TISSUE REGENERATION AFTER THERMAL BURNS USING CHITOSAN DERIVATIVES

Islamov Nurali Hikmatovich
Lecturer at the Department of Dermatology and Venereology Samarkand State Medical University
Ro‘ziqulov Dilshod Xakimovich
Samarkand Branch of the Republican Scientific Center for Emergency Medical Care
Nomanxo‘jaev Bexzod Shuxratxo‘ja o‘gli
Clinical Resident Department of Dermatovenerology and Venereology Samarkand State Medical University

Abstract: The challenge of improving burn wound healing is closely associated with the risk of secondary infection, metabolic disturbances caused by intense inflammatory responses, oxygen-independent phagocytosis, and increased production of free radicals. One of the major causes of mortality in acute burn toxemia is the development of septic complications accompanied by metabolic and microbial intoxication. Chitosan promotes faster resolution of inflammation by stimulating leukocytes and macrophages, which is manifested in the active formation of cellular elements in wound exudate.

Keywords: Burns, Wound Repair and Regeneration, Journal of Biomaterials Applications

Аннотация: Проблема улучшения заживления ожоговых ран тесно связана с риском вторичной инфекции, метаболическими нарушениями, вызванными интенсивными воспалительными реакциями, кислород-независимым фагоцитозом и повышенным образованием свободных радикалов. Одной из основных причин смертности при острой ожоговой токсемии является развитие септических осложнений, сопровождающихся метаболической и микробной интоксикацией. Хитозан способствует более быстрому разрешению воспалительного процесса за счёт стимуляции лейкоцитов и макрофагов, что проявляется в активном формировании клеточных элементов в раневом экссудате.

Ключевые слова: ожоги, заживление и регенерация ран, журнал «Journal of Biomaterials Applications».

Annotatsiya: Yong‘in (kuylik) jarohatlarini bitishini yaxshilash muammosi ikkilamchi infeksiya xavfi, kuchli yallig‘lanish reaksiyalari natijasida yuzaga keladigan metabolik buzilishlar, kislorodsiz fagotsitoz va erkin radikallarning ortiqcha hosil bo‘lishi bilan chambarchas bog‘liq. O‘tkir kuyish toksimiyasida o‘limning asosiy sababi metabolik va mikroblar bilan bog‘liq intoksikatsiya bilan kechuvchi septik asoratlarning rivojlanishidir.

ISSN 3030-3907

Xitozan leykotsitlar va makrofaglarni faollashtirish orqali yallig‘lanish jarayonining tezroq bartaraf bo‘lishiga yordam beradi, bu esa yara eksudatida hujayraviy elementlarning faol shakllanishida namoyon bo‘ladi.

Kalit so‘zlar: kuyish, yara bitishi va regeneratsiyasi, *Journal of Biomaterials Applications* jurnali.

Introduction

Modern pharmaceutical technology faces an important task — the development of new, effective, and safe therapeutic agents. Equally crucial, however, is the improvement of existing drugs, including those designed for local regenerative treatment [1–5]. Many currently available wound-healing agents provide limited therapeutic efficacy due to their narrow mechanism of action — antibacterial, osmotic, or necrolytic. In addition, antibiotic-based treatments may cause allergic reactions; therefore, antiseptics are often preferred in wound management due to their broad antimicrobial spectrum, effectiveness against antibiotic-resistant strains, and low production cost [6–10].

Among these, furacilin is one of the most widely used antiseptics in surgical practice, available in ointment, aqueous, and alcoholic forms. However, these traditional forms offer only short-term activity, falling short of modern antimicrobial standards and reducing therapeutic efficiency.

An emerging strategy in regenerative medicine is the use of biodegradable polysaccharide-based wound dressings, particularly those derived from natural polymers such as chitosan. Chitosan-based composites exhibit multifunctional properties — being biocompatible, eco-friendly, and effective in medical applications [11–15].

The objective of this study was to evaluate the regenerative, prolonged antimicrobial, osmotic, and adsorptive properties of chitosan derivatives in the treatment of thermal burns.

Materials and Methods

The experimental model of thermal burns was established on 40 adult male white outbred rats (140–160 g). In accordance with the principles of the Helsinki Declaration on animal welfare, burns were induced under light ether anesthesia. The skin area was immersed in boiling water for 10 seconds, following the method of Bogatova et al. (2005), resulting in third-degree burns involving all skin layers. The total wound area ranged from 12–15 cm² (18–20%) of the body surface.

After two hours, animals were randomly divided into four groups (n=10 each):

Group I: Treated with a chitosan–furacilin combination.

