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Analysis of the surgical treatment results of large idiopathic macular holes using tamponade with internal limiting membrane flaps and platelet-rich plasma

Andrey D. Shchukin, Anastasia G. Veryasova, Yury V. Gnatyuk, Oleg B. Smirnov

Saint Petersburg Multifield Hospital No. 2, Saint Petersburg, Russia

ABSTRACT

BACKGROUND: Penetrating macular holes of the retina remain today one of the main reasons for a significant loss of central vision, especially in working age patients. At the same time, the mainstream problem are the validity and effectiveness of treatment of large and giant macular holes with a diameter of more than 500–1000 μm.

AIM: to optimize the treatment method for patients with large and long-standing macular holes. To analyze the results of treatment of patients with this condition.

MATERIALS AND METHODS: In 2023, 56 patients were operated on for idiopathic large macular hole. During vitrectomy, a new surgical technique was used for the macular hole bed tamponade with flaps of the internal limiting membrane in combination with the introduction of platelet-rich plasma.

RESULTS: After the resorption of the gas-air mixture (1–1.5 months after surgery), ophthalmoscopically and according to optical coherence tomography data, closure of the macular hole was observed in 51 of 56 operated patients, which amounted to 91.1%.

CONCLUSIONS: The surgical treatment technique used allows for closure of large macular holes in 91.1%.

Keywords: macular hole; microinvasive vitrectomy; platelet-rich plasma; internal limiting membrane.

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Анализ результатов хирургического лечения больших идиопатических макулярных разрывов с использованием тампонады лоскутами внутренней пограничной мембраны и богатой тромбоцитами плазмы

А.Д. Щукин, А.Г. Верясова, Ю.В. Гнатюк, О.Б. Смирнов

Городская многопрофильная больница № 2, Санкт-Петербург, Россия

АННОТАЦИЯ

Актуальность. Сквозные макулярные разрывы сетчатки на сегодняшний день остаются одной из основных причин значительного снижения центрального зрения, особенно у пациентов трудоспособного возраста. При этом наибольшую проблему вызывает обоснованность и результативность лечения больших и гигантских макулярных разрывов диаметром более 500–1000 мкм.

Цель — оптимизировать методику лечения пациентов с большими и длительно существующими макулярными разрывами. Проанализировать результаты лечения пациентов с данной патологией.

Материалы и методы. За 2023 г. прооперировано 56 пациентов по поводу идиопатического большого макулярного разрыва. При этом в ходе витрэктомии использовали новую хирургическую методику тампонады ложа макулярного разрыва лоскутами внутренней пограничной мембраны в сочетании с введением богатой тромбоцитами плазмы.

Результаты. После резорбции газовоздушной смеси (через 1–1,5 мес. после операции) офтальмоскопически и по данным оптической когерентной томографии наблюдалось закрытие макулярного разрыва у 51 из 56 прооперированных пациентов, что составило 91,1 %.

Выводы. Применяемая хирургическая техника лечения позволяет добиться закрытия больших макулярных разрывов в 91,1 %.

Ключевые слова: макулярный разрыв; микроинвазивная витрэктомия; богатая тромбоцитами плазма; внутренняя пограничная мембрана.

Как цитировать

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BACKGROUND

Penetrating macular holes (MH) of the retina remain today one of the main reasons for a significant loss of central vision, especially in working age patients. Penetrating MH is an acquired disease, at which a full-thickness defect is observed in the foveolar part of the retina — from the internal limiting membrane to the exterior segment of the photoreceptor layer [1]. Yearly prevalence of this disease is 8.69 cases per 100,000 people [2]. The peak incidence falls on the sixth-seventh decade of patients' life, women are susceptible to this disease 3 times more often than men. In 15–20% of cases, the MH develops in both eyes. The occurrence of full-thickness MH leads to progressing decrease of visual acuity, appearance of metamorphopsias, and this significantly reduces the patients' quality of life.

The main method of treatment for MH patients is a surgical procedure aimed at the closure of the anatomical defect of the retina in any way, what predetermines future increase of visual functions. To this date, the microinvasive 25G or 27G vitrectomy with staining and removal of the internal limiting membrane (ILM) to increase the mobility of macular hole's edges with subsequent air-gas tamponade is commonly believed to be a gold standard of treatment for MH patients. As a rule, this method alone allows to reach good anatomical results in treatment of small MH (of a diameter up to 400 μm) with disease duration up to 6 months.

