https://doi.org/10.52889/1684-9280-2025-76-1-41-47

Comprehensive approach to treating a mangled hand injury using innovative wound coverage: A clinical case

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Abstract

Mangled hand injuries caused by entrapment in rotating industrial machinery pose a significant challenge in trauma and reconstructive surgery. This clinical case describes the treatment of a 45-year-old female patient with a mangled injury to the right hand, who presented one month after the initial trauma.

Following the injury, the patient underwent primary amputation of the first, fourth, and fifth fingers with surgical wound debridement. Upon admission, signs of a chronic wound with soft tissue necrosis, edema, and inflammation were noted. Within the first 24 hours, radical surgical debridement (necroectomy) was performed to remove necrotic tissues and sanitize the wound. An innovative wound covering based on modified alginate hydrogel with silver ions and the antibiotic cefepime was applied to the wound surface. Three days later, the antibacterial covering was replaced with a wound covering containing fibroblast growth factor (FGF-2) to stimulate tissue regeneration. Two weeks later, after wound preparation, free autografting was performed using skin grafts harvested from the patient's thigh. The postoperative period was uneventful. Two weeks after the skin grafting, satisfactory wound healing was observed.

This case demonstrates the effectiveness of innovative wound coverings with sequential use of antibacterial and regenerative strategies in combination with staged surgical treatment. This approach successfully closed the complex wound defect and improved the functional state of the hand.

Keywords: hand injury, chronic wound, necroectomy, autografting, wound covering, silver ions, fibroblast growth factor.

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J Trauma Ortho Kaz 76 (1) 2025: 41-47
Recieved: 19-01-2025
Accepted: 07-02-2025

Introduction

Mangled hand injuries caused by entrapment in rotating industrial machinery pose a significant challenge in modern trauma and reconstructive surgery [1]. These injuries are characterized by extensive soft tissue damage, necrosis development, and the formation of chronic infected wounds, significantly complicating treatment [2]. Given the high level of disability and the complexity of restoring hand function, finding optimal approaches to treat such injuries remains an urgent task [3].

Despite the existence of various methods for treating mangled hand injuries, such as the use of skin grafts and reconstructive techniques, there is a significant gap in the application of innovative solutions to prepare complex wounds for definitive reconstruction. Specifically, the use of wound coverings containing antibacterial components and growth factors in conditions of chronic inflammation and infection has not been sufficiently studied [4,5]. Furthermore, additional research is needed to clarify their role in accelerating tissue regeneration and minimizing the risk of complications.

The aim of this study is to demonstrate the effectiveness of a comprehensive staged approach to treating a mangled hand injury using an innovative wound covering based on alginate hydrogel with silver ions, the antibiotic cefepime, and fibroblast growth factor (FGF-2). This approach ensured the successful closure of a chronic wound defect, the prevention of infectious complications, and the improvement of the functional condition of the limb.

Case Description

A 45-year-old female patient was admitted to the National Scientific Center for Traumatology and Orthopedics named after Academician Batpenov N.D., one month after sustaining a severe occupational injury. The injury occurred due to the entrapment of the right hand in rotating industrial machinery. In the context of emergency hospitalization at the site of the injury (Russian Federation) (Figure 1), the patient underwent primary surgical debridement of the wound and amputation of the first, fourth, and fifth fingers. However, during the postoperative period, the patient reported worsening pain, progressive necrosis of soft tissues, inflammation, and swelling, necessitating reconsultation for specialized medical care.

Figure 1 - External appearance of the limb 10 days after initial surgical debridement (primary wound treatment)

Upon admission to the hospital, the patient's general condition was assessed as moderate (Figure 2). She was conscious, coherent, and oriented. Her body temperature was recorded at 37.5°C. The patient reported severe pain in the area of the right hand, pronounced swelling, and the presence of a non-healing postoperative wound with signs of inflammation.

The right hand appeared deformed, with postoperative stumps of the first, fourth, and fifth fingers. The skin around the wound showed areas of necrosis with a black, moist appearance, located on both the dorsal and palmar surfaces of the hand. The second and third fingers were swollen with a cyanotic hue, and movement was absent due to significant edema and pain. Surrounding the wound, hyperemia, hyperthermia, and pronounced soft tissue swelling were noted.

The wound surface was moist, covered with seropurulent exudate and detached necrotic masses. Despite local signs of inflammation, systemic infection symptoms were absent, indicating a localized nature of the lesion.

