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## INJECTION USE OF PLATELET RICH PLASMA IN THE TREATMENT OF BORDERLINE SKIN BURNS

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**Abstract. Introduction.** The use of platelet-rich plasma is a promising method for treating burn patients. Today, there are many publications devoted to autodermoplasty in combination with the patient's blood plasma for deep skin burns, but less attention has been paid to the problem of borderline lesions. **Objective of the study** — to evaluate the improvement in the treatment efficacy of burn victims with borderline burns using platelet-rich plasma. **Materials and methods.** The work demonstrates the results of treatment of 40 patients with borderline skin burns, aged from 18 to 59 years, hospitalized at the State Budgetary Institution of St. Petersburg Research Institute of Emergency Medicine named after. I.I. Janelidze in the period from 2021 to 2023. The criterion for inclusion in the study was the area of a second degree burn wound according to ICD 10, with a total area of up to 15% of the body surface. The results of treatment with platelet-rich plasma were assessed on 2% of the area, which averaged  $327.6 \pm 15.2$  cm<sup>2</sup>. During the work, clinical, planimetric, cytological and histological research methods were used. **Results.** Our proposed method of a single injection of platelet-rich plasma into the area of a border burn wound made it possible to accelerate the time for the onset of epithelization by 19.2% ( $p < 0.05$ ), the time for final healing of the wound by 25.1% ( $p < 0.05$ ), and also reduce the incidence of infectious complications by 15% ( $p < 0.05$ ). The obtained clinical and planimetric data were confirmed by cytological and histological studies. In fingerprint smears, by the twelfth day of observation, the number of neutrophils decreased by 33.7% ( $p < 0.05$ ) and the number of fibroblasts and macrophages increased by 41.4% ( $p < 0.05$ ) and 29.3% ( $p < 0.05$ ) respectively. During the histological study, it was noted that the patients in the study group had less pronounced leukocyte infiltration, swelling of the dermis, and a more clearly formed collagen framework. **Conclusion.** The use of platelet-rich plasma makes it possible to achieve earlier relief of the inflammatory reaction and ensure an earlier transition to the regenerative phase of the wound process in the area of a border burn wound.

**Keywords:** burns, borderline burns, blood plasma, platelet-rich plasma, inflammation, regeneration

## ИНЪЕКЦИОННОЕ ПРИМЕНЕНИЕ ОБОГАЩЕННОЙ ТРОМБОЦИТАМИ ПЛАЗМЫ ПРИ ЛЕЧЕНИИ ПОГРАНИЧНЫХ ОЖОГОВ КОЖИ

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**Резюме. Введение.** Использование обогащенной тромбоцитами плазмы является перспективным методом лечения обожженных. На сегодняшний день существует множество публикаций, посвященных выполнению аутодермопластики в сочетании с плазмой крови пациента при глубоких ожогах кожи, однако меньше внимания уделено проблеме пограничных поражений. **Цель исследования** — оценить повышение эффективности лечения обожженных с пограничными ожогами с использованием плазмы, обогащенной тромбоцитами. **Материалы и методы.** В работе продемонстрированы результаты лечения 40 пациентов в возрасте от 18 до 59 лет с пограничными ожогами кожи, госпитализированных в ГБУ СПб НИИ СП им. И.И. Джанелидзе в период с 2021 по 2023 гг. Критерием включения в исследование было определение площади ожоговой раны II степени по МКБ-10 общей площадью до 15% поверхности тела. Результаты лечения плазмой, обогащенной тромбоцитами, оценивали на 2% площади, что в среднем составляло 327,6±15,2 см<sup>2</sup>. В ходе выполнения работы были использованы клинический, планиметрический, цитологический и гистологический методы исследования. **Результаты.** Предложенный нами способ однократного инъекционного введения обогащенной тромбоцитами плазмы в область пограничной ожоговой раны позволил ускорить сроки начала эпителизации на 19,2% ( $p < 0,05$ ), сроки окончательного приживления раны на 25,1% ( $p < 0,05$ ), а также снизить частоту развития инфекционных осложнений на 15% ( $p < 0,05$ ). Полученные клинические и планиметрические данные были подтверждены цитологическим и гистологическим исследованиями. В мазках-отпечатках к 12-м суткам наблюдения снизилось число нейтрофилов на 33,7% ( $p < 0,05$ ) и увеличилось число фибробластов и макрофагов на 41,4% ( $p < 0,05$ ) и 29,3% ( $p < 0,05$ ) соответственно. В ходе проведения гистологического исследования было отмечено, что у пациентов исследуемой группы была менее выражена лейкоцитарная инфильтрация, отек дермы и более отчетливо сформирован коллагеновый каркас. **Заключение.** Использование обогащенной тромбоцитами плазмы позволяет достигнуть более раннего купирования воспалительной реакции и сократить длительность перехода к регенераторной фазе раневого процесса в области пограничной ожоговой раны.