Among additional mechanisms of intraoperative closure of retinal defect in the foveolar area, following directions are highlighted [3]:

1. Use of an inverted ILM flap (flaps) or fragment, which is not completely detached from the macular edge.

2. Mechanical opposition or approximation of macular defect edges.

3. Use of bio-adhesive substances — of platelet-rich plasma (PRP) or of autologous conditioned plasma (ACP), of autologous blood.

Without an additional use of above-mentioned methods in treatment of large (minimal diameter more than 400 μm) and old (existing more than 6 months) MH, acceptable anatomical results are not always achieved. The detection rate of MH of III–IV stages (according to the classification by J.D. Gass), according to data of various authors, amounts to 86–93% [4]. In the case of recurrent failure of MH closure, after surgery, it often increases in dimensions, its edges become more rigid, the patient's visual acuity worsens [5]. If surgical treatment of patients with MH diameter up to 400 μm, according to majority of the authors' data, is predictable and highly effective (the closure rate reaches 96–97%), the maximal problem today is the reasonableness and effectiveness of treatment of large and giant MH with diameter more than 500–1000 μm. The anatomical success in such cases does not exceed 57–80% [4–9].

The use of an inverted ILM flap method and of its variants described by various authors demonstrates a significant increase of the anatomical success in cases with large MH (more than 400 μm) in comparison with the method of the ILM peeling and removal [10–13]. A formed free ILM flap is sufficiently mobile, could be easily divided from the foveolar edge when performing manipulations and by intraocular flows, and its fixation in the lumen of the hole demands from the surgeon performing additional measures. Some authors for the positioning of the ILM flap practice intraoperational introduction of perfluororinated compounds (PFCs), viscoelastics, autologous blood, use of silicone tamponade [6–9, 11, 14].

Thus, further studies and search for effective treatment modes of this surgical problem are actual and sought-after.

The aim of the study is to analyze the results of treatment of patients with large (minimal diameter more than 400 μm) and long-term (more than 6 months) existing MH. To optimize the treatment method for patients with this condition.

MATERIALS AND METHODS

The study was performed on the basis of the Ophthalmology center of the City Multifunctional hospital No. 2 of Saint Petersburg. The results of treatment of patients operated in the clinical setting of the vitreoretinal department of the center during 2023 for idiopathic large MH were analyzed. In the sample, patients with the history of a long-term MH of stage IV (from 6 months to 3 years), minimal diameter of more than 400 μm, and diameter of the base of more than 700 μm were included. In total, 56 patients (56 eyes) were operated, 40 women (71.4%) and 16 men (28,6%) aged from 58 to 80 years. 11 patients (20%) were pseudophakic. In 7 patients (12.5%) — 5 women and 2 men — MH were revealed in both eyes.

The distribution of patients according to the diameter of the hole base (maximal diameter) is presented in the diagram (Fig. 1).

In 22 patients (39%) and 23 patients (41%), MH dimensions were from 700 to 1,000 μm and from 1,000 to 1,300 μm at the base respectively; in 11 patients (20%), giant MH were noted — from 1,300 to 1,600 μm.

Surgical procedures were performed by the same surgeon on the Constellation device (Alcon, USA) using the Lumera 700 microscope (Carl Zeiss, Germany). Into the study, patients with diabetic retinopathy, glaucoma of III–IV stages, high myopia, retinal vascular occlusions and their sequellae, advanced manifestations of macular degeneration were not included. In all patients, standard

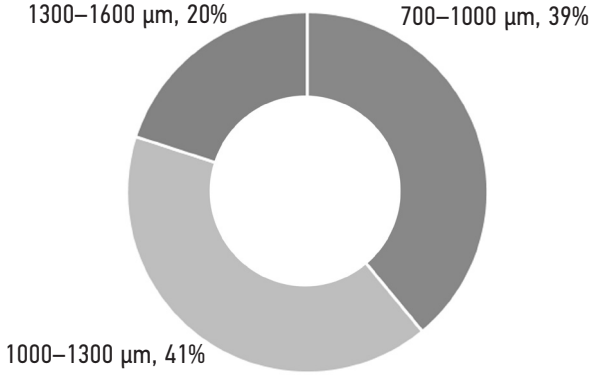


Fig. 1. Distribution of patients according to the diameter of the macular hole's base
Рис. 1. Распределение пациентов по диаметру основания разрыва

