PRA observed in the first months of BFSCLs usage is comparable to the results of instrumental action on the accommodation apparatus. Advantages of BFSCLs over SSCLs in terms of "harmonizing" accommodation are assumed to be related to induction of peripheral myopic defocus due to the presence of add power in the peripheral part of the contact lens; however, further research is required.

The **Table** and **Fig. 2** show the results of axial length measurements in different study groups – the parameter known to be the main criteria for assessment of myopia progression. The axial length had a tendency for elongation already in the first 6 months of the follow-up in all study groups, but it was statistically unreliable. By the end of the follow-up, significant increase of the axial length was observed in SSCL users with low myopia (group C1) changing from 24.58±0.21 to 25.12±0.14 mm, i.e. an increase of 0.54±0.22 mm in 12 months ($p<0.05$). In moderate myopia group (C2), the change amounted to 0.58 mm, progressing from 25.19±0.19 to 25.32 mm (p<0.05). Thus, SSCLs showed to be reliable for gradual axial length increase regardless of myopia level. At the same time, while the tendency for axial length increase was still present in subjects with both low and moderate myopia who used BFSCLs, it had statistically unreliable effect on the axial length increasing it by 0.11 mm by the end of the follow-up.

Absence of significant "elongation" of the eye after wearing BFSCLs may be associated with the development

Mean axial length ($M±m$, mm) at various observation times

Study group	Initial axial length	After 6 months	Δ 0–6 months	p	After 12 months	Δ 0–12 months	p
O1	24,65±0,19	24,71±0,21	0,06	>0,05	24,76±0,18	0,11	>0,05
K1	24,58±0,21	24,96±0,21	0,38	>0,05	25,12±0,14	0,54	<0,05
O2	25,21±0,23	25,29±0,21	0,08	>0,05	25,32±0,21	0,11	>0,05
K2	25,19±0,19	25,59±0,22	0,31	>0,05	25,86±0,22	0,58	<0,05