Figure 2 - External appearance of the limb upon admission to the National Scientific Center for Traumatology and Orthopedics, 30 days after the injury

The patient was admitted to the trauma sequelae department with the diagnosis: "Mangled trauma of the right hand with amputation of the first, fourth, and fifth fingers, soft tissue necrosis, and formation of a chronic infected wound." A staged treatment plan was developed, including radical wound sanitation, the application of innovative wound coverings, and subsequent skin reconstruction.

As part of intensive therapy, antibacterial treatment was initiated based on the results of a bacteriological culture. The wound discharge revealed the presence of Enterococcus

faecalis (3×10^3 CFU/mL) with multidrug resistance to antibiotics, including benzylpenicillin, erythromycin, levofloxacin, and tetracycline, but with preserved sensitivity to vancomycin and linezolid. Antibacterial therapy included the administration of vancomycin. To support the patient's general condition, intravenous infusions of sodium chloride with added ascorbic acid were administered. Anti-inflammatory and analgesic therapy involved tramadol, diphenhydramine, and metamizole, which effectively controlled pain and reduced local inflammation.

Figure 3 - X-ray of the right hand at the time of admission

Within 24 hours of hospitalization, considering the severity of the condition, pronounced tissue necrosis, intense inflammation, and the presence of purulent discharge, the patient underwent the first stage of surgical intervention. Under general anesthesia, and following standard surgical preparation of the field, radical wound debridement was performed. Necrotic areas of skin and soft tissues with a black, moist appearance were removed from the dorsal and palmar surfaces of the hand as well as from the stumps of the first, fourth, and fifth fingers using a scalpel, scissors, and a Volkman spoon. Examination during debridement revealed hematomas with dense blood clots, purulent pockets, and areas of necrotic tissue liquefaction. The wounds were thoroughly irrigated with a 3% hydrogen peroxide solution and antiseptic solutions.

The procedure was completed without complications. It significantly reduced inflammation, decreased the volume of necrotic tissues, and prepared the wound for further treatment.

Following the necroectomy, an innovative wound covering based on modified alginate hydrogel with silver ions and the antibiotic cefepime was applied to the wound surface. This covering provided an antibacterial effect, protected the wound from secondary infection, and promoted the cleansing of the wound bed (Figure 4).

Figure 4 - External appearance of the limb on the fourth day after admission, following necroectomy and three days of treatment with a wound covering containing the antibiotic cefepime

Three days later, after achieving localized infection control, the antibacterial covering was replaced with a wound covering containing fibroblast growth factor (FGF-2). This step facilitated the stimulation of tissue regeneration processes and further prepared the wound for the reconstructive phase of treatment (Figure 5).

Figure 5 - External appearance of the limb on the eighth day after admission, following four days of treatment with the second-stage wound covering containing fibroblast growth factor (FGF-2)

On the 10th day after admission, a repeat bacteriological culture of the wound discharge was performed, which revealed no growth of pathogenic microflora. This confirmed the effectiveness of the antibacterial therapy and local wound management. The elimination of the infectious process allowed for a safe transition to the next stage of treatment.

Two weeks after the initial surgical debridement, the patient's condition had significantly improved. The wound surface was cleared of necrotic tissues, and inflammation

and swelling were notably reduced. These improvements allowed for the second stage of surgical treatment aimed at closing the wound defect.

The second stage involved free autografting. Under general anesthesia, and after preparing the surgical field, three skin grafts measuring 0.3 mm in thickness were harvested using an electric dermatome from the anterior and lateral surfaces of the patient's thigh. Two grafts measuring up to 13 cm in length and 4 cm in width, and one graft measuring 5×4 cm, were perforated to improve drainage and placed over the prepared wound surface of the hand.

The grafts were sutured to the wound edges with Vicryl, ensuring uniform coverage of the dorsal and palmar surfaces of the hand as well as the stumps of the fingers. A fixative dressing with saline solution was applied to complete the procedure (Figure 6).

Figure 6 - External appearance of the limb on the 14th day after admission, following the complete course of innovative wound covering treatment and the second-stage surgical intervention for defect closure

The postoperative period was uneventful. On the 10th day after autografting, satisfactory graft adherence was observed. The wound surface was clean, and no signs of inflammation were noted. The patient continued to receive comprehensive therapy aimed at supporting tissue regeneration and preventing secondary infectious complications.