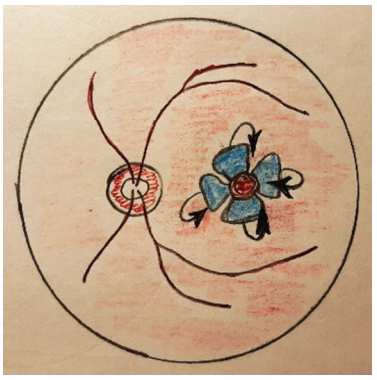


Fig. 2. Inverted ILM flap technique used
Рис. 2. Используемая техника перевернутого лоскута внутренней пограничной мембраны

ophthalmological examination, as well as optical coherence tomography (OCT) of the macular area in dynamics by the optical coherence tomograph Zeiss Cirrus HD-OCT 5000 (Germany) were carried on. During the surgical procedure, a combination of the tamponade of the hole bed by a flap (flaps) of the ILM and of the introduction of the platelet-rich plasma into the hole area after the fluid-air exchange was used.

In all patients, posterior vitrectomy (25 G) was performed, with the removal of the posterior hyaloid membrane of the vitreous. After the ILM staining (Membrane-Blue-Dual dye, DORC, the Netherlands), its peeling was performed, concentrically to the hole edges as several flaps in such a way as to preserve the adhesion of them with macular hole edges. Hereafter, if necessary, peripheral ends of the flaps were evened by vitrector and placed on the hole's bed using closed ends of endovitreal forceps, delicately, without efforts, producing the hole's tamponade. In our study, the inverted ILM flap technique, according to N. Andrew, et al. [15] was used (Fig. 2).

After fluid-air exchange (at control of the position of ILM flaps, 2–3 drops of platelet-rich plasma were introduced on the macular areausing a 25 G cannula; the substance was obtained from the patient's autologous blood using a centrifuge (Rotofix 32A, Hettich, Germany). At the end of the procedure, into the vitreous cavity, the C_3F_8 gas (Alcon, USA) was added, the volume of it being about 1 ml to obtain 20–25% gas-air mixture. There were no intraoperational complications noted.

In the post-op period, patients received standard anti-inflammatory therapy, they were recommended to stay in a face-down position or on the contra-lateral side during 3–4 days after the procedure.

RESULTS AND DISCUSSION

To solve the problem, we were guided by following principles:

1. The use of an ILM flap (flaps) is, to our mind, a requisite condition and a sufficient measure for the large diameter hole tamponade. As ILM is connected to the neurosensory retinal tissue, it does not pose a risk of pathological changes in its structure, at the same time, the ILM flap is transparent and does not reduce the transparency of optical media.

2. Not to use mechanical approximation of the hole edges because of their rigidity and high risk of retinal tissue damage.

3. To stimulate the healing of the hole's edges and to increase the ILM flap stabilization during the post-op period, it was decided to use the platelet-rich plasma, obtained from the patient's autologous blood drawn immediately before surgery.

4. To exclude a toxic effect on the retina and the optic nerve, as well as to avoid re-operations, it was decided to refrain from the use of PFO and from the silicone tamponade.

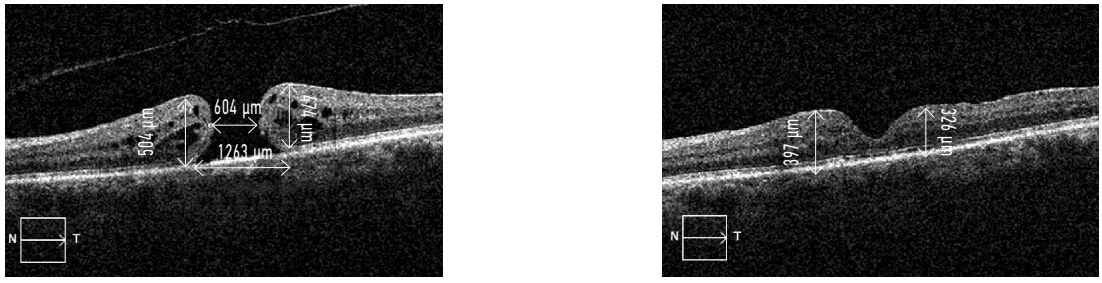
During the early post-op period, there were no complications, possible short-time rise of intraocular pressure, caused by the gas-air tamponade, was reversed by a local use of hypotensive medications. After the gas-air mixture resorption, in general in 1–1.5 months after surgery, ophthalmoscopically and according to OCT data, there was a MH closure in 51 out of 56 operated patients, making 91.1%. In 5 patients (8.9%), a residual hole in the macular area persisted. Visual acuity of patients before surgery and to the moment of complete gas-air mixture resorption in the vitreous cavity is shown in the table.