**Ключевые слова:** ожоги, пограничные ожоги, плазма крови, обогащенная тромбоцитами плазма, воспаление, регенерация

## INTRODUCTION

Human blood has been used for therapeutic purposes for more than a hundred years. In 1898, Swedish physicians Grafstrom and Elfstrom injected autologous blood in a salt solution to treat pneumonia and tuberculosis for the first time [5]. Subsequently, blood and its components were repeatedly used in the treatment of patients with acute and chronic diseases [4].

Among all variants of blood products use, plasma is of special importance in the context of wound defects treat-

ment, which is its liquid part containing form elements and tissue factors [6]. If we consider plasma therapy from the position of regenerative medicine, the most effective option is the use of platelet-rich plasma (PRP). In 2003, R.R. Akhmerov and R.F. Zarudiy developed a technique for obtaining platelet-rich plasma. Zarudiy developed a technique for obtaining this biological medication [3]. Subsequently, the technique became widespread and was actively used in clinical practice.

The main regenerative components contained in PRP include: transforming growth factor beta (TGF-β),

platelet-derived epidermal growth factor (PDEGF), vascular endothelial growth factor (VEGF), insulin-like growth factor 1 (IGF-1), fibroblast growth factor (FGF), and epidermal growth factor (EGF) [3]. Such an optimal composition of biological compounds forms favorable conditions for organ and tissue regeneration.

The use of PRP deserves special attention in burn patients. According to studies conducted under the guidance of V.G. Bogdan et al., PRP in combination with autodermoplasty increases the area of complete engraftment of the transplanted skin graft by more than 13% [1]. A team of authors from the I.I. Janelidze Research Institute of Emergency Medicine obtained similar data. They proved that the rate of regeneration significantly increases when PRP is combined with the transplantation of a perforated skin autoderm graft [2].

Notwithstanding a substantial number of scientific papers devoted to the treatment of deep burns by autodermoplasty combined with PRP, the problem of stimulation of borderline burn recovery has remained unresolved.

## AIM

To evaluate the effectiveness of treatment in patients with borderline skin burns using PRP injections into the affected derma.

## MATERIALS AND METHODS

The work is based on the analysis of treatment results in 40 patients with borderline skin burns, aged from 18 to 59 years, hospitalized at the I.I. Janelidze St. Petersburg Research Institute of Emergency Medicine in the period 2021-2023. The following parameters were chosen as inclusion criteria: age from 18 to 59 years, total area of borderline skin burns up to 15%. Exclusion criteria were also determined: patient's refusal to use platelet-rich autoplasm, oncological diseases detected in the last 5 years, pregnancy or breastfeeding, patient's intake of immunosuppressive drugs, confirmed carriage of HIV, syphilis, hepatitis B or C. Burned patients were divided into two groups. The first (control) group consisted of patients whose borderline burns were treated in accordance with the methods generally accepted in combustiology (ointment dressings with Levomekol water-soluble ointment and atraumatic wound coverings Activtex (Altex LLC, Russia)). The experimental group consisted of patients who received single injection of PRP in the amount of 2.8 ml for 1% of the border burn area on  $5.9 \pm 1.2$  days of standard conservative treat-

ment. The mean age of patients in the control group was  $35.3 \pm 11.08$  years, the area of burn wounds was  $5.9 \pm 2.8\%$ . The mean age of patients in the experimental group was  $39.8 \pm 9.55$  years, the burn wound area in the group was  $6.35 \pm 2.78\%$ .

The research was approved by the local ethical committee of the I.I. Dzhanelidze St. Petersburg Research Institute of Emergency Medicine, protocol No. 1-8 of 10.10.2020. All patients signed an additional voluntary informed consent for treatment with PRP.

