

## INNOVATIVE APPROACH TO BARRIER AMNIOPLASTY IN SURGICAL TREATMENT OF PRIMARY PROGRESSIVE PTERYGIUM

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✦ **The aim** is to evaluate the efficacy of new method of barrier amnioplasty in surgical treatment of primary progressive pterygium. **Materials and methods.** 40 patients (40 eyes) with primary progressive pterygium, divided into two groups depending on surgical features of barrier amnioplasty: in the main group (20 patients), plastic surgery was carried out in the semilunar fold area; in the control group (20 patients) – in the limbal area. All patients underwent special examination: tear pH measurement and cytological evaluation of the cellular composition from the wound surface. The treatment efficacy was evaluated: in the early postoperative period – by the timing of conjunctival inflammation disappearance, corneal epithelialization and vitalization of the amnion; after 1 year – according to the state of the limbus, cornea, visual acuity, degree of corneal astigmatism. **Results and conclusions.** The use of amnioplasty method in the area of semilunar fold developed and implemented by us in clinical practice showed high efficacy: time reduction in local cellular inflammatory reactions in the cytological composition of swabs and scrapings and postoperative inflammation of ocular surface, which led to shortening of periods of corneal epithelialization by 1.7 times and vitalization of the amnion by 1.5 times. Uncomplicated postoperative course of inflammatory-regenerative reactions allows avoiding the pterygium recurrence and causes reduction of the degree of corneal astigmatism and visual acuity increase.

✦ **Keywords:** pterygium; surgery; amnioplasty.

## ИННОВАЦИОННЫЙ ПОДХОД К БАРЬЕРНОЙ АМНИОПЛАСТИКЕ В ХИРУРГИЧЕСКОМ ЛЕЧЕНИИ ПЕРВИЧНОГО ПРОГРЕССИРУЮЩЕГО ПТЕРИГИУМА

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✦ **Цель.** Оценка эффективности нового способа барьерной амниопластики при хирургическом лечении первичного прогрессирующего птеригиума. **Материалы и методы.** Сорок пациентов (40 глаз) с первичным прогрессирующим птеригиумом были разделены на две группы в зависимости от хирургических особенностей барьерной амниопластики: в основной группе (20 пациентов) пластику выполняли в зоне полулунной складки; в контрольной (20 пациентов) — в зоне лимба. Всем пациентам проводили специальные методы обследования: рН-метрию слезы и цитологическую оценку клеточного состава с раневой поверхности. Эффективность лечения оценивали: в раннем послеопе-

рационном периоде — по срокам исчезновения воспаления конъюнктивы, эпителизации роговицы и витализации амниона; спустя 1 год — по состоянию лимба, роговицы, остроте зрения, степени роговичного астигматизма. **Результаты и выводы.** Разработанный и внедренный нами в клиническую практику способ амниопластики в зоне полулунной складки показал высокую эффективность: сокращение длительности местных клеточных воспалительных реакций в цитологической картине мазков-соскобов и послеоперационного воспаления поверхности глаз, что привело к укорочению сроков эпителизации роговицы в 1,7 раза и витализации амниона в 1,5 раза. Неосложнённое послеоперационное течение воспалительно-регенераторных реакций позволяет избежать возникновения рецидивов птеригиума и обуславливает снижение степени астигматизма и повышение остроты зрения.

✧ **Ключевые слова:** птеригиум; хирургическое лечение; амниопластика.

## INTRODUCTION

A pterygium is a progressive fibrovascular conjunctival lesion that penetrates the corneal stroma causing degenerative changes and opacities [1, 2]. Active expansion of degenerative abnormal subconjunctival connective tissue and new vessels in the stroma toward the corneal center leads to a significant loss of visual functions and a reduction in the patients' quality of life [2–5].

The occurrence of pterygium is etiologically associated with adverse effects of solar ultraviolet (UV) radiation, wind, and dust [4, 6, 7]. Excessive solar radiation and UV radiation cause alteration of limbal stem cells, which normally function as a barrier and prevent the growth of the abnormal conjunctiva on the cornea. In development and progression of pterygium, the role of allergic and immunological factors, as well as human papillomavirus infection, is also not excluded [8–11].

