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OPTICAL BIOMETRY FEATURES IN SILICON OIL FILLED EYES

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✧ ***Background.*** The article presents results of axial length (AL) measurement in eyes filled with silicone oil and in those without silicone oil with IOLMaster and Lenstar LS 900 optical biometry methods. ***Materials and methods.*** The anteroposterior axis was measured in 27 eyes of 27 patients with silicone oil tamponade after surgical treatment of several vitreoretinal conditions. Using IOLMaster, the AL of eyes without silicone oil tamponade varied from 21.99 mm to 29.38 mm, Lenstar LS 900 biometry gave results from 21.96 mm to 29.41 mm. ***Results.*** According to data obtained and to their distribution, all cases were divided into 2 groups: I group — eyes with AL less than 23.63 mm, and II group — eyes with AL more than 23.63 mm. In the group II, the disparity of consecutive measurements was reliable and amounted to 0.28 ± 0.46 mm ($p = 0.024$) for IOLMaster and 0.23 ± 0.44 mm ($p = 0.029$) for Lenstar LS 900. ***Conclusion.*** So AL values at IOLMaster and Lenstar LS 900 biometry of silicone oil filled eyes may significantly overestimate the real ones when exceeding 23.63 mm. In case of simultaneous phacoemulsification with IOL implantation, this could lead to hypermetropic shift of postoperative refraction. Lenstar LS 900 measurement error in silicon oil filled eyes is less than that of IOLMaster, thus making the first biometry method preferable. In eyes with AL shorter than 23.63 mm, the measurement difference was not reliable, thus the biometry accuracy in silicone oil filled “short” eyes becomes higher.

✧ ***Keywords:*** optical biometry; silicone oil filled eye; IOL power calculation.

ОСОБЕННОСТИ ОПТИЧЕСКОЙ БИОМЕТРИИ ГЛАЗ С СИЛИКОНОВОЙ ТАМПОНАДОЙ СТЕКЛОВИДНОЙ КАМЕРЫ

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✧ ***Резюме.*** В работе представлены результаты измерения аксиальной длины глаз на фоне тампонады стекловидной камеры (СК) силиконовым маслом (СМ) и без неё с помощью оптической биометрии IOLMaster и Lenstar LS 900. ***Материал и методы.*** Выполнено измерение передне-задней оси (ПЗО) 27 глаз 27 пациентов с силиконовой тампонадой (СТ) после хирургического лечения различных витреоретинальных патологий. По данным IOLMaster величина ПЗО глаз вне СТ варьировала от 21,99 до 29,38 мм, по данным Lenstar LS 900 — от 21,96 до 29,41 мм. ***Результаты.*** На основании полученных значений и их распределения относительно величин ПЗО наблюдения были разделены на две группы: I группа — с ПЗО менее 23,63 мм, II группа — с ПЗО более 23,63 мм. Во II группе разница последовательных измерений была достоверной и составила для IOLMaster 0,28 ± 0,46 мм ($p = 0{,}024$), а для Lenstar LS 900 — 0,23 ± 0,44 мм ($p = 0{,}029$). ***Выводы.*** При аксиальной длине глаза выше 23,63 мм биометрия IOLMaster 500 и Lenstar LS 900 на фоне СТ СК может давать значимо завышенные значения ПЗО, что приведёт к гиперметропическому сдвигу послеоперационной рефракции в случае одномоментной замены хрусталика. Разница измерений Lenstar LS 900 при наличии СМ в витреальной полости и без него меньше, чем у IOLMaster, что делает его предпочтительным методом биометрии. Для глаз с аксиальной длиной менее 23,63 мм эта разница измерений недостоверна, что снижает погрешность биометрии «коротких» глаз на фоне СТ витреальной полости.

✧ ***Ключевые слова:*** оптическая биометрия; силиконовая тампонада; расчёт силы ИОЛ.