Effectiveness of the treatment was evaluated on burn areas covering about 2% of the body area, i.e.  $327.6 \pm 15.2$  cm<sup>2</sup> on average. Clinical (daily examination, photofixation, control of the nature of detachment, epithelialization and graft healing) and planimetric methods were used in the research. The latter was performed according to the original method (patent of the Russian Federation No. 2798225 dated 03.08.2022). The depth of a burn wound was estimated by checking a vascular reaction and pain sensitivity. Features of reparative processes were profoundly analyzed by cytological and morphological methods. A cytological method was used to take swabs from the surface of burn wounds before treatment, as well as on the 3<sup>rd</sup> and 12<sup>th</sup> day. Skin biopsies were taken on the 3<sup>rd</sup> day after a single injection of PRP into the area of a border burn wound.

PRP was produced according to the following procedure (Fig. 1). At first, 1 ml of sodium citrate is drawn into a 10 ml syringe (Fig. 1, a), then 10 ml of the patient's whole venous blood is drawn into the same syringe (Fig. 1, b). The syringe is stirred by progressive movements and then transferred to a special tube (Fig. 1, c), which is centrifuged for 10 minutes at a speed of 2600 spins per minute. 4 layers are formed after this manipulation (Fig. 1, d): a — platelet-poor plasma; b — platelet-rich plasma; c — leucocyte film; d — erythrocyte suspension. Platelet-poor plasma was removed and was not used in present research. We transferred platelet-rich plasma (Fig. 1, e) and leukocyte film into a regular syringe for easier use (Fig. 1, f).

On average, we obtained  $2.3 \pm 0.2$  ml of PRP out of 10 ml of whole venous blood. To determine the number of platelets in the final product, Sysmex KX-21N hematology analyzer (Japan) was used. Their average concentration was  $1.043 \pm 41.7 \times 10^6$  cells/ $\mu$ l.

Statistical data were analyzed by STATISTICA 12.6 for Windows, as well as MS Excel. The nonparametric Mann-Whitney test was applied to compare quantitative indices in the studied groups, and Pearson's  $\chi^2$  test was used to compare frequency indices. An alternative hypothesis was accepted at  $p < 0.05$ .