The morphological basis of pterygium is represented by disorganization of connective tissue with phases of mucoid and fibrinous swelling, foci of inflammation and necrosis, and the accumulation of mast and plasma cells [4–6]. The presence in pterygium fibroblasts of morphological signs characteristic of tumor cells and a significant increase in insulin-like and other growth factors, in comparison with the normal conjunctiva, allows researchers to rank the pterygium among benign neoplastic conditions [12, 13].

Recent data on a significant increase in vascular endothelial growth factor (VEGF) in pterygium tissues have led to active studies of the anti-VEGF therapy efficacy in treatment of this condition, but this did not lead to a significant decrease in recurrence rate [14].

Therefore, the main method of pterygium treatment remains its surgical removal, and much attention has been drawn to this issue [15–17]. To date, more than

100 different methods of surgical treatment have been proposed for pterygium, including simple excision with suturing, which has been replaced by more effective surgical technologies such as barrier auto- and alloplasty in the limbal area using conjunctival grafts, mucous membranes from the lips, dura mater, renal capsule, and other materials [18–20]. However, cosmetic defects registered by authors after surgery in the form of conjunctival tension, deformation and displacement of the semilunar fold and lacrimal caruncle, restriction of eyeball motility, and a high rate of the disease relapses (40%–70%) [16, 17, 19, 21], demonstrate the need for searching new surgical approaches and the selection of optimal biological materials for barrier plastic surgery when removing the pterygium.

Currently, when choosing a plastic material for the formation of a barrier in the limbal area, ophthalmologists pay special attention to the amniotic membrane [3, 13, 18, 22]. Amnion, which is the innermost layer of the fetal membrane, has the advantage of being histologically similar to the conjunctiva. The absence of HLA antigens on the cell surface prohibits immunological response and rejection after transplantation and leads to a significant inhibition of the processes of excessive fibrosis and neovascularization of tissues in the area of surgery [3, 18]. In addition, a cryopreserved amniotic membrane (produced in Ufa) is used in pterygium surgery, which is centrally supplied and simplifies the organizational capabilities when receiving it. At the same time, data reported in the literature indicate that the use of amnion to form a barrier in the limbal area after pterygium removal does not completely eliminate the risk of disease recurrence, the rate of which is between 7% and 20% [22].

This recurrence rate is a primary reason behind the search for new, more efficient surgical approaches to

barrier amnioplasty in patients with primary progressive pterygium.

Taking into account the characteristic aspects of the growth of new vessels at the initial stages of the pterygium from the semilunar fold of the conjunctiva toward the cornea in the form of 2–3 parallel episcleral branches that converge at the limbus and form deep and superficial capillary networks throughout the growth [9, 23], we found it advisable to move the location of the barrier amnioplasty from the limbus into the area of the initial growth of blood vessels to prevent them from propagating over the ocular surface.

The fact is no less important that anatomic-topographic approach to barrier amnioplasty chosen by us avoids trauma to the limbus, which is an immunocompetent and germinal zone, any trauma to which is always accompanied by a inflammatory response reaction and abnormal regeneration with formation of rough scars and cornea clouding, as well as by an increase in the risk of disease recurrence [15, 24]. A positive aspect of the chosen location of the amnion after surgical pterygium removal is the possibility to eliminate the appearance of cosmetic defects of the medial area of the conjunctival cavity, inherent to all methods of barrier plastic in the limbal zone.

This work aimed to evaluate the efficiency of the new method of barrier amnioplasty in the surgical treatment of primary progressive pterygium.

## PATIENTS AND METHODS

This study included 40 patients (40 eyes) with primary progressive pterygium (27 men, 13 women), age range from 46 to 79 years (average age,  $67.7 \pm 2.58$  years). Degree III pterygium growth with its head on the cornea reaching the medial edge of the pupil was diagnosed in 25 patients. Degree IV pterygium growth with its head located on the cornea in the projection of the pupil center was diagnosed in 15 patients. All patients had corneal astigmatism from 1.25 to 4 diopters before surgery (average,  $2.87 \pm 0.46$ ). Visual acuity ranged from 0.03 to 0.5 (average,  $0.2 \pm 0.09$ ). Patients complained of eye redness, visual discomfort, and foreign body sensation.