Group II: Treated with a chitosan derivative.

Group III: Treated with the reference drug *Levomekol*.

Group IV (control): Treated with physiological saline.

ISSN 3030-3907

Chitosan-based preparations were applied topically once at a dose of 1 mg/kg body weight to the burn site, following treatment with 3% hydrogen peroxide solution. On days 3, 7, and 10, three animals from each group were decapitated under light ether anesthesia; blood and tissue samples were collected for biochemical and histological analysis.

The wound area was measured by applying a sterile polyethylene film over the wound to trace its contour, which was then transferred to graph paper for surface area calculation. Measurements were repeated every five days. The rate of epithelialization (V) was calculated using the formula proposed by *L.N. Popova (1942)*.

Results and Discussion

Within the first 24 hours after burn induction, the rats exhibited signs of acute burn disease — lethargy, weakness, dyspnea, polydipsia, and frequent urination. By the third day, burn scabs formed, and the animals' condition gradually improved.

Rats in Group I (chitosan + furacilin) showed the most significant improvement, becoming more active with restored appetite during treatment. Similar, though less pronounced, changes were observed in Groups II and III, while Group IV animals exhibited prolonged intoxication symptoms and developed purulent-septic complications.

Histological and morphological assessments of the burn site revealed structural and functional tissue alterations, including inflammation and regenerative activity. In the control group, blister formation and infection were evident around the burn site, with wound area increasing by 1.3–1.5 times due to inflammation and necrosis.

Dynamic analysis of wound surface reduction showed the following trends:

Group I: Rapid reduction on days 3 and 7, slightly slower by day 10.

Group II: Minimal reduction on day 3, but accelerated by day 7, then declined by day 10.

Group III: Moderate reduction on days 7 and 10.

Group IV: Negligible reduction on day 3, minimal by day 7, and slightly improved by day 10 (Tables 1–2).

Overall, the chitosan–furacilin formulation demonstrated superior regenerative efficiency compared to other treatments, likely due to synergistic effects combining antimicrobial activity, moisture retention, and biostimulatory action on tissue repair.

ISSN 3030-3907

Table 1.

Dynamics of wound surface area reduction after thermal burn injury

Group	Days	Wound area (cm²)	Reduction (%)
	1	3	7
1	14.078	13.833	11.600
2	13.256	13.134	11.100
3	12.922	12.777	11.703
4	12.329	12.246	11.808

Table 2.

Wound healing rate after thermal burn injury

Group	Healing rate (V) on day	3	7	10
1	0.883	4.834	1.918	
2	0.471	4.322	3.406	
3	0.590	3.138	3.745	
4	0.337	1.048	1.733	

No increase in wound size was observed in rats of the first and second groups throughout the experimental period. These animals developed a uniform wound scab, beneath which homogeneous epithelial regeneration occurred without inflammatory signs. In contrast, the Levomekol-treated group (Group 3) retained visible signs of inflammation.

Wound area analysis demonstrated the most pronounced reduction in the first group. The healing effects observed in the second and third groups were comparable, while regeneration in the control group (Group 4) lagged significantly behind.

By the 10th day, wound contraction in Group 1 was from 14.08 ± 0.66 cm² to 9.47 ± 0.41 cm², and in Group 2 — from 13.26 ± 0.65 cm² to 10.90 ± 0.52 cm². Meanwhile, rats in Groups 3 and 4 showed slower healing dynamics, consistent with prolonged inflammation and delayed epithelialization.

Chitosan-based preparations demonstrated antioxidant, antimicrobial, and regenerative properties. Their application accelerated all stages of tissue repair, leading to a significant reduction in overall wound healing time. The accelerated resolution of inflammation was associated with the activation of leukocytic and macrophage phases, manifested by an increase in the number and functional activity of these cells within the wound exudate, and their transformation into macrophages with enhanced phagocytic potential.

Conclusion

Under the influence of chitosan derivatives, wound healing was characterized by rapid formation of granulation tissue with a well-developed

ISSN 3030-3907

microvascular network and a diverse population of cells and fibrous structures. Accelerated cell differentiation promoted the formation of horizontally oriented fibroblast layers, which quickly transformed into mature connective tissue. These processes facilitated early epithelialization, faster wound contraction, and ultimately the restoration of normal tissue architecture.

The results confirm that chitosan-based formulations, especially when combined with furacilin, have a significant regenerative and protective effect in the treatment of thermal burns, making them a promising basis for the development of advanced biodegradable wound-healing materials.