Figure 7 - External appearance of the limb at the time of discharge for further outpatient treatment

The patient was discharged in satisfactory condition with recommendations for outpatient rehabilitation and regular follow-up to evaluate the final outcomes of the treatment. This staged approach resulted in the successful closure of the wound defect, the elimination of infection, and a significant improvement in the functional condition of the hand. (Figure 7).

Three months after the staged treatment, the patient underwent follow-up examination. The condition of the skin in the area of the previous autograft was satisfactory, with no signs of active inflammation or complications. The skin grafts were well integrated, and the wound surfaces were fully closed. (Figure 8).

Figure 8 - External appearance of the limb three months post-treatment during follow-up examination

However, a minor necrosis and mummification process of the distal phalanges were observed. The medical team decided on a watchful waiting approach, as in such cases, necrotic tissues often separate naturally without requiring additional intervention. The patient remains under regular observation to monitor the process and address any potential complications promptly.

The patient is also undergoing rehabilitation therapy aimed at restoring hand mobility and improving the functional state of the limb. The program includes physiotherapy and specific exercises to enhance movement and strengthen the muscles. These rehabilitation measures are contributing to the recovery of strength, range of motion, and overall quality of life.

Written informed consent was obtained from the patient for the dissemination of their medical information.

Discussion

The treatment of mangled hand injuries complicated by infection and soft tissue necrosis is a challenging task [7]. Existing methods for reconstructing soft tissue defects include the use of skin grafts, vacuum-assisted therapy, and various wound coverings [8]. In this case, the focus was on a combined approach involving radical wound debridement, the application of innovative wound coverings, and autografting [9].

Global studies demonstrate the high effectiveness of such technologies. For instance, in a study conducted by Mark S. Granick et al., a bioabsorbable temporizing matrix (BTM), initially developed for burn treatment, was successfully used for complex traumatic wounds, including mangled injuries. It facilitated neodermis formation, promoted wound cleansing, and stimulated tissue regeneration prior to autografting. Its resistance to infection and ease of use make such coverings an essential stage in managing complex wounds [10].

Another study conducted in the United States described the use of Integra® as a temporary measure before definitive reconstruction of injured extremities. The covering was used to protect areas of vascular reconstruction and stabilize the wound surface. This approach allowed the postponement of free or rotational flap procedures until the extent of necrosis was determined and the defect stabilized. Additionally, the formation of a collagen layer reduced the need for more complex reconstructive techniques and minimized the risk of donor site morbidity [11].

Innovative wound coverings based on alginate hydrogel with added silver ions, antibiotics, and growth factors play a key role in treating complex wounds. The use of an antibacterial covering in the first stage of therapy ensured effective control of local infection, as confirmed by bacteriological culture results that showed no growth of pathogenic flora on the 10th day. This indicates a significant reduction in microbial load and the prevention of secondary infectious complications.

Replacing the silver ion-based covering with a fibroblast growth factor (FGF-2) covering accelerated tissue regeneration processes. Studies have shown that such coverings stimulate angiogenesis, promote re-epithelialization, and improve wound healing quality. In our case, this strategy ensured the cleaning and preparation of the wound surface for the subsequent stage of surgical treatment.

The main stage of reconstruction involved free autografting. This intervention remains the gold standard for closing extensive skin defects, especially in cases of mangled injuries with soft tissue loss. The use of perforated skin grafts improved their adherence, provided even coverage of the wound surface, and minimized the risk of seroma formation. By the 10th day after surgery, satisfactory graft adherence was observed, indicating the effectiveness of the chosen treatment strategy.

The combined approach of using wound coverings and autografting allowed not only the elimination of infection and closure of the wound defect but also the creation of favorable conditions for restoring hand functionality. This method has proven to be a reliable solution for managing chronic infected wounds, especially in the presence of resistant microflora.

Conclusion

The presented clinical case demonstrates the effectiveness of a comprehensive approach to treating mangled hand injuries complicated by chronic infected wounds. The use of innovative wound coverings with antibacterial components and growth factors, as well as autografting, enabled successful wound healing, prevented the development of complications, and ensured significant improvement in hand functionality.

Thus, the combination of modern wound treatment methods and a staged surgical approach makes it possible to effectively manage such complex clinical cases, ensuring both the resolution of the infectious process and the restoration of integrity and functionality in the injured area.

Funding Statement

The Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan provided financial support for this study (Grant No. AP13068136).

Conflict of Interest. The authors declare no conflicts of interest related to this work.

