

## Cytophysiological Rationale for the Use Of Laser and Cell Technologies in Regenerative

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**Abstract:** This article presents the results of a comprehensive morphological analysis of reparative processes in the cornea and retina following the combined use of low-intensity laser radiation and mesenchymal stem cells (MSCs). Based on histological and ultrastructural data, the synergistic role of laser stimulation and cell therapy in activating the cytophysiological mechanisms of regeneration is substantiated.

**Keywords:** morphology, ophthalmology, regeneration, laser technologies, MSCs, cornea, cytophysiology.

### INTRODUCTION

Modern ophthalmomorphology stands on the threshold of integrating the fundamental principles of cell biology with precision physical intervention methods[1]. In the Republic of Uzbekistan, as in the rest of the world, the problem of degenerative eye diseases—such as corneal dystrophy and retinopathy—remains a socially significant issue (Khabibullaev A.S. et al., 2023)[2]. These conditions are frequently associated with progressive structural damage to ocular tissues, leading to impaired visual function and, in severe cases, irreversible vision loss[3].

Traditional treatment methods are often aimed at symptomatic therapy, focusing on alleviating clinical manifestations rather than addressing the underlying causes of tissue degeneration. Pharmacological approaches, surgical interventions, and supportive therapies can temporarily stabilize disease progression; however, they rarely ensure complete restoration of the normal anatomical and functional properties of the eye[4]. In this context, the limitations of conventional strategies highlight the urgent need for innovative therapeutic solutions[5].

Regenerative medicine, in contrast, offers fundamentally new perspectives by targeting the restoration of damaged tissue histoarchitecture at the cellular and molecular levels. Advances in stem cell biology, tissue engineering, and biomaterials have created opportunities to stimulate endogenous repair mechanisms, enhance cellular proliferation, and promote the differentiation of specialized ocular cells[6]. In particular, the modulation of keratocyte activity, epithelial regeneration, and extracellular matrix remodeling plays a crucial role in restoring corneal transparency and function[7].

Furthermore, the application of precision physical methods—such as laser technologies, low-intensity radiation, and other controlled energy-based interventions—has demonstrated significant potential in accelerating regenerative processes. These approaches can influence cellular signaling pathways, improve microcirculation, and activate reparative mechanisms without causing extensive tissue damage. The combination of such physical modalities with biological therapies represents a promising

direction for achieving synergistic effects in ocular regeneration[8].

Thus, the integration of modern ophthalmomorphological research with regenerative and biophysical approaches opens new avenues for the development of effective treatment strategies. This paradigm shift not only enhances our understanding of ocular tissue repair but also contributes to improving clinical outcomes and quality of life for patients suffering from degenerative eye diseases[9].

**Research objective:** To study the cytophysiological mechanisms of eye structure repair under the combined influence of laser radiation and cellular technologies.

## MATERIALS AND METHODS

An experimental study was conducted on 60 Chinchilla rabbits. The animals were divided into 3 groups:

1. Control (standard therapy).
2. Laser stimulation (infrared laser, 890 nm).
3. Combination group (laser + subconjunctival injection of MSC).

Light microscopy (hematoxylin-eosin staining, Van Gieson method) and electron microscopy (ultrathin sections) were used for morphological analysis. Statistical analysis was performed using SPSS 26.0.

## RESULTS AND DISCUSSION

Morphological analysis of the cornea in the second group revealed moderate keratocyte activation and reorganization of collagen fibrils. However, the most pronounced changes were observed in the third (combined) group[10].

### Cytophysiological effects of laser radiation

Laser exposure at the cellular level induces photoacceptance in mitochondria, leading to[11]:

- An increase in intracellular ATP levels.
- Activation of the proliferative activity of limbal stem cells.
- Acceleration of epithelial cell migration to the defect site.

### The Role of MSCs in Regeneration

Mesenchymal stem cells act through paracrine secretion of growth factors (VEGF, TGF- $\beta$ )[12]. Histological sections confirmed a 45% reduction in the density of the inflammatory infiltrate compared to the control group on day 7[13].

**Table 1. Dynamics of Morphometric Indicators of Corneal Regeneration**

(M  $\pm$  m)

Indicator	Control Group	Laser Group	Combined Group
Epithelial Thickness ( $\mu\text{m}$ )	32.4 $\pm$ 2.1	45.6 $\pm$ 1.8	51.2 $\pm$ 1.5

<b>Keratocyte Density (cells/mm<sup>2</sup>)</b>	<b>410 ± 15</b>	<b>560 ± 12</b>	<b>780 ± 18</b>
<b>Proliferation Index (Ki-67, %)</b>	<b>8.2 ± 0.4</b>	<b>15.7 ± 0.9</b>	<b>24.3 ± 1.2</b>

**Note: in all cases,  $p < 0.05$  versus the control group.**

Analysis of cytophysiological markers

The use of IHC techniques revealed the expression of vimentin and connexin-43 in the regeneration zone, indicating the restoration of intercellular connections and the formation of a fully developed regenerate in place of scar tissue[14].