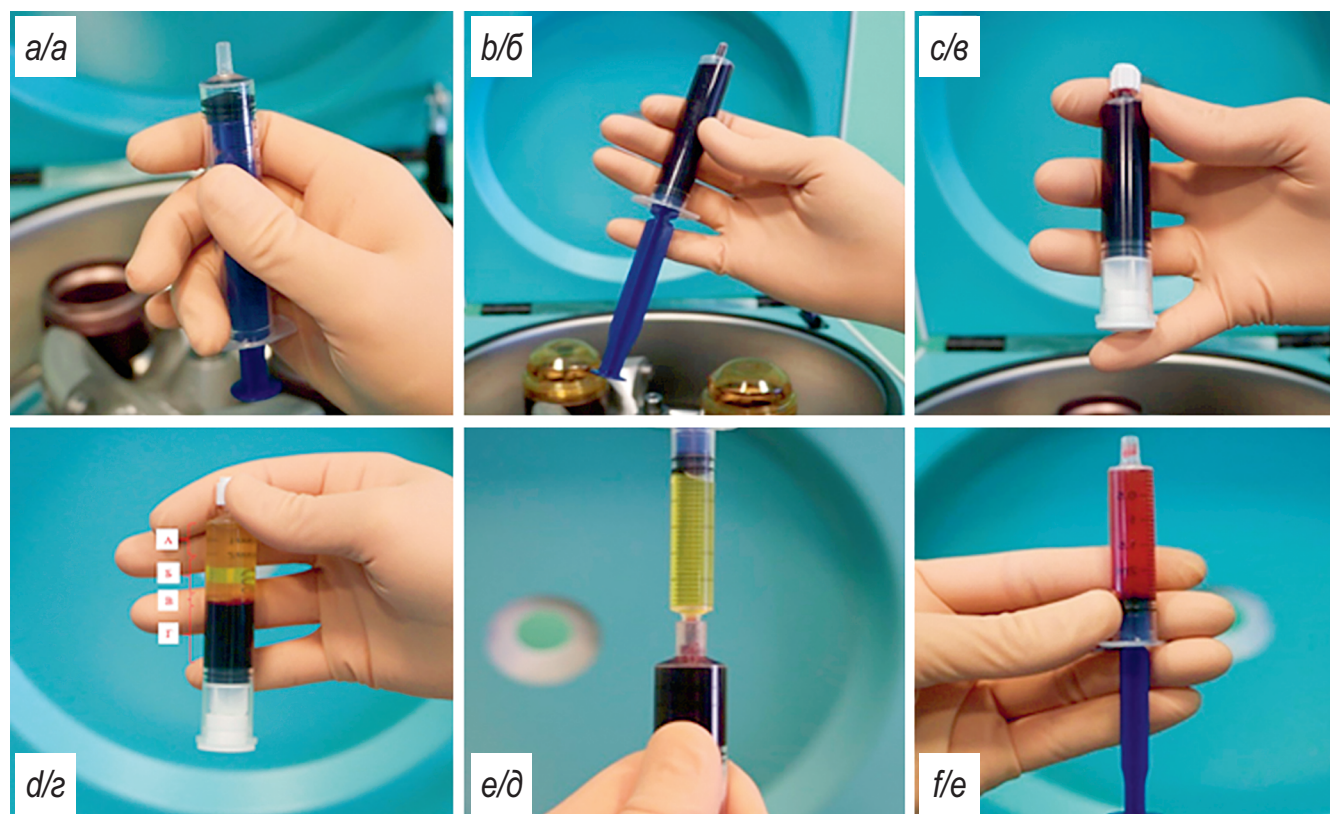


Fig. 1. Stages of obtaining platelet-rich autoplasm (explanations in the text)

Рис. 1. Этапы получения аутоплазмы, обогащенной тромбоцитами (пояснения в тексте)

Table 1

Features of the phases of the wound process taking into account a single injection of autoplasm enriched with platelets

Таблица 1

Особенности фаз раневого процесса с учетом однократного инъекционного введения аутоплазмы, обогащенной тромбоцитами

Группа наблюдения / Observation group	Средняя продолжительность периода (M±m), сутки / Average duration of the period (M±m), days			
	сосудистой реакции / vascular reaction	очистения раны / wound cleansing	начала эпителизации / beginning of epithelialization	окончательного заживления / final healing
Контрольная / Control	4,9±0,7	6,2±1,1	7,8±1,8	24,3±1,2
Исследуемая / Under study	4,7±0,4	5,9±1,2	6,3±1,4*	18,2±1,1*

Note: Mann-Whitney U test: \* p < 0.05 compared to the control group.

Примечание: критерий U Манна-Уитни: \* p < 0,05 по сравнению с контрольной группой.

## RESULTS AND DISCUSSION

At stage 1 the duration of wound healing phases was assessed according to M.I. Kuzin (Table 1).

According to the results presented in Table 1, there were no significant differences in the timing and duration of a vascular reaction and wound cleansing, since PRP injection was carried out only after a wound had been cleaned. However, it was ascertained that the time of epi-

thelialization initiation in the experimental group reduced by 19.2% (p < 0.05). At the same time, final healing time of a border burn wound also decreased by 25.1% (p < 0.05).

Frequency of infectious complications was assessed next. The results presented in Figure 2 show that a single injection of platelet-rich autoplasm into the area of a border burn wound reduced the incidence of infectious complications by 15% (p < 0.05).



Частота осложнений /  
Frequency of complications, %



**Fig. 2.** Frequency of wound infection in borderline burns taking into account the introduction of platelet-rich autoplasm

**Рис. 2.** Частота раневой инфекции при пограничных ожогах с учетом введения аутоплазмы, обогащенной тромбоцитами

Planimetric evaluation of a healing rate was one of the most important indicators in our work (Fig. 3).