Author Contributions. Conceptualization – A.M.A., D.A.S.; Methodology – A.M.A., D.V.R.; Formal Analysis – A.M.A., Zh.K.R., A.A.K.; Writing (original draft preparation) – A.M.A.; Writing (review and editing) – D.A.S., Zh.S.A.; Visualization – Zh.K.R., A.A.K.; Resources – D.V.R., M.A.A.; Project Administration – S.S.B., Zh.S.A.

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Қолдың жарақаттанған жарасын емдеудің кешенді тәсілі: Инновациялық жара жапқышты қолдану мысалы

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Түйіндеме

Айналмалы өнеркәсіптік жабдықтың қысылуынан туындаған қолдың пішіні бұзылған жарақаттар жарақаттық-реконструкциялық хирургияның негізгі проблемасы болып табылады. Бұл клиникалық жағдай бастапқы жарақаттан кейін бір айдан кейін келген оң қолының жарақаты бар 45 жастағы науқасты емдеуді сипаттайды.

Жарақат алғаннан кейін науқасқа жараны хирургиялық тазарту арқылы бірінші, төртінші және бесінші саусақтарының ампутациясы жасалды. Түскен кезде жұмсақ тіндердің некрозы, ісінуі және қабынуы бар созылмалы жараның белгілері анықталды. Бірінші күні некротикалық тіндерді жою және жараны санитарлық тазарту үшін радикалды хирургиялық емдеу (некроэктомия) жүргізілді. Жара бетіне күміс иондары мен цефепим антибиотикі бар модификацияланған альгинат гидрогелі негізіндегі инновациялық жара жабыны қолданылды. Үш күннен кейін бактерияға қарсы таңғыш тіндердің регенерациясын ынталандыру үшін құрамында фибробласт өсу факторы (FGF-2) бар жара таңғышымен ауыстырылды. Екі аптадан кейін жараны дайындағаннан соң науқастың жамбасынан алынған тері трансплантаты арқылы еркін автотрансплантация жасалды. Операциядан кейінгі кезең асқынусыз өтті. Тері егуден кейін екі аптадан кейін жараның қанағаттанарлық жазылуы байқалды.

Бұл жағдай антибактериалды және регенеративті стратегияларды кезеңді хирургиялық емдеумен біріктіріп қолдану кезіндегі инновациялық жара таңғыштарының тиімділігін көрсетеді. Аталмыш тәсіл күрделі жара ақауын сәтті жауып, қолдың функционалдық жағдайын жақсартты.

Түйін сөздер: қол жарақаты, созылмалы жара, некректомия, аутотрансплантация, жараны жабу, күміс иондары, фибробласт өсу факторы.

Комплексный подход к лечению размозженной травмы кисти с использованием инновационного раневого покрытия: клинический случай

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Резюме

Изуродованные травмы рук, вызванные защемлением во вращающемся промышленном оборудовании, представляют собой серьезную проблему в травматологической и реконструктивной хирургии. В данном клиническом случае описывается лечение 45-летней пациентки с увечьем правой руки, обратившейся через месяц после первичной травмы.

После травмы пациенту произведена первичная ампутация первого, четвертого и пятого пальцев с хирургической санацией раны. При поступлении отмечены признаки хронической раны с некрозом мягких тканей, отеком и воспалением. В первые сутки проводили радикальную хирургическую обработку (некроэктомию) с целью удаления некротических тканей и санации раны. На раневую поверхность наносили инновационное раневое покрытие на основе модифицированного альгинатного гидрогеля с ионами серебра и антибиотика цефепима. Через три дня антибактериальное покрытие было заменено на раневое покрытие, содержащее фактор роста фибробластов (FGF-2) для стимуляции регенерации тканей. Через две недели, после подготовки раны, была проведена свободная аутотрансплантатация с использованием кожных трансплантатов, взятых с бедра пациента. Послеоперационный период протекал без осложнений. Через две недели после пересадки кожи наблюдалось удовлетворительное заживление ран.

Данный случай демонстрирует эффективность инновационных раневых покрытий при последовательном использовании антибактериальных и регенеративных стратегий в сочетании с поэтапным хирургическим лечением. Данный доступ успешно закрыл сложный раневой дефект и улучшил функциональное состояние кисти.

Ключевые слова: травма руки, хроническая рана, некрэктомия, аутотрансплантат, раневое покрытие, ионы серебра, фактор роста фибробластов.