In this study, the first stage of surgery in all patients was performed using standard technology and included resection of the pterygium head and clearing the corneal bed from vasoproliferative tissue

remnants of, incisions of the conjunctiva at 1.5–2 mm from the limbus, and separation and removal of scar subconjunctival tissue and Tenon's capsule up to the semilunar fold. The patients were divided into 2 groups depending on the surgical aspects of the next stage, barrier amnioplasty.

In 20 control group patients (20 eyes), barrier plasty was performed in the limbal area by covering the exposed sclera with an amnion flap and fixing it to the episclera and conjunctiva with 5 or 6 interrupted 8–0 silk sutures. In 20 patients (20 eyes) of the main group, barrier plasty of the exposed sclera was performed at the medial canthus after additional relaxing incisions of the conjunctiva in the semilunar fold area. The formed wound surface of the sclera near the limbus was closed with an intact separated conjunctiva, displacing it toward the conjunctival fornices (upper or lower), thereby changing the vectors of the vessels and replacing the limbus area with healthy conjunctiva [24].

Sutures were removed on Days 7–10 after surgery.

At the postoperative period, standard therapy was prescribed, namely antibacterial drops (0.3% ciprofloxacin solution, 0.01% Okomistin solution) and cornea protectors (Corneregel, Bausch & Lomb) for 10–14 days. After epithelialization of the cornea, use of 0.1% dexamethasone solution was recommended for 3–4 weeks.

The follow-up groups were comparable in terms of the number of patients, sex, age, degree of pterygium growth, corneal astigmatism, and initial visual acuity ( $p > 0.05$ ). A standard ophthalmological examination included determining the best corrected visual acuity (BCVA) (Snellen optotypes), pneumotometry (FT-1000; Tomey, Aichi, Japan), autorefractometry (RC-5000; Tomey), biomicroscopy (Xcel-255; Reichert Technologies, Depew, NY), indirect ophthalmoscopy (Omega 500; HEINE Optotechnik, Herrsching am Ammersee, Germany).

For an objective assessment of inflammatory and reparative processes in the area of surgical exposure, pH-metry of the tear fluid and cytological evaluation of the cellular composition from the wound edge of the operated area was performed. To determine the pH of tears, acid test ratio strips (Lach-Ner, Neratovice, Czech Republic) with a measurement range of 0–12.0 and an interval of 0.2 units were used. The results were assessed 2–4 min after a single touch of the test strip to the conjunctiva in the middle third of the lower fornix. As the normal tear pH range values 6.6–7.4

were considered (average,  $7.1 \pm 0.3$ ), after samples have been taken from 15 healthy individuals. The presence of acidosis and its severity indicate the activity of the postoperative inflammatory process [25–27].

For cytological examinations, material was obtained by scraping the wound edge of the operated area. The scrape content was evenly distributed on a defatted glass slide with subsequent Romanowsky-Giemsa staining. Under the Leica DM LS2 immersion microscope (Leica, Wetzlar, Germany), the cell composition of smears [neutrophilic leucocytes (NL), macrophages (MF), lymphocytes (LC), and fibroblasts (FB)] was calculated in 10 fields of view and expressed as a percentage. In accordance with the phases of the wound healing process, a cytological study of the cell composition was conducted at 1–3, 5–7, and 10–14 days [28–30].

Biomicroscopic monitoring of the ocular surface state was performed daily until complete corneal epithelization, and then weekly until amnion vitalization. After restoration of the corneal epithelial defect and amnion vitalization, patients were monitored for 1 year with examinations once a month in the first 6 months, and every 3 months thereafter.

The efficacy of treatment of primary progressive pterygium in the early postoperative period was evaluated by the timing of conjunctival inflammation (hyperemia, edema) disappearance, corneal epithelization, and amnion vitalization. The final evaluation of pterygium surgical treatment results was performed 1 year after surgery according to the state of the limbus and cornea, BCVA, and the degree of corneal astigmatism. Numerical values obtained during the study were processed statistically using Excel 2007 software (Microsoft Corp., Redmond, WA). The normality of distributions was tested using the Shapiro-Wilk test. The data were presented as  $M \pm m$ , where  $M$  was the average value, and  $m$  was the standard error. Quantitative indices were compared using Student's  $t$ -test. Differences were considered significant at 0.05.