The obtained data are presented in Figure 3. It allows us to conclude that a single injection of platelet-enriched autoplasm starting from the 5<sup>th</sup> day after the injection significantly accelerates epithelization of a border burn wound. Thus, by the 15<sup>th</sup> day it allows to reduce a wound

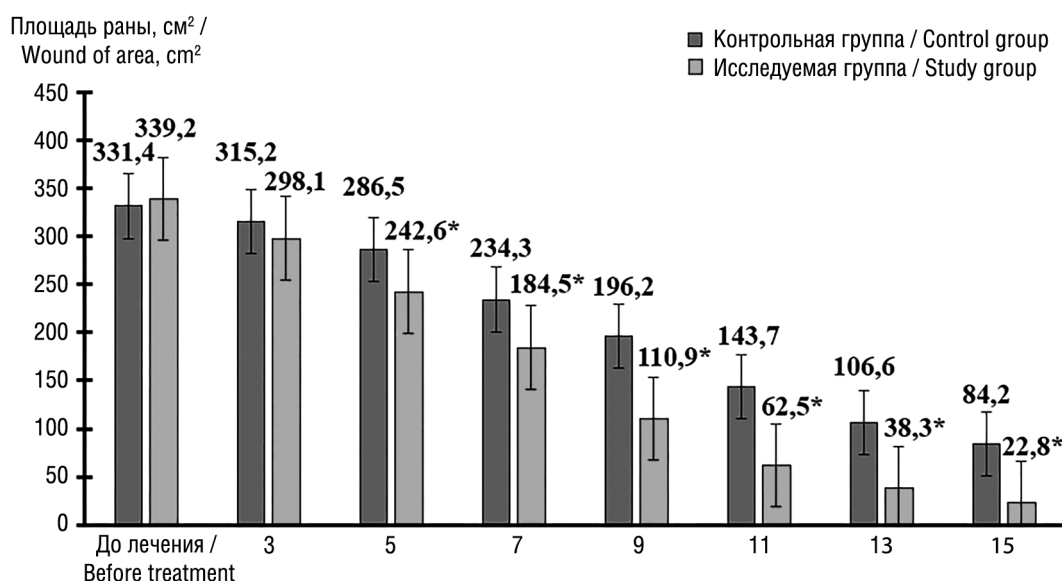
area by 3.7 times ( $p < 0.05$ ) in comparison with the controls.

A cytological research of smears-prints before treatment, on the 3<sup>rd</sup> and 12<sup>th</sup> day after the beginning of treatment was carried out to confirm the obtained clinical data. Comparative data presented in Table 2 allow us to conclude that a single injection of platelet-enriched autoplasm on  $5.9 \pm 1.2$  days after the burn allows to reduce the number of neutrophils by 18.8% by the 3<sup>rd</sup> day after the injection as well as to lower the content of neutrophil cells by 33.7% ( $p < 0.05$ ) by the 12<sup>th</sup> day after the injection in comparison with the control group.

In addition, a reliable increase in the number of fibroblasts by the 12<sup>th</sup> day by 41.4% ( $p < 0.05$ ) was observed ( $p < 0.05$ ). The number of macrophages also showed a 29.3% growth ( $p < 0.05$ ). When analyzing the percentage of lymphocytes, no significant dynamics and differences were found.

In order to confirm clinical, planimetric and cytological data, it was decided to perform histological examination of skin biopsy samples in both groups on the 3<sup>rd</sup> day after treatment (9<sup>th</sup> day from the moment of injury). When examining skin biopsy specimens with hematoxylin-eosin staining it is possible to conclude that neutrophilic and leukocytic infiltration and dermal edema were more pronounced in controls (Fig. 4).

To objectify a regenerative component of derma, Picro-Mallory staining was performed (Fig. 5).



**Fig. 3.** Planimetric assessment of the healing dynamics of borderline burn wounds taking into account the introduction of autologous plasma enriched with platelets

**Рис. 3.** Планиметрическая оценка динамики заживления пограничных ожоговых ран с учетом введения аутоплазмы, обогащенной тромбоцитами

Table 2

Cytological picture of borderline burns taking into account the introduction of autoplasm enriched with platelets

Таблица 2

Цитологическая картина пограничных ожогов с учетом введения аутоплазмы, обогащенной тромбоцитами

