Scientific Research Publishing

Journal of Biosciences and Medicines, 2024, 12, 238-244
https://www.scirp.org/journal/jbm
ISSN Online: 2327-509X
ISSN Print: 2327-5081

The Application of Bilayer Artificial Dermis Combined with VSD Technology in Chronic Wounds

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How to cite this paper: Dong, X.J. and Luo, H.S. (2024) The Application of Bilayer Artificial Dermis Combined with VSD Technology in Chronic Wounds. *Journal of Biosciences and Medicines*, **12**, 238-244.
https://doi.org/10.4236/jbm.2024.123020

Received: February 11, 2024
Accepted: March 19, 2024
Published: March 22, 2024

Abstract

Background: Bilayer artificial dermis promotes wound healing and offers a treatment option for chronic wounds. **Aim:** Examine the clinical efficacy of bilayer artificial dermis combined with Vacuum Sealing Drainage (VSD) technology in the treatment of chronic wounds. **Method:** From June 2021 to December 2023, our hospital treated 24 patients with chronic skin tissue wounds on their limbs using a novel tissue engineering product, the bilayer artificial dermis, in combination with VSD technology to repair the wounds. The bilayer artificial dermis protects subcutaneous tissue, blood vessels, nerves, muscles, and tendons, and also promotes the growth of granulation tissue and blood vessels to aid in wound healing when used in conjunction with VSD technology for wound dressing changes in chronic wounds. **Results:** In this study, 24 cases of chronic wounds with exposed bone or tendon larger than 1.0 cm^2 were treated with a bilayer artificial skin combined with VSD dressing after wound debridement. The wounds were not suitable for immediate skin grafting. At 2 - 3 weeks post-treatment, good granulation tissue growth was observed. Subsequent procedures included thick skin grafting or wound dressing changes until complete wound healing. Patients were followed up on average for 3 months (range: 1 - 12 months) post-surgery. Comparative analysis of the appearance, function, skin color, elasticity, and sensation of the healed chronic wounds revealed superior outcomes compared to traditional skin fl repairs, resulting in significantly higher satisfaction levels among patients and their families. **Conclusion:** The application of bilayer artificial dermis combined with VSD technology for the repair of chronic wounds proves to be a viable method, yielding satisfactory therapeutic effects compared to traditional skin flap procedures.

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Keywords

Bilayer Artificial Dermis, Vacuum Sealing Drainage (VSD), Chronic Wounds, Wound Healing, Application

1. Introduction

Chronic wounds refer to wounds that experience obstruction or delay in healing, persisting for weeks or even months without closure, possibly due to various reasons [1] [2]. They are characterized by long healing times, recurrent occurrences, susceptibility to infection, irregular edges, high risk of scarring, and high demands for treatment. Conventional treatment approaches in clinical practice often fail to achieve the desired therapeutic outcomes [3]. Therefore, trauma and orthopedic surgeons are continuously exploring new methods to repair chronic wounds. In recent years, bilayer artificial dermis has emerged as a novel approach for wound repair, with ongoing clinical maturation and development. From June 2021 to December 2023, a total of 24 patients with chronic wounds on their extremities were treated using a novel tissue engineering product, the bilayer artificial dermis, in combination with VSD technology. The outcomes of repairing chronic wounds were found to be promising. The following is the current report.

2. Materials and Methods

2.1. General Information

A total of 24 cases were included in this study, with 13 males and 11 females. The patients' ages ranged from 12 to 77 years, with a mean age of 38.5 years. The cases included 9 instances of infected skin ulcers, 8 cases of crush injuries, 3 cases of venous ulcers, and 2 cases of degloving injuries. The injured sites were: dorsal foot (8 cases), lower leg (6 cases), fingers (4 cases), dorsum of the hand (2 cases), sole of the foot (2 cases), medial malleolus (1 case), and forearm (1 case). All wounds exhibited exposed tendons or bones, with skin defects ranging from 1.0 cm × 3.0 cm to 5.0 cm × 12.0 cm. Material used: Lando bilayer artificial dermis (Shenzhen Qikang Medical Devices Co., Ltd.) [4].

2.2. Inclusion and exclusion criteria

Inclusion criteria: meet the diagnostic criteria for chronic non-healing wounds; presence of tendon and/or bone exposure; eligible for surgical treatment; informed consent provided for this study. Exclusion criteria: concurrent severe cardiac, cerebral, pulmonary, hepatic or renal functional disorders; severe infections; profound coagulation abnormalities; psychiatric disorders or poor comlaiance.

2.3. Surgical Procedures

The surgeries in this study were all conducted under regional nerve block anes-

thesia. The surgical area was routinely disinfected with iodine, thoroughly debrided, necrotic tissues were removed, and wound edges were trimmed neatly, paying special attention to protecting the surrounding soft tissue blood supply. The wound was then washed twice with iodine, hydrogen peroxide and normal saline, followed by selecting an appropriate size of artificial dermis according to the wound size. The artificial dermis was soaked in sterile 0.9% saline solution for 3 - 5 minutes. After softening, the artificial dermis was trimmed according to the size and shape of the wound, positioned with the dermal side facing downwards covering important tissues like bones and tendons, intermittently sutured for fixation. Silicone membrane was evenly punctured with a blade for adequate drainage. Subsequently, a VSD dressing was placed over the wound and connected to a negative pressure device, controlled between 125 - 200 mmHg, and removed after approximately one week. Depending on the growth of granulation tissue at the wound site, the VSD dressing could be replaced 2 - 3 times postoperatively. Routine anti-infective therapy was administered along with symptomatic pain management. Upon sufficient growth of granulation tissue at the wound site, the artificial dermis was removed, following which different treatment options could be chosen based on wound size, granulation tissue growth, and patient preference. Most patients opted for skin grafting, with compression bandaging for fixation [5] [6]. Following surgery, regular anti-inflammatory and pain management measures were implemented with successful graft survival seen upon bandage removal after one week, leading to discharge after dressing changes. A few patients with smaller wounds, good granulation tissue