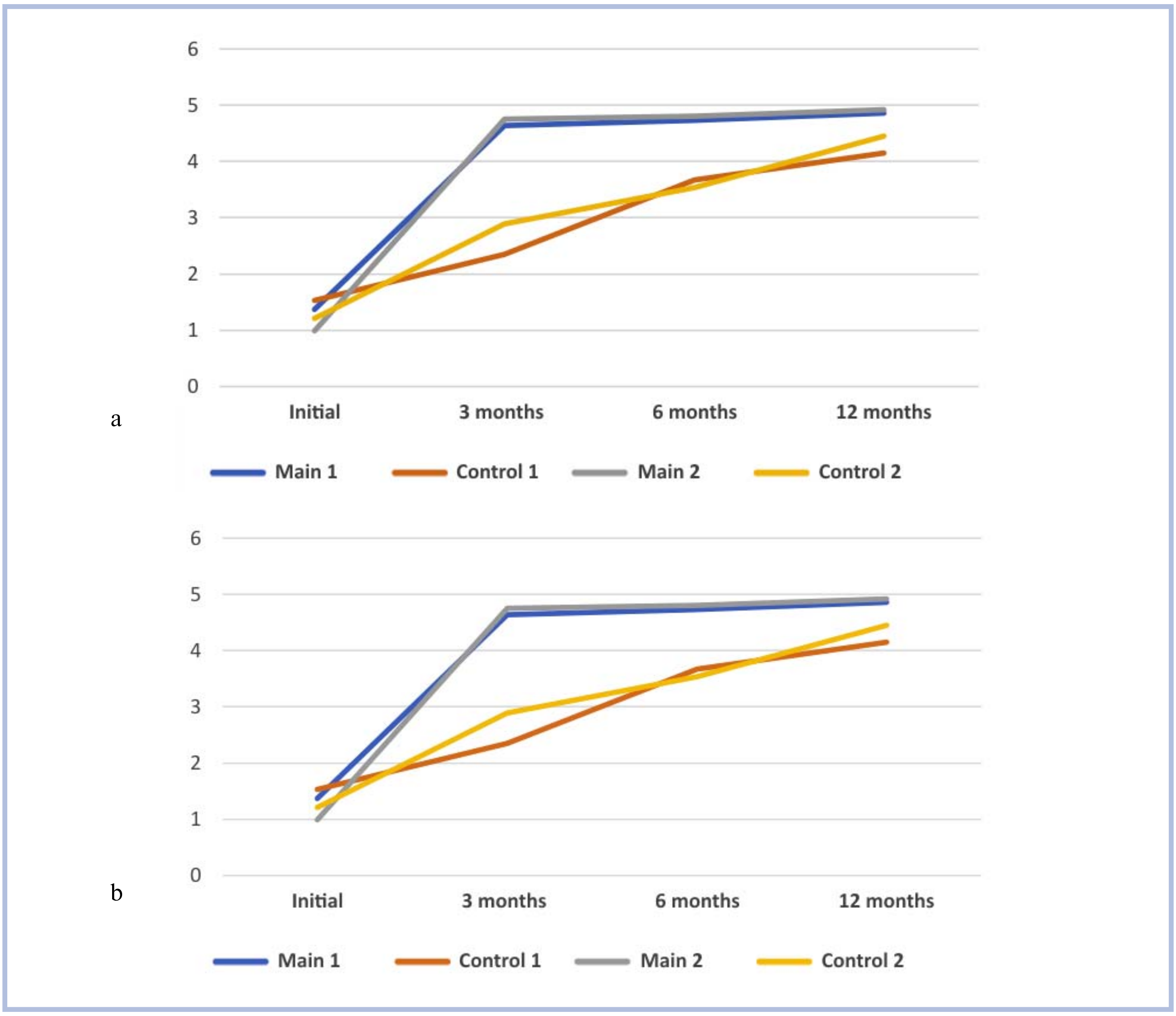

Fig. 1. **Graphic representation of AA (a) and RPA (b) dynamics in different groups.**
Horizontal axis — the parameters dynamics (Diopters), vertical axis — observation time (months).

of either central focus, or “induced” myopic peripheral defocus, formation of which was indirectly confirmed by patients’ complains about blurring peripheral vision when they looked into distance during the early periods of BF-SCLs usage. It is possible that fast adaptation to the phenomenon is explained by the relatively well-known phenomenon of reduced sensitivity to defocusing of the image in myopia [9]. Improvement of clinical refraction and eye elongation may be accompanied by the change in peripheral defocus [10].

Currently there is no consensus on the mechanism of stabilizing action that myopic peripheral defocus has on myopia progression. One possible explanation involves dopaminergic neurotransmitter system realized through amacrine cells of inner plexiform layer of the retina: formation of peripheral defocus is the initiation factor for this system. Dopamine, known to increase nerve conduction and enhance metabolic activity in the choroid, thus stimulates synthesis of proteoglycans, which in turn improve biomechanical characteristics of the sclera [11].

Conclusions

1. Correction of myopia with contact lenses is accompanied by increased amplitude of accommodation and positive relative accommodation. Usage of bifocal contact lenses with central zone for distance and add power of 4.0 Diopters for periphery, which induce myopic peripheral

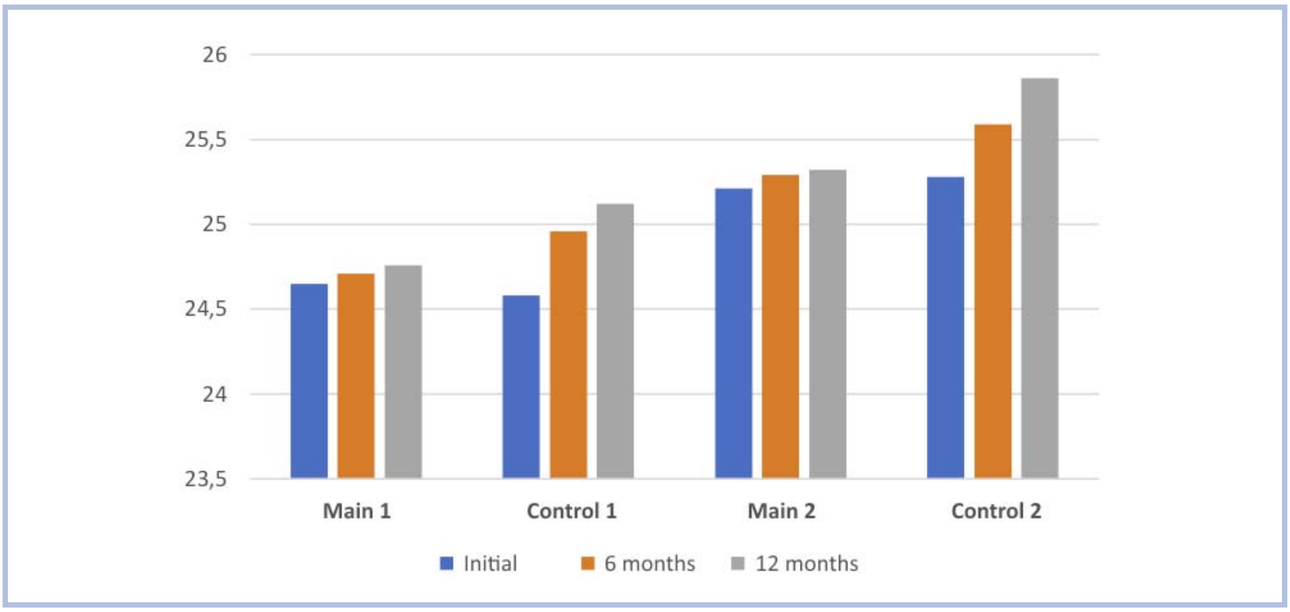

***Fig. 2.* Graphic representation of mean axial length at various observation times.**
Horizontal axis — the axial length (mm), vertical axis — observation time (months).

defocus, normalizes initially diminished accommodative function in less time than spherical soft contact lenses.