Анализируемые параметры / Analyzed parameters	Содержание (M±m) в мазке-отпечатке, в срок (сутки)/% / Content (M±m) in smear-print, within a period (day)/%					
	контрольная группа / control group			исследуемая группа / study group		
	до начала лечения / before treatment	3-и	12-е	до начала лечения / before treatment	3-и	12-е
Нейтрофилы / Neutrophils	67,2±4,4	39,2±3,5	18,7±1,3	69,4±5,2	31,8±4,6	12,4±1,3*
Фибробласты / Fibroblasts	2,2±0,5	2,9±1,2	22,4±1,9	2,3±0,6	3,7±1,1	31,1±2,2*
Макрофаги / Macrophages	12,3±2,1	13,8±1,4	20,3±1,9	13,5±2,7	15,3±1,2	28,7±2,1*
Лимфоциты / Lymphocytes	2,9±1,1	2,5±0,7	2,3±1,2	3,1±1,1	2,9±1,3	2,6±1,3

Note: Mann–Whitney U test: \* p <0.05 compared to the control group.  
Примечание: критерий U Манна–Уитни: \* p <0,05 по сравнению с контрольной группой.

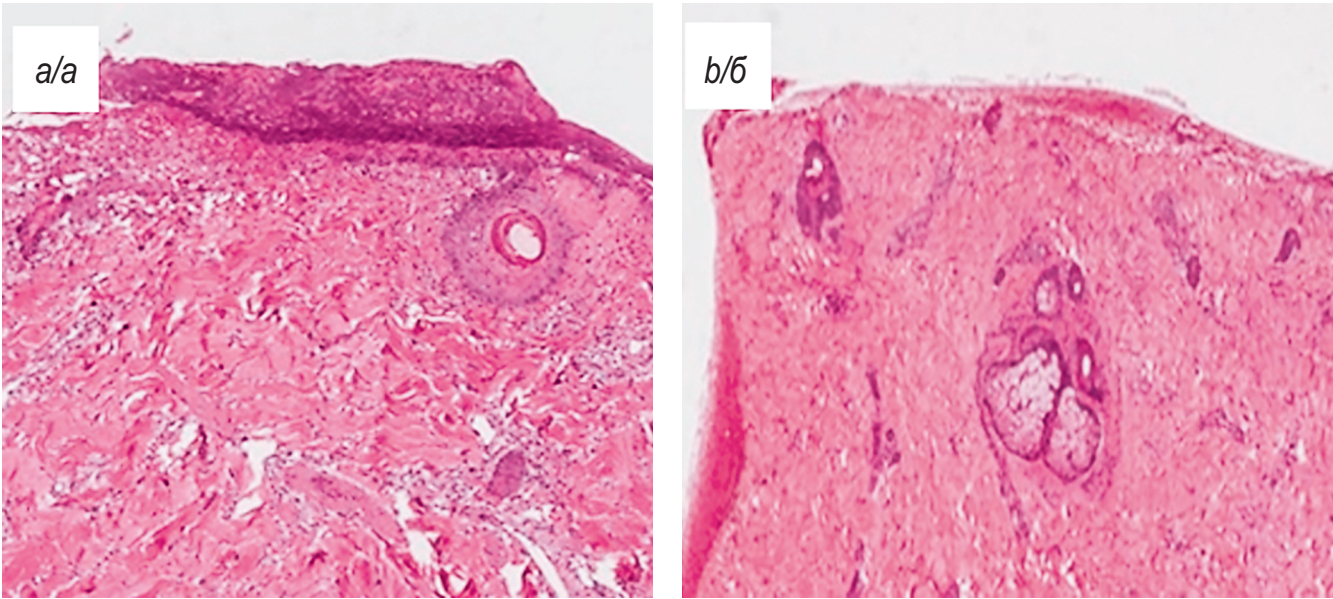


Fig. 4. Patients' skin on the 10<sup>th</sup> day after receiving a burn: a — without the introduction of autoplasm enriched with platelets; b — against the background of the injection of autoplasm enriched with platelets. Hematoxylin–eosin staining, ×100  
Рис. 4. Кожа пациентов на 10-е сутки после получения ожога: а — без введения аутоплазмы, обогащенной тромбоцитами; б — на фоне инъекционного введения аутоплазмы, обогащенной тромбоцитами. Окраска гематоксилином–эозином, ×100

Skin biopsy specimens in the comparison group had a poorly developed collagen frame and no fibrin, which indicates less intensive reparative processes.