According to the data presented in the table, before surgery, in the overwhelming number of patients (85.8%), visual acuity was from 0.01 to 0.1, during the post-op period, in a significant number of patients (76.8%), visual acuity raised up to 0.2–0.3 and higher. As examples, pre- and postoperative OCT results of patients L. and G. and their visual functions are shown on Fig. 3 and 4, respectively.

Table. Visual acuity of patients before and after surgical treatment

Таблица. Острота зрения пациентов до и после проведения оперативного лечения

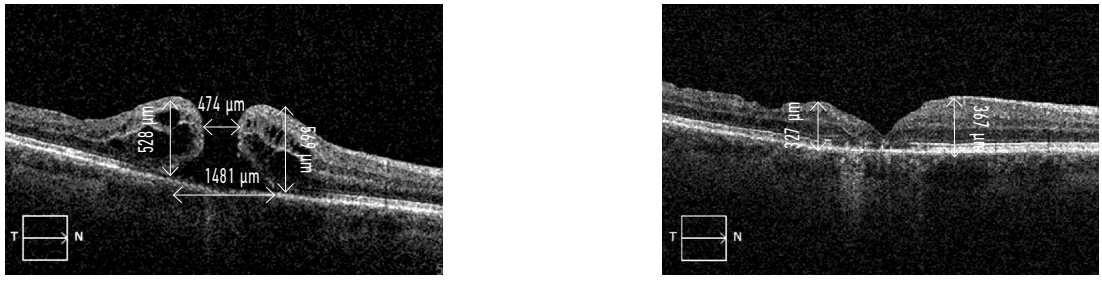
Visual acuity (with correction)	0.01–0.05	0.06–0.1	0.2–0.3	0.4–0.8	In total
Before surgery	15 (26.8%)	33 (59%)	8 (14.2%)	0	56
After surgery	0	13 (23.2%)	29 (51.8%)	14 (25%)	56



a *b*

Fig. 3. Patient L. Right eye: macular hole stage 4, the macular hole history is longer than a year: *a* — Right eye: Vis before surgery 0.09; *b* — Right eye: Vis after surgery 0.4

Рис. 3. Пациент Л. Макулярные разрывы правого глаза (OD) IV стадии, длительность существования макулярного разрыва (из анамнеза) более года: *a* — Vis OD 0,09 до операции; *b* — Vis OD 0,4 после операции



a *b*

Fig. 4. Patient G. Right eye: macular hole stage 4, the macular hole history is about 1.5–2 years: *a* — Right eye: Vis before surgery 0.08; *b* — Right eye: Vis after surgery 0.3–0.4

Рис. 4. Пациент Г. Макулярные разрывы правого глаза (OD) IV стадии, длительность существования МР (из анамнеза) около 1,5–2 лет: *a* — Vis OD 0,08 до операции; *b* — Vis OD 0,3–0,4 после операции

Most of patients noted an increase in quality of vision after surgery. However, in spite of the anatomical MH closure, many patients, along with a visual acuity increase, noted the preservation of metamorphopsias in one form or another, the necessity to "look closely" by visual acuity testing. We could explain this phenomenon by some displacement of the fixation point on the background of decreasing retinal edema after the healing of MH edges. At that, a scotoma could be found in the area of the fovea itself, taking into account large dimensions of observed MH along with a scar tissue formation.

Evaluating the anatomical outcome of surgery based on the OCT data, it has to be mentioned that in all studied cases the ellipsoid zone of the foveola was deformed without significant dynamics after successful surgery. A complete MH closure was observed in 51 out of 56 patients (91%). When investigating the cases of macular hole closure, conspicuous is the fact that retinal edema was absent in 22 cases (42%), in 30 eyes (58%), positive dynamics was observed in the form of edema decrease, restoration of the structure of most of macular area layers was visualized in 27 (53%), traces of the interior limiting membrane's flap were absent in 33 patients (63%), foveolar pseudocysts were visualized in 11 cases (21%), fibrotic changes of external retinal layers at long-term (more than 8 months) were observed in 15 eyes (29%). Quoted data are of preliminary character, as the dynamic follow-up of patients continues.

The central retinal thickness in the foveal area is a new, highly informative index for the prognosis of the anatomical effect of macular hole surgical treatment, superior in prognostic value to most other criteria [16]. In our sample, this index before surgery was 386 ± 146 µm, after surgery, the average thickness in the foveolar area decreased by a mean of 70 µm (18%), and amounted to 269 ± 76 µm (Fig. 5).