REFERENCES

1. Kenjayevich B. A., Baxriddinovna U. G. Experimental giperxolesterolemiyada nitrergik tizim dinamikasi //Новости образования: исследование в XXI веке. – 2023. – Т. 1. – №. 9. – С. 1452-1458.
2. Байкулов А. К., Убайдуллаева Г. Б., Хайитова Б. А. Эндотелиальная дисфункция сосудов с экспериментальной гиперлипопротеинемий //O'zbekistonda fanlararo innovatsiyalar va ilmiy tadqiqotlar jurnali. – 2023. – Т. 2. – №. 18. – С. 620-626.
3. Убайдуллайева Г. Б. и др. Экспериментал миокард инфарктини ЛДГ билан коррекциялаш //Tadqiqotlar. uz. – 2024. – Т. 35. – №. 1. – С. 167-171.
4. Байкулов А. К., Убайдуллаева Г. Б., Эшбуриева Б. Р. Коррекция экспериментальной гиперлипопротеинемии с производными хитозана //World of Scientific news in Science. – 2024. – Т. 2. – №. 2. – С. 937-947.
5. Акрамова А. А., Хайитова Б. А., Убайдуллаева Г. Б. Динамика показателей продуктов пол в крови у крыс с экспериментальным термическим ожогом //Ta'lim innovatsiyasi va integratsiyasi. – 2024. – Т. 17. – №. 3. – С. 25-32.
6. Яхшибоева Л., Убайдуллаева Г. Б. Эмбриотоксическая активность препаратов производных хитозана //Ta'lim innovatsiyasi va integratsiyasi. – 2024. – Т. 17. – №. 3. – С. 18-24.
7. Убайдуллаева Г. Б., Хайитова Б. А. Динамика эндотелиальной дисфункции при экспериментальной гиперлипоротеинемии //Zamonaviy fan va ta'lim yangiliklari xalqaro ilmiy jurnal. – 2023. – Т. 1. – №. 5. – С. 95-103.
8. Байкулов А. К. и др. Иследования эффективности производных хитозана на процессы репаративной регенерации ожоговых ран в эксперименте //World science. – 2016. – Т. 3. – №. 5 (9). – С. 53-58.
9. Байкулов А. К., Муртазаева Н. К., Тошбоев Ф. Н. Динамика влияния лактатдегидрогеназы при экспериментальном инфаркте миокарда //World of Scientific news in Science. – 2024. – Т. 2. – №. 3. – С. 244-251.

ISSN 3030-3907

10. Милушева Р. Ю. и др. Синтез противоожоговых препаратов на основе хитозана bombyx mori //Известия Уфимского научного центра РАН. – 2018. – №. 3-2. – С. 18-21.
11. Кадырова Д. А. и др. Изучение связывания хитозана со специфическими участками ДНК при термическом ожоге //Вестник Новосибирского государственного университета. Серия: Биология, клиническая медицина. – 2012. – Т. 10. – №. 5. – С. 31-35.
12. Bayqulov A. K., Halimova S. A., Eshburieva N. R. Dynamics of the influence of lactate dehydrogenase during experimental myocardial infarction //World of Scientific news in Science. – 2024. – Т. 2. – №. 3. – С. 232-238.
13. Ermanov R. T., qizi Xudoyorova M. B., Baykulov A. K. Investigation of variations in vitamin d in eggs based on the season of the year //World of Scientific news in Science. – 2024. – Т. 2. – №. 4. – С. 340-348.
14. Рахмонов Ж., Тошпулатов Э., Убайдуллаева Г. Б. Регенерация ран термического ожога с использованием хитозана //Ta'lim innovatsiyasi va integratsiyasi. – 2024. – Т. 17. – №. 3. – С. 11-17.
15. Ermanov R. T., Qarshiev S. M., Baykulov A. K. Changes in the nitrergic system during experimental hypercholesterolemia //World of Scientific news in Science. – 2024. – Т. 2. – №. 4. – С. 326-339.
16. Hikmatovich I. N., Xolmatovich J. A., Axtamovna A. F. Applications of Elidel for Lichen Plane //Texas Journal of Medical Science. – 2022. – Т. 8. – С. 113-115.
5- Ачилова Ф. А., Жалилов А. Х. Данные эхокардиографии при малых аномалий сердца у детей //E Conference Zone. – 2022. – С. 136140.
17. Hikmatovich I. N., Xolmatovich J. A., Axtamovna A. F. O‘smirlardagi vulgar acne kassaligini kompleks davolashni ishlab chiqish va samaradorlikni aniqlash //barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali. – 2022. – С. 323-326.
18. 3.Hikmatovich I. N., Temirovich E. R., Xolmatovich J. A. herpis virusini mahalliy davolash uchun vifironni qo‘llash //barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali. – 2022. – С. 349-351.
19. Hikmatovich I. N., Xolmatovich J. A., Axtamovna A. F. Atopik dermatitli bemorlarni progressiv bosqichda mahalliy davolash samaradorligini baholash //barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali. – 2022. – С. 259-263.
20. Hikmatovich I. N., Xolmatovich J. A., Axtamovna A. F. Applications of Elidel for Lichen Plane //Texas Journal of Medical Science. – 2022. – Т. 8. – С. 113115.
21. Islamov N. H., Jalilov A. X., Achilova F. A. Ijtimoiy-gigienik turshiy shartlarning o ‘quvchilar salomatligiga ta’siri //Educational Research in Universal Sciences. – 2023. – Т. 2. – №. 14. – С. 314-318.