INTRODUCTION

Modern vitreoretinal surgery (VRS) with temporary tamponade of the vitreous chamber using silicone oil is the gold standard treatment for retinal detachment complicated by stage C proliferative vitreoretinopathy (PVR) [1–4]. Silicone oil may remain in the vitreous chamber for up to several months [5, 6]. However, its contact with the lens for 2 weeks to 2 years can trigger the development of cataract in 60%–100% of cases [5, 7–10], necessitating phacoemulsification and intraocular lens (IOL) power calculation in a silicone-tamponaded eye. The procedure is particularly challenging in patients with ocular disorders that hinder biometry at the initial stage, such as retinal detachment involving the central area (maculaoff), funnel-type retinal detachment, significant epiretinal membranes, and choroidal detachment. Combined VRS with extrascleral constructions changes the axial eye length (AEL) and requires postoperative biometry and IOL power calculation in a silicone-tamponaded eye with subsequent IOL implantation. Low visual acuity and difficulties with gaze fixation [11–13], observed in patients with posterior segment eye diseases and tamponaded eyes, significantly affect the accuracy of AEL measurement. Inaccurate measurement is the main cause of refractive errors in surgeries combined with phacoemulsification. Therefore, accurate ocular biometry in silicone-tamponaded eyes is highly relevant for patients requiring phacoemulsification and IOL implantation combined with VRS.

We compared the results of AEL measurement in eyes with a silicone oil-tamponaded vitreous chamber with normal eyes using optical biometry with the IOLMaster (Carl Zeiss Meditec, Germany) and Lenstar LS900 (HaagStreit, Koeniz, Switzerland) devices.

MATERIALS AND METHODS

We analyzed the results of optical biometry conducted in 27 patients (27 eyes; mean age, 58.04 ± 19.11 years; range, 20–84 years) who underwent surgery for macular hole (MH) > 450 μm, retinal detachment complicated by stage C PVR, or endophthalmitis. Patients with pronounced postoperative corneal edema that prevented AEL measurement were examined after edema regress. AEL was measured using Lenstar LS900 and IOLMaster biometers in silicone-tamponaded eyes (using the regimen “silicone oil filled” in Lenstar LS900) and in eyes without silicone oil. We also used “pseudophakic acrylate” and “aphakic” regimens in patients who had previously undergone IOL implantation. We excluded patients who required extrascleral constructions in the intervals between measurements. Without silicone oil, the AEL was 21.99–29.38 (mean 24.36 ± 1.74) and 21.96–29.41 (24.44 ± 1.78) mm as measured by the IOLMaster and Lenstar LS900 devices, respectively.

Statistical analysis was performed using Microsoft Excel 2010 (Microsoft, Inc., Redmond, WA, USA) and IBM SPSS Statistics 23.0 (IBM SPSS, Inc., Chicago, IL, USA). Differences were considered significance at $p < 0.05$.

RESULTS

The calculated differences between AELs measured with and without silicone oil using both devices are shown in Figures 1 and 2. Considering the AEL of the schematic model of the human eye developed by Gullstrand in 1908 [14] and the area where the trend line crossed the x-axis, we divided the study participants into two groups. Group 1 included patients with AEL < 23.63 mm (11 eyes: seven eyes with MH, one after endophthalmitis surgery, two with retinal detachment, and one with epiretinal fibrosis, degenerative retinoschisis, and peripheral retinal rupture). Group 2 included patients with AEL ≥ 23.63 mm (16 eyes: three with MH, one after endophthalmitis surgery, and 12 with retinal detachment).

In Group 1, AELs measured using the IOLMaster and Lenstar LS900 devices were 22.69 ± 0.67 and 22.71 ± 0.66, and 22.81 ± 0.56 and 22.81 ± 0.59 mm, respectively, for eyes with and without silicone oil tamponade, respectively (Table 1). The differences between AELs measured in tamponaded and normal eyes were −0.12 ± 0.25 ($p = 0.130$) and −0.09 ± 0.23 ($p = 0.213$) mm for the IOLMaster and Lenstar LS900 devices, respectively (Table 1). Mean difference between AELs in eyes with and without tamponade measured by the