2. During the one-year observation period, mean increase of the axial length when wearing bifocal soft contact lenses turned out to be significantly less prominent than with prescribed spherical lenses (0.11 versus 0.58 Diopters, respectively), which may be caused by simultaneous formation of central defocus and induced peripheral myopic defocus.

Author contributions:
Study conception and design: S.A., A.M.
Acquisition and processing of data: A.M., A.E.
Statistical analysis: A.E.
Drafting of manuscript: A.M.
Critical revision: S.A., A.M.

The authors declare that there are no conflicts of interest.

ЛИТЕРАТУРА/REFERENCES

1. Sun J, Zhou J, Zhao PN, et al. High prevalence of myopia and high myopia in 5060 Chinise university students in Shanghai. *Invest Ophthalmol Vis Sci.* 2012;53(12):7504-7509. https://doi.org/10.1001/archophthalmol.2009.138
2. Willem J, Tideman L, Snabel Margaretha CC, et al. Association of Axial Length With Risk of Uncorrectable Visual Impairment for Europeans With Myopia. *JAMA Ophthalmol.* 2016;134(12):1355-1363. https://doi.org/10.1001/jamaophthalmol.2016.4009
3. Толорая Р.Р. *Исследование эффективности и безопасности ночных ортокератологических линз в лечении прогрессирующей близорукости:* Дис. ... канд. мед. наук. М. 2010. [Toloraya RR. *Study of efficacy and safety of night orthokeratological lenses in the treatment of progressive myopia:* Dis. ... kand. med. nauk. M. 2010. (In Russ.)]. https://elibrary.ru/item.asp?id=19224993
4. Аветисов Э.С. *Близорукость.* М.: Медицина; 2002. [Avetisov ES. *Blizorukost.* M.: Medicine; 2002. (In Russ.)].
5. Michaud L, Simard P. Myopia control with ortho-k. *CLSpectrum.* 2017;32(9): 20-26. https://www.clspectrum.com/issues/2017/september-2017/myopia-control-with-ortho-k
6. Aller TA, Liu M, Wildsoet CF. Myopia Control with Bifocal Contact Lenses: A Randomized Clinical Trial. *Optom Vis Sci.* 2016;93 (4):344-352.
7. Walline J, Greiner K, McVey M, Jones-Jordan L. Multifocal contact lens myopia control. *Optom Vis Sci.* 2013;90 (11):1207-1214. https://doi.org/10.1097/OPX.0000000000000036
8. Li SM, Kang MT, Wu SS. Studies using concentric ring bifocal and peripheral add multifocal contact lenses to Slow myopia progression in school-aged children:a meta analysis. *Ophthalmic Physiol Opt.* 2017;37(1):51-59. https://doi.org/10.1111/opo.12332.Epub2016 Nov 23
9. Зарайская М.М., Бодрова С.Г., Паштаев Н.П. Влияние различных способов коррекции близорукости на динамику ее прогрессирования у детей. *Вестник ТГУ.* 2014;19(4):1124-1127. [Zarayskaya MM, Bodrova SG, Pashtaev NP. Influence of various methods of correction of myopia on the dynamics of its progression in children. *Vestnik TGU.* 2014;19(4):1124-1127. (In Russ.)].
10. Нероев В.В., Тарутта Е.П., Арутюнян С.Г., Ханджян А.Т., Ходжыбекян Н.В. Аберрации волнового фронта и аккомодация при миопии. *Вестник офтальмологии.* 2017;2:5-9. [Neroev VV, Tarutta EP, Haroutiunian SG, Sargsyan AT, Hajibekian NV. The wave front aberrations and accommodation in myopia. *Vestnik oftal'mologii.* 2017;2:5-9. (In Russ.)]. https://doi.org/10.17116/oftalma201713325-9
11. Тарутта Е.П., Иомдина Е.Н., Кварацхелия Н.Г., Милаш С.В., Кружкова Г.В. Периферическая рефракция и рефрактогенез: причина или следствие? *Вестник офтальмологии.* 2017;1:70-74. [Tarutta EP, Iomdina EN, Kvaratskhelia NG, Milash SV, kruzhkova GV. Peripheral refraction and refractogenesis: cause or effect? *Vestnik oftal'mologii.* 2017;1:70-74. (In Russ.)]. https://doi.org/10.17116/oftalma2017133170-74
12. Лагасе Ж.П. Теория изменения ретинального периферического дефокуса и прогрессирование миопии. *Вестник оптометрии.* 2011;1:48-57. [Lagace JP. The Theory of change of the retinal peripheral defocus and myopia progression. *Vestnik optometrii.* 2011;1:48-57. (In Russ.)].

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