Table 1 / Таблица 1

**Comparative analysis of indices of wound surface in compared groups,  $M \pm m$**   
**Сравнительный анализ показателей раневого процесса в сравниваемых группах,  $M \pm m$**

Indexes	Group of observation		$p$ — veracity of intergroup differences
	main	control	
Timing for stopping of conjunctival inflammation, day			
• hyperaemia	$7.1 \pm 0.1$	$11.3 \pm 0.3$	<0.05
• edema	$5.0 \pm 0.2$	$8.3 \pm 0.2$	<0.05
Timing for stopping of corneal epithelialization, day	$7.7 \pm 0.2$	$12.9 \pm 0.4$	<0.05
Timing for normalization tear pH, day	$9.1 \pm 0.2$	$14.0 \pm 0.5$	<0.05

## RESULTS

Surgical procedure in patients of both groups was performed without complications. There were no signs of postoperative infection in the operated eyes. Clinical aspects of the wound healing process in the surgical treatment of progressive pterygium are presented in Table 1.

The data analysis presented in Table 1 showed that the persistence of clinical signs of conjunctival inflammation (hyperemia, edema) in patients of the main group was significantly shorter compared with the control group. The terms of complete corneal epithelization decreased by 1.7 times in patients of the main group compared with the control group ( $p < 0.05$ ).

One week after surgery, the corneal epithelium at the site of the former head of the pterygium in all patients in the main group did not differ from the rest of the cornea. By comparison, in a significant number of patients ( $n = 12$ , 60%) in the control group, the cornea had a matte hint at the area of surgery with a positive fluorescein staining test.

An examination of the tear pH revealed that patients in the main and control groups had moderate acidosis ( $6.2 \pm 0.1$  and  $5.7 \pm 0.1$ , respectively; normal values  $7.1 \pm 0.3$ ) during the first 3 days postoperatively. By Days 5–7, there was a tendency of a shift in the tear pH toward the neutral range. The time required for complete restoration of pH values to the normal variant was 1.5 times less in patients in the main group compared with the control group ( $p < 0.05$ ).

A comparison of cytological presentation of the wound healing process at various amnioplasty options is presented in Table 2.

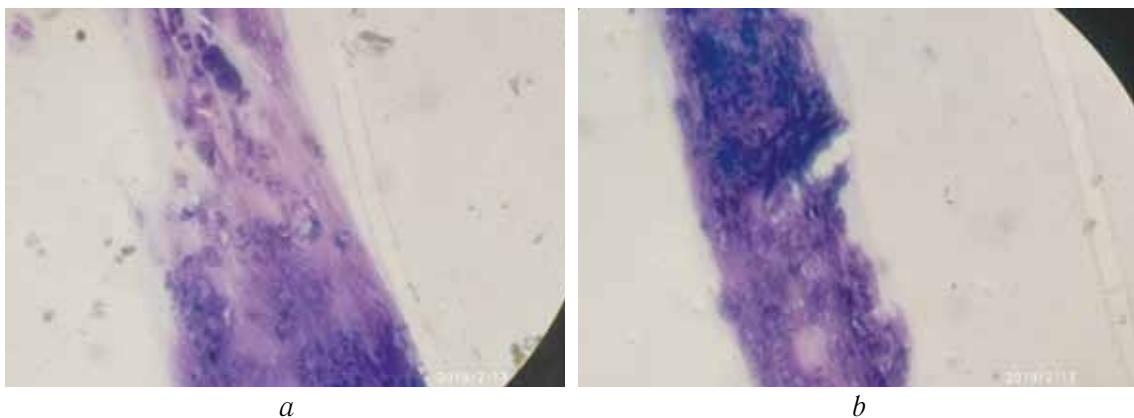
As can be seen from the data presented, a significant increase in NL and MF was registered in cytograms from scraping smears performed in the first 3 days postoperatively, which indicates the manifestation of an exudative inflammation reaction.