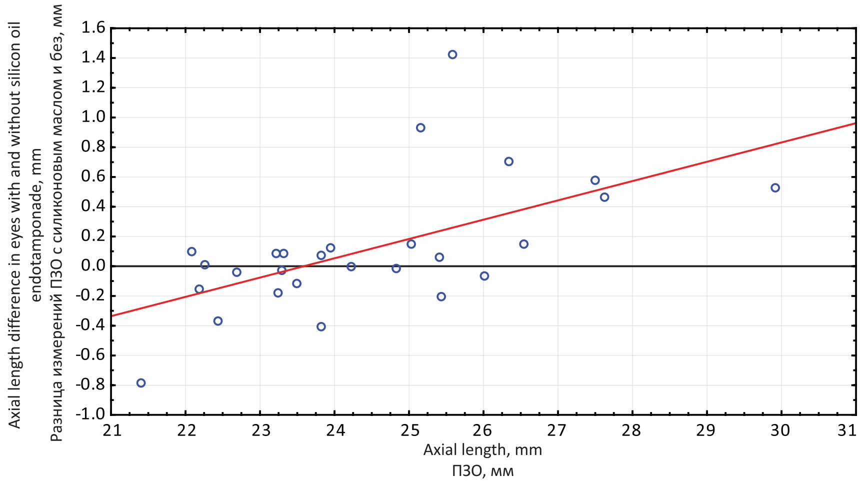

Fig. 1. Axial length difference in eyes with and without silicon oil endotamponade, IOLMaster biometry

Рис. 1. Разница измерений передне-задней оси на фоне силиконовой тампонады и без при биометрии IOLMaster

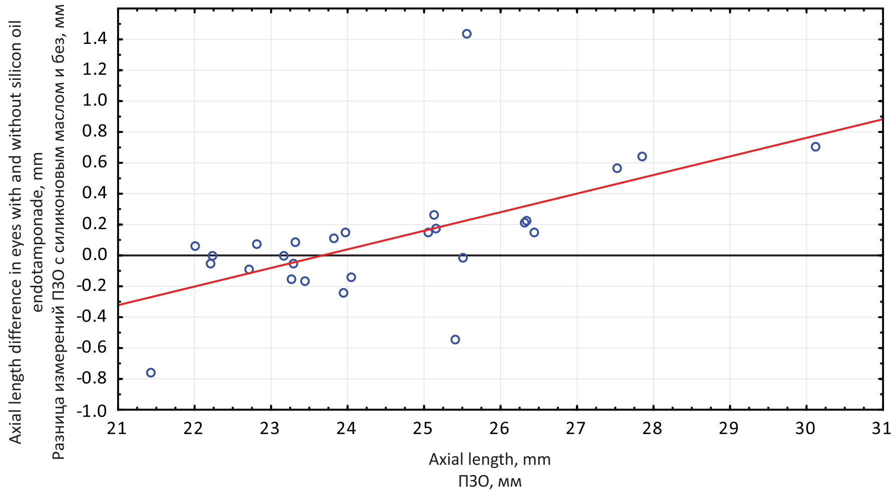

Fig. 2. Axial length difference in eyes with and without silicon oil endotamponade, Lenstar LS 900 biometry

Рис. 2. Разница измерений передне-задней оси на фоне силиконовой тампонады и без при биометрии Lenstar LS 900

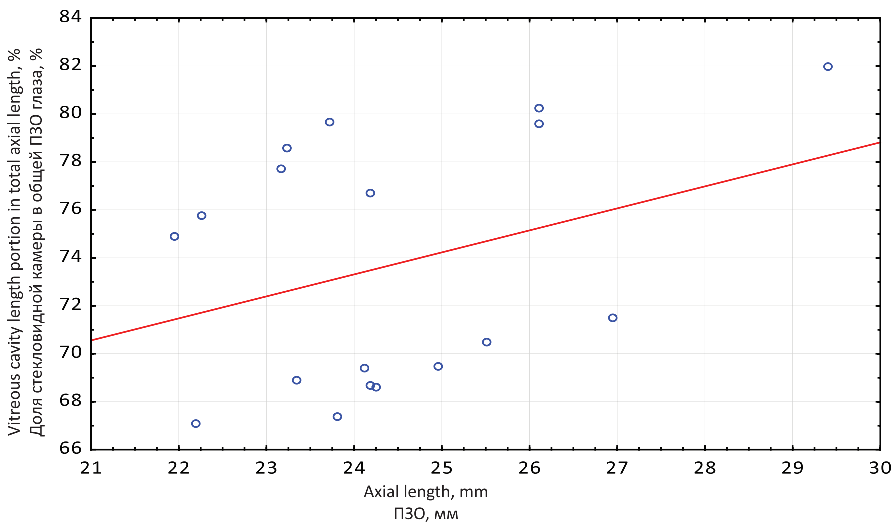

Fig. 3. Vitreous cavity length portion in total axial length according Lenstar LS 900 biometry