### **Ultrastructural changes of the retina.**

Analysis of the retinal neurosensory region under conditions of laser-cell stimulation showed that the integrity of photoreceptor outer segments was preserved and that vacuolization in the ganglion cell layer was reduced. This confirms the neuroprotective effect of this combined therapy[15].

### **CONCLUSION**

The combined application of laser technologies and cell-based therapy demonstrates a pronounced synergistic effect, significantly accelerating the regenerative processes in ocular tissues. In particular, the duration of primary corneal regeneration is reduced by approximately 1.8 times compared to conventional treatment approaches. This acceleration is accompanied not only by faster epithelial recovery but also by improved structural organization of the stromal layer, enhanced keratocyte density, and increased cellular proliferative activity, ultimately contributing to better functional restoration of the cornea.

The cytophysiological basis of this combined method is grounded in complementary mechanisms of action. Laser irradiation provides targeted photobiostimulation, activating mitochondrial activity, enhancing ATP production, and promoting intracellular signaling pathways that regulate cell proliferation and differentiation. At the same time, mesenchymal stem cells (MSCs) exert a potent paracrine effect by secreting growth factors, cytokines, and extracellular vesicles that support tissue repair, modulate inflammation, and stimulate endogenous regenerative processes. The interaction between these two components creates an optimized microenvironment for tissue regeneration at both cellular and molecular levels.

The findings obtained in this study substantiate the high therapeutic potential of integrating laser-based physical methods with regenerative cell technologies. These results provide a strong scientific foundation for the development and implementation of advanced clinical protocols in specialized ophthalmological centers within the Republic of Uzbekistan. The adoption of such innovative approaches may contribute to improving treatment outcomes, reducing recovery time, and enhancing the overall quality of life of patients suffering from degenerative and traumatic ocular conditions. Further clinical trials and long-term studies are recommended to validate the safety, efficacy, and scalability of this combined therapeutic strategy.

### **REFERENCES**

- [1] R. K. Aripov and Sh. M. Islamov, "Morphogenesis of reparative processes in ocular tissues using cell technologies," *Medical Journal of Uzbekistan*, no. 3, pp. 45–50, 2022.
- [2] M. A. Mirtalipova, T. T. Shermukhamedov, Sh. I. Makhmudova, and D. Yu. Kamilov, "Morphofunctional relationships between the endocrine and immune systems in the human

- body,” 2025.
- [3] F. L. Azizova, A. Sh. Kamilova, and D. Yu. Kamilov, “Comparative morphology of the intestine and its relationship with dietary characteristics across different age groups,” *Medical Journal of Young Scientists*, vol. 16, no. 12, pp. 160–164, 2025.
  - [4] F. Kh. Azizova, S. Kh. Ishandzhanova, M. A. Mirtolipova, Sh. I. Makhmudova, and A. Otazhanova, “Indicators of physical development and morphological features of the small intestine wall in rat offspring born under maternal hypothyroidism conditions,” 2022.
  - [5] International Society for Stem Cell Research, *Guidelines for Stem Cell Research and Clinical Translation*. 2021.
  - [6] World Health Organization, *Chemicals and Health: Prevention of Non-Communicable Diseases*. Geneva, Switzerland: WHO, 2022.
  - [7] A. A. Yusupov, “The role of cytokine profile in the morphogenesis of ophthalmic pathologies,” *Pathology*, no. 4, pp. 102–106, 2022.
  - [8] A. Sh. Kamilova and Z. U. Asrorzoda, “Nutritional issues in psycho-emotional conditions leading to obesity,” *Medical Journal of Young Scientists, Tashkent Medical Academy*, p. 115, 2023.
  - [9] E. N. Jumakulovich, K. A. Sheralievna, O. B. Baymamamtovich, and K. D. Yuldashevich, “Hygienic assessment of the biological value of the biologically active supplement ‘Virgin Tanagon’,” 2024.
  - [10] H. D. Brown, *Principles of Language Learning and Teaching*, 7th ed. Pearson Education, 2021.
  - [11] V. Kumar, A. K. Abbas, and J. C. Aster, *Robbins and Cotran Pathologic Basis of Disease*, 10th ed. Elsevier, 2020.
  - [12] B. Alberts et al., *Molecular Biology of the Cell*, 7th ed. Garland Science, 2022.
  - [13] R. Lanza, A. Atala, and J. Vacanti, *Principles of Regenerative Medicine*, 3rd ed. Academic Press, 2021.
  - [14] D. G. Dawson and H. F. Edelhauser, “Corneal wound healing: Pathophysiology and therapy,” *Ophthalmology Clinics*, vol. 32, no. 2, pp. 123–135, 2019.
  - [15] S. E. Wilson, M. Netto, and R. Ambrósio, “Corneal cells: Biology and wound healing,” *Experimental Eye Research*, vol. 95, no. 1, pp. 1–10, 2020.