Table 2 / Таблица 2

**Dynamics of cellular composition of swabs-scrappings from surgical area in compared groups,  $M \pm m$**   
**Динамика клеточного состава мазков-соскобов из зоны хирургического воздействия в сравниваемых группах,  $M \pm m$**

Observation days after surgery	Main group				Control group				$p$ – validity of intergroup differences
	Indexes, %				Indexes, %				
	NL	Mφ	L	FI	NL	Mφ	L	FI	
1–3	23.0 ± 0.5	32.1 ± 2.9	10.3 ± 0.7	5.0 ± 0.3	40.4 ± 2.0	45.5 ± 1.7	14.1 ± 0.2	1.2 ± 0.0	<0.05
5–7	9.9 ± 0.3	12.2 ± 0.6	8.4 ± 0.3	9.9 ± 0.2	11.9 ± 0.2	25.4 ± 0.5	12.9 ± 0.1	20.5 ± 1.1	<0.05
10–14	0.0 ± 0.0	3.0 ± 0.0	3.4 ± 0.0	2.4 ± 0.1	4.2 ± 0.1	2.1 ± 0.1	4.2 ± 0.1	9.2 ± 0.1	<0.05

Notes: NL – neutrophil leukocytes, Mφ – macrophages, L – lymphocytes, FI – fibroblasts.



**Fig. 1.** Cytological scraping from wound surface of surgical area on 5–7<sup>th</sup> postoperative day: *a* – the main group; *b* – the control group

**Рис. 1.** Цитологический соскоб с раневого края оперированной зоны на 5–7-е послеоперационные сутки: *a* — основная группа, *b* — контрольная группа

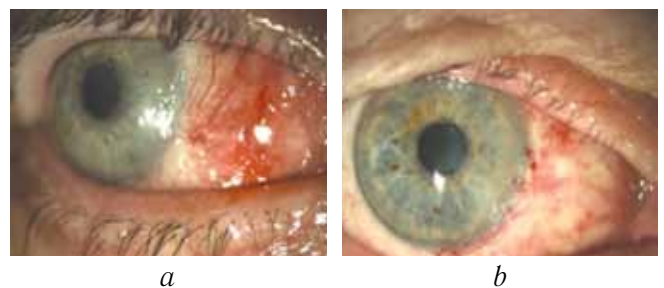
Moreover, the degree of their increase prevailed in patients in the control group compared with the main group ( $p < 0.05$ ).

By postoperative Days 5–7, positive changes in cytograms were registered mostly in patients of the main group. They were characterized by a significantly lower content of NL, MF, and LC, indicating a more rapid subsidence of the inflammatory process compared with patients in the control group ( $p < 0.05$ ) (Fig. 1).

By postoperative Days 10–14, all patients in the main group demonstrated a significant decrease in the cytological signs of inflammation in scraping smears. At the same time, MF, LC, and FB were found in cytograms in the control group, and indicated incomplete resolution of inflammatory process and noncompletion of reparative reactions.

When analyzing the terms of amnion vitalization, depending on the variant of barrier amnioplasty,

it was found that in the main group patients, the process of its vitalization averaged  $16.4 \pm 2.0$  days, whereas it took significantly longer in the control group ( $24.9 \pm 2.2$  days) (Fig. 2).



**Fig. 2.** Vitalization of the amnion depending on variant of barrier amnioplasty: *a* – the main group; *b* – the control group

**Рис. 2.** Витализация амниона в зависимости от варианта барьерной амниопластики: *a* — основная группа; *b* — контрольная группа

Table 3 / Таблица 3

**Comparative analysis of anatomical and functional results of various variants of barrier amnioplasty in compared groups**  
**Сравнительный анализ анатомо-функциональных результатов различных вариантов барьерной амниопластики в сравниваемых группах**

Indexes	Group of observation		<i>p</i> – veracity of intergroup differences
	main ( <i>n</i> = 20)	control ( <i>n</i> = 20)	
Biomicroscopic image, absolute value			
Limbus is not changed	16	7	–
Vascularization of the limbus	4	5	–
Vascularization of the limbus with peripheral corneal opacification	–	5	–
Recurrent pterygium	–	3	–
Best corrected visual acuity, <i>M</i> ± <i>m</i>			
Initial	0.19 ± 0.03	0.21 ± 0.05	>0.05
After surgery	0.74 ± 0.1	0.54 ± 0.1	<0.05
Degree of corneal astigmatism, <i>M</i> ± <i>m</i>			
Initial	4.54 ± 0.3	4.62 ± 0.2	>0.05
After surgery	1.56 ± 0.1	2.83 ± 0.1	<0.05
External examination, absolute value			
Outward mobility limitation	–	3	–
The development of deformations and tensions of semilunar fold and lacrimal caruncle	–	1	–