Рис. 3. Доля стекловидной камеры без силиконового масла в общей передне-задней оси глаза при биометрии Lenstar LS 900

Table 1 / Таблица 1

Axial length evaluation with different biometry methods
Величина передне-задней оси при измерении с помощью биометров разного типа

Group	Biometry method	Silicone tamponade of the vitreous chamber, mm		Difference in AELs, mm	Significance of differences (Wilcoxon test), *p*
		With	Without		
I	IOLMaster	22.69 ± 0.67	22.81 ± 0.56	–0.12 ± 0.25	0.130
	Lenstar LS 900	22.71 ± 0.66	22.81 ± 0.57	–0.09 ± 0.23	0.213
II	IOLMaster	25.69 ± 1.63	25.41 ± 1.51	0.28 ± 0.46	0.024
	Lenstar LS 900	25.76 ± 1.67	25.52 ± 1.51	0.23 ± 0.44	0.029

Table 2 / Таблица 2

Axial length difference in eyes with and without silicon oil endotamponade in groups using various biometry methods
Разница измерений передне-задней оси приборами разного типа на фоне силиконовой тампонады и без между группами

Biometry method	Changes in Group 1	Changes in Group 2	Significance of differences (Mann-Whitney test), *p*
IOLMaster. mm	–0.12 ± 0.25	0.28 ± 0.46	0.016
Lenstar LS 900, мм	–0.09 ± 0.23	0.23 ± 0.44	0.007

Lenstar LS900 was slightly lower than that measured by the IOLMaster.

In Group 2, AELs measured by the IOLMaster and Lenstar were 25.69 ± 1.63 and 25.76 ± 1.67 mm, respectively, in silicone-tamponaded eyes, and 25.41 ± 1.51 and 25.52 ± 1.51 mm, respectively, in eyes without silicone oil. We observed a significant difference between the results of serial AEL measurements in Group 2: 0.28 ± 0.46 ($p = 0.024$) and 0.23 ± 0.44 ($p = 0.029$) mm with the IOLMaster and Lenstar LS900, respectively (Table 1).

There was a trend towards underestimation of mean AELs in eyes with silicone oil in Group 1 and towards overestimation in Group 2 (Figs. 1, 2). Mean difference between measurements obtained with the Lenstar LS900 was lower than that obtained with IOLMaster (Table 1).

We also compared the differences in AEL in eyes with and without tamponade between the two groups. In Group 2, the difference was significantly higher than in Group 1 for the IOLMaster (Mann-Whitney U test, $p = 0.016$) and Lenstar LS900 (Mann-Whitney test, $p = 0{,}007$) measurements (Table 2).

Using Lenstar LS900, we also estimated the size of the vitreous cavity compared with the total eyeball length. The vitreous cavity fraction varied between 67.10% and 80.23% (73.37% ± 4.70%) and did not correlate with AEL (Spearman correlation coefficient 0.18, $p > 0.05$).

DISCUSSION

Evaluation of average refractive indices of the ocular media in silicone-tamponaded eyes with extreme AELs using devices, such as the IOLMaster, can lead to measurement errors despite the special biometric regimens offered by the manufacturer. This can cause significant deviations in the refractive result from the planned one due to inaccurate IOL power calculation, because this device does not allow segment-by-segment estimation of eyeball length [15, 16]. The Lenstar LS900 demonstrated less significant differences in AEL between eyes with and without tamponade in both groups. Our findings suggested a higher accuracy of this device compared to the IOLMaster, which certainly is associated with use of the average refractive index for each measured segment, including the vitreous cavity.