CONCLUSION

1. A single injection of PRP in combination with conservative treatment of borderline skin burns allowed to accelerate

terms of epithelialization on 19,2% (p <0,05), final wound healing on 25,1% (p <0,05), as well as to reduce the frequency of infectious complications on 15% (p <0,05).

2. The results of cytological and histological examinations confirm the clinical data indicating a decrease in the severity of inflammatory processes, as well as stimulation of regeneration in a border burn zone against the background of PRP administration. By the 12th day of observation, the



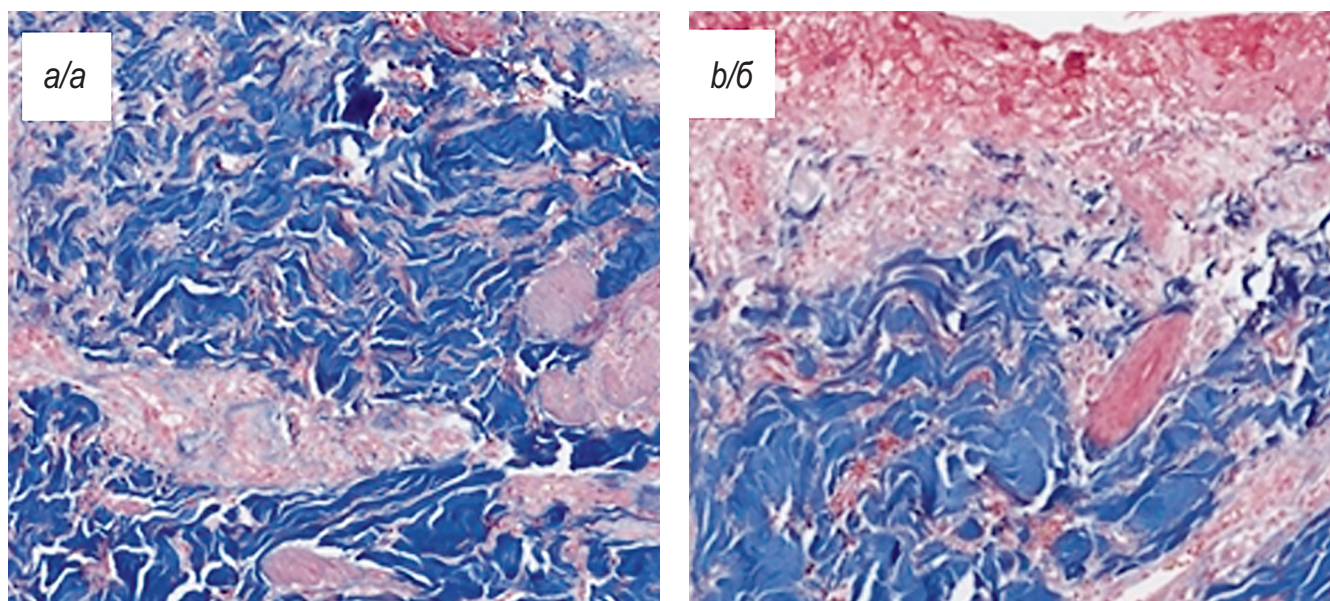


Fig. 5. Patients' skin on the 9<sup>th</sup> day after injury: *a* — without the introduction of platelet-rich autoplasm; *b* — against the background of the injection of platelet-rich autoplasm. Picro–Mallory staining,  $\times 100$

Рис. 5. Кожа пациентов на 9-е сутки после получения травмы: *а* — без введения аутоплазмы, обогащенной тромбоцитами; *б* — на фоне инъекционного введения аутоплазмы, обогащенной тромбоцитами. Окраска Пикро–Маллори,  $\times 100$

number of neutrophils decreased by 33.7% ( $p < 0.05$ ) and the number of fibroblasts and macrophages increased by 41.4% ( $p < 0.05$ ) and 29.3% ( $p < 0.05$ ) respectively.

3. A single injection of PRP allows to stop an inflammatory reaction in the area of borderline burn wounds and accelerate a regenerative phase of a wound process, which, in turn, reduces the time of final skin recovery.

#### ADDITIONAL INFORMATION

**Author contribution.** Thereby, 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.

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

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**Consent for publication.** Written consent was obtained from the patient for publication of relevant medical information within the manuscript.

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ния и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

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