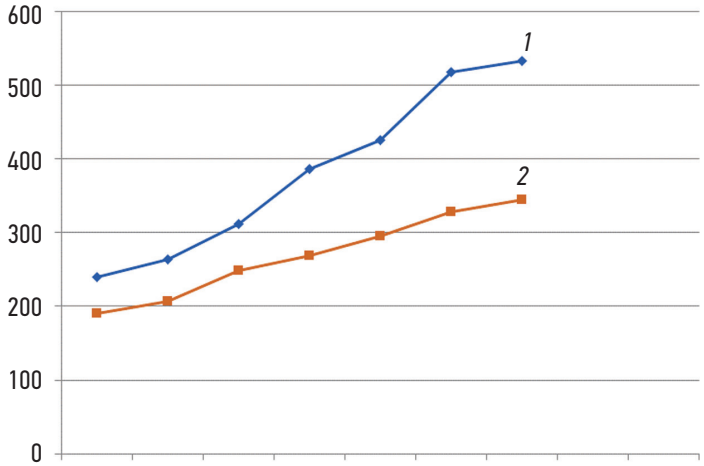


Fig. 5. Distribution of mean retinal thickness before (*1*) and after (*2*) surgical treatment of the macular hole
Рис. 5. Распределение средней толщины сетчатки до (*1*) и после (*2*) хирургического лечения макулярного разрыва

In one female patient with moderate degree myopia, in 2.5 months after surgery, the development of rhegmatogenous retinal detachment was observed, the cause for which was the appearance of a peripheral retinal tear. In this patient, cerclage scleral buckling was performed, resulting in a blockage of the tear and reattachment of the retina.

CONCLUSIONS

1. The used surgical method of the MH bed tamponade with ILM flaps in combination with the introduction of platelet-rich plasma allows to achieve a closure of large MH in 91.1% of cases.

2. In spite of the improvement in quality of vision after surgical treatment, many patients mentioned the preservation of scotomata and metamorphopsias, this is due to the formation of scar tissue in the hole area.

Further investigations of this problem will serve as reason for future publications.

ADDITIONAL INFO

Authors' contribution. All authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study. Personal contribution of each author: A.D. Shchukin — author of the idea, concept and design of the study, surgery, collection and processing of materials, writing the text, literature review; A.G. Veryasova — performing OCT studies, analyzing the data obtained, writing the text; Yu.V. Gnatyuk — collection and processing of materials; O.B. Smirnov — collection and processing of materials, preparation of platelet-rich plasma during operations.

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Competing interests. The authors declare that they have no competing interests.

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Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией. Личный вклад каждого автора: А.Д. Щукин — автор идеи, концепция и дизайн исследования, хирургия, сбор и обработка материалов, написание текста, обзор литературы; А.Г. Верясова — выполнение ОКТ-исследования, анализ полученных данных, написание текста; Ю.В. Гнатюк — сбор и обработка материалов; О.Б. Смирнов — сбор и обработка материалов, приготовление богатой тромбоцитами плазмы в ходе операций

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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AUTHORS' INFO

***Andrey D. Shchukin,** MD, Cand. Sci. (Medicine);
address: 5 Uchebnii lane, Saint Petersburg, 193318, Russia;
ORCID: 0009-0001-3635-8392; e-mail: Shchukin.a.d@mail.ru

Anastasia G. Veryasova, MD; ORCID: 0000-0002-2080-655X;
eLibrary SPIN: 9180-8024; e-mail: verangenn@mail.ru

Yury V. Gnatyuk, MD; ORCID: 0009-0001-2061-0805;
e-mail: yuragnatyuk@yandex.ru

Oleg B. Smirnov, MD;
e-mail: Smirnovolegborisovic@gmail.com

* Corresponding author / Автор, ответственный за переписку

ОБ АВТОРАХ

***Андрей Дмитриевич Щукин,** канд. мед. наук;
адрес: Россия, 193318, Санкт-Петербург, Учебный пер., д. 5;
ORCID: 0009-0001-3635-8392; e-mail: Shchukin.a.d@mail.ru

Анастасия Геннадьевна Верясова; ORCID: 0000-0002-2080-655X;
eLibrary SPIN: 9180-8024; e-mail: verangenn@mail.ru

Юрий Витальевич Гнатюк; ORCID: 0009-0001-2061-0805;
e-mail: yuragnatyuk@yandex.ru

Олег Борисович Смирнов;
e-mail: Smirnovolegborisovic@gmail.com