We found no correlation between vitreous cavity size (percentage of total eyeball length) and AEL. We also observed no significant differences in biometric parameters between the IOLMaster and Lenstar LS900 measurements in Group 1. These facts prevented us from concluding that a smaller error is associated with a decreased vitreous cavity fraction, which has a refractive index different from the average refractive index, in the total eye length when converting the optical wavelength into a geometric distance. Most probably, it can be attributed to small sample size and requires additional observations.

Some investigators believe that significant inaccuracy in IOL power calculation associated with errors in AEL measurement in a silicone-tamponaded eye can be addressed by lens replacement (repetitive surgery) 2–3 months after receiving more accurate measurements [17]. In our opinion, this treatment strategy increases the risk of complications, including recurrent retinal detachment, infectious complications, etc. Increased accuracy of IOL power calculation will help avoiding repeated surgeries and reducing the probability of complications; thus, decreasing the time of rehabilitation and professional adaptation of patients after treatment.

We observed an insignificant underestimation (Group 1) and a significant overestimation (Group 2) of mean AELs (evaluated with the IOLMaster and Lenstar LS900) in silicon-tamponaded eyes. This finding suggested that, in the case of IOL implantation, target refraction should be low myopia in eyes with AEL > 23.63 mm and low hypermetropia in eyes with AEL < 23.63 mm to avoid measurement errors in silicone-tamponaded eyes and incorrect final refraction. However, such recommendations certainly must be confirmed by further studies.

CONCLUSION

Use of the IOLMaster and Lenstar LS900 in silicone-tamponaded eyes with AEL > 23.63 can lead to measurement errors, despite the special biometric regimens "silicone-filled eye" and "silicone oil–filled." Overestimated AELs will lead to a hypermetropic shift in postoperative refraction in the case of simultaneous lens replacement. The Lenstar LS900 demonstrated less significant differences in AEL between eyes with and without tamponade than the IOLMaster, which makes it a method of choice in eyes requiring simultaneous removal of silicone oil and complicated cataract surgery. This difference was insignificant in eyes with AEL < 23.63 mm, which reduces the possibility of errors in "shorter" eyes with silicone tamponade of the vitreous cavity.

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Authors' contribution:

A.N. Kulikov and E.V. Kokareva developed the research concept.

A.R. Kuznetsov performed data analysis and drafted the manuscript.