ISSN 3030-3907

22. Islamov N. H. et al. Principles of treatment of laryngotracheitis in children //Modern Scientific Research International Scientific Journal. – 2023. – T. 1. – №. 7. – C. 136-142.
23. Islamov N. H., Jalilov A. X., Achilova F. A. Development of papillomavirus infection in men //Modern Scientific Research International Scientific Journal. – 2023. – T. 1. – №. 7. – C. 128-135.
24. Hikmatovich I. N., Temirovich E. R., Muradovich Y. M. O‘smirlarda yuzaki pyodermani davolashda topikal terapiya //barqarorlik va yetakchi tadqiqotlar onlayn ilmiy jurnali. – 2022. – C. 355-358.
25. Salamova L. A., Baratova M. R., Islamov N. H. Does bacterial vaginosis cause pelvic inflammatory disease? //Theoretical & Applied Science. – 2020. – T. 91. – №. 11. – C. 250-254.
26. Islamov N. H., Baratova M. R., Salamova L. A. Factors related to the efficiency of treatment by a doctor-dermatovenerologist and the recommended treatment of gonorrhea //ISJ Theoretical & Applied Science, 11 (91). – 2020. – C. 255-258.
27. Salamova L. A., Baratova M. R., Islamov N. H. Вызывает ли бактериальный вагиноз воспалительное заболевание органов малого таза? //Theoretical & Applied Science. – 2020. – №. 11. – C. 250-254.
28. Baratova M. R., Salamova L. A., Islamov N. H. Эпидермальные паразитарные кожные заболевания как пренебрегаемая категория болезней, связанных с бедностью //Theoretical & Applied Science. – 2020. – №. 11. – C. 259264.
29. Baratova M. R., Salamova L. A., Islamov N. H. Epidermal parasitic skin diseases as a neglected category of diseases related to poverty //ISJ Theoretical & Applied Science, 11 (91). – 2020. – C. 259-264.
30. Исламов Н. Х., Шадыев У. Х., Саламова Л. А. Применение «Бетаметазон-Дарница» в лечении микробной экземы //Тюменский медицинский журнал. – 2011. – №. 2. – C. 50-51.
31. Islamov N. H., Baratova M. R., Salamova L. A. Факторы, связанные с эффективностью лечения врача-дерматовенеролога и рекомендуемой схемы лечения гонореи //Theoretical & Applied Science. – 2020. – №. 11. – C. 255-258.
32. Islamov N. H. et al. Ultrasound Picture of the Case of Liver Echinococcosis //Academicia Globe: Inderscience Research. – 2021. – T. 2. – №. 05. – C. 98-103.
33. Hikmatovich I. N., Temirovich E. R., Raximjon o‘g‘li N. S. The Use of Advantan in the Local Treatment of Genital Herpes //Texas Journal of Medical Science. – 2022. – T. 8. – C. 110-112.
34. Hikmatovich I. N., Temirovich E. R., Egamberdiyevich M. A. Clinical Evaluation of the Efficacy of Acne Vulgaris Laser Therapy //Central Asian Journal of Medical and Natural Science. – 2022. – T. 3. – №. 5. – C. 667-669.

ISSN 3030-3907

35. Hikmatovich I. N., Temirovich E. R., Egamberdiyevich M. A. Development of a Complex Method for the Treatment of Chronic Pyoderma //Central Asian Journal of Medical and Natural Science. – 2022. – Т. 3. – №. 5. – С. 663-666.

ISSN 3030-3907