Table 3 presents long-term (1 year after surgery) anatomical and functional results of various variants of barrier amnioplasty. One year after surgery, the vast majority of patients in the main group (*n* = 16, 80%) did not have biomicroscopic changes in the limbus, and only 4 patients had moderate limbus capillarization. On the contrary, in the control group, patients with varying degrees of limbus capillarization and peripheral corneal opacity prevailed (*n* = 10, 50%), and an unaltered limbus state occurred almost 2.3 times less often as a result of surgery. Pterygium recurrence was also diagnosed in 3 control group patients during this period. There were no cases of recurrence in the main group. Cosmetic defects of the semilunar fold and the lacrimal caruncle were noted only in the control group. Moreover, a limitation of the eyeball motility was noted in 3 patients.

The values of the BCVA parameters and those of induced astigmatism before surgery did not differ in patients in the 2 study groups. One year after surgery, patients in the main group reported a significantly higher rate of obvious positive changes than those of the control group (*p* < 0.05).

## DISCUSSION

The main aspect of the problem of pterygium surgical treatment is the high risk of recurrence, as well as cosmetic dissatisfaction with the results of surgery, which prompts ophthalmologists to search for new approaches to surgical treatment to avoid these complications.

Considering the fact that one of the main components of the progressive growth of pterygium is its vascularization originating from the semilunar fold vasculature, we have developed and introduced into clinical practice our own technique of amnioplasty at the medial canthus, which impedes the advancement of the vasculature along the ocular surface and does not affect the limbal area. It is known that any additional trauma or antigenic stimulation of the limbus can cause immunological stress, the clinical manifestation of which is accompanied by an inadequate inflammatory response, activation of the proliferative process, neovascularization, and, as a result, the occurrence of recurrence [21, 30].

Another positive aspect of the surgical barrier amnioplasty technique we described is the covering of the sclera in the limbal area after pterygium

removal with own intact conjunctiva with preserved germ cells and an intact vascular network, which prevents the progression of limbal insufficiency and restores the barrier functions of the limbus necessary for complete corneal epithelization and prevention of disease recurrence.

With a follow-up period of 1 year, the positive effects of the described method of barrier amnioplasty after pterygium removal, as compared with amnioplasty in the limbal area, were significant reduction in the duration of postoperative inflammation, corneal epithelization, and amnion vitalization; decrease in the degree of corneal astigmatism; increase in BCVA; improvement in the cosmetic results of surgery; and reduction of the recurrence risk ( $p < 0.05$ ).

## CONCLUSIONS

A new, effective method for primary progressive pterygium surgical treatment has been developed and introduced into practice. This method works by moving the location of barrier amnioplasty from the limbal area to the area of the pterygium blood vessels initial growth, i.e., to the semilunar fold area. The results of pH-metric and cytological examinations confirmed the ability of the described anatomic and topographic approach to positively influence the course of the inflammatory and restorative processes at the surgical procedure site, preventing the development of pterygium recurrences and cosmetic cicatricial deformities. Our proposed method for surgical treatment of primary progressive pterygium with displacement of the location of barrier amnioplasty from the limbal area to the periphery of the ocular surface could be used in ophthalmology as an effective alternative to existing methods of pterygium surgical treatment.

*Disclosure:* None of the authors has a financial interest in the materials or methods presented.

There is no conflict of interest.

### Contribution of authors

A.N. Bochkareva obtained data (personal performance of experiments and studies) and conducted the data analysis. V.V. Egorov created the study concept and design, and received approval for the manuscript publication. G.P. Smolyakova interpreted the results. A.D. Pilipenko performed diagnostic studies. P.A. Banshchikov obtained the data (personal performance of experiments and studies) and conducted the data analysis.

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