REFERENCES

1. Захаров В.Д., Ходжаев Н.С., Горшков И.М., Маляцинский И.А. Современная хирургия рецидива отслойки сетчатки. Обзор литературы // Офтальмология. – 2012. – Т. 9. – № 1. – С. 10–13. [Zakharov VD, Khodzhaev NS, Gorshkov IM, Malyatsinskiy IA. Current surgery of Retinal detachment recurrence. Review. *Ophthalmology in Russia.* 2012;9(1):10-13. (In Russ.)]. doi: 10.18008/1816-5095-2012-1-10-13.
2. Тахчиди Х.П. Состояние эндовитреальной хирургии — реальности времени / Тезисы докладов IX Съезда офтальмологов России; Москва, 16–18 июня 2010 г. – М., 2010. – С. 232–233. [Tahchidi HP. Sostoyanie endovitreal'noy khirurgii – real'nosti vremeni. In: Proceedings of the 9th Congress of Ophthalmologists of Russia; Moskow, 16-18 Jun 2010. Moscow; 2010. P. 232-233. (In Russ.)]
3. Riemann CD, Miller DM, Foster RE, Petersen MR. Outcomes of transconjunctival sutureless 25-gauge vitrectomy with silicone oil infusion. *Retina*. 2007;27(3):296-303. doi: 10.1097/01.iae.0000242761.74813.20.
4. Shah CP, Ho AC, Regillo CD, et al. Short-term outcomes of 25-gauge vitrectomy with silicone oil for repair of complicated retinal detachment. *Retina*. 2008;28(5):723-728. doi: 10.1097/IAE.0b013e318166976d.
5. Касьянов А.А., Сдобникова С.В., Троицкая Н.А., Рыжкова Е.Г. Расчёт оптической силы интраокулярной линзы у пациентов с силиконовой тампонадой // Вестник офтальмологии. – 2015. – Т. 131. – № 5. – С. 26–31. [Kas'yanov AA, Sdobnikova SV, Troitskaya NA, Ryzhkova EG. Intraocular lens power calculation in silicone-filled eyes. *Annals of ophtalmology*. 2015;131(5):26-31. (In Russ.)]. doi: 10.17116/oftalma2015131526-31.
6. Столяренко Г.Е., Сдобникова С.В. Современное состояние трансвитреальной хирургии глаза // Вестник Российской академии медицинских наук. – 2003. – № 2. – С. 15–20. [Stolyarenko GE, Sdobnikova SV State-of-art of endo-and transvitreal surgery of the eye. *Annals of the Russian Academy of Medical Sciences.* 2003;(2):15-20. (In Russ.)]
7. Юодкайте Г.Ю. Изменение тканей глаза при введении силикона в стекловидное тело // Офтальмологический журнал. – 1971. – Т. 26. – № 2. – С. 96–98. [Yuodkayte GY. Izmenenie tkaney glaza pri vvedenii silikona v steklovidnoe telo. *Oftalmol Zh.* 1971;26(2):96-98. (In Russ.)]
8. Batra A, Vemuganti GK, Das T, et al. Does Silicone Oil Penetrate the Lens Capsule? *Retina.* 2001;21(3):275-277. doi: 10.1097/00006982-200106000-00019.
9. Oner HE, Durak I, Saatci OA. Phacoemulsification and foldable intraocular lens implantation in eyes filled with silicone oil. *Ophthalmic Surg Lasers Imaging*. 2003;34(5):358-362. doi: 10.3928/1542-8877-20030901-03.
10. Tanner V, Haider A, Rosen P. Phacoemulsification and combined management of intraocular silicone oil. *J Cataract Refract Surg*. 1998;24(5):585-591. doi: 10.1016/s0886-3350(98)80250-2.
11. Аванесова Т.А. Регматогенная отслойка сетчатки: современное состояние проблемы // Офтальмология. – 2015. – Т. 12. – № 1. – С. 24–32. [Avanesova TA. Rhegmatogenous retinal detachment: current opinion. *Ophthalmology in Russia.* 2015;12(1):24-32. (In Russ.)]. doi: 10.18008/1816-5095-2015-1-24-32.
12. Gharbiya M, Grandinetti F, Scavella V, et al. Correlation between Spectral-Domain Optical Coherence Tomography Findings and Visual

Outcome after Primary Rhegmatogenous Retinal Detachment Repair. *Retina*. 2012;32(1):43-53. doi: 10.1097/IAE.0b013e3182180114.
13. Wakabayashi T, Oshima Y, Fujimoto H, et al. Foveal microstructure and visual acuity after retinal detachment repair: imaging analysis by Fourier-domain optical coherence tomography. *Ophthalmology*. 2009;116(3):519-528. doi: 10.1016/j.ophtha.2008.10.001.
14. Gullstrand A. Die Optische Abbildung in heterogen Medien die Dioptrik der Kristallince des Menschen. *K Sven Vetenskapsakad Handl*. 1908;43:1-32. (In German).
15. Даниленко Е.В. Оптимизация расчёта оптической силы интраокулярной линзы, имплантируемой при факоэмульсификации: Дис. … канд. мед. наук. – СПб., 2012. [Danilenko EV. Optimizatsiya rascheta opticheskoy sily intraokulyarnoy linzy, implantiruemoy pri fakoemul'sifikatsii. [dissertation] Saint Petersburg; 2012. (In. Russ.)]
16. Haigis W, Lege B, Miller N, Schneider B. Comparison of immersion ultrasound biometry and partial coherence interferometry for intraocular lens calculation according to Haigis. *Graefes Arch Clin Exp Ophthalmol*. 2000;238(9):765-773. doi: 10.1007/s004170000188.
17. Dietlein TS, Roessler G, Luke C, et al. Signal quality of biometry in silicone oil-filled eyes using partial coherence laser interferometry. *J Cataract Refract Surg*. 2005;31(5):1006-1010. doi: 10.1016/j.jcrs.2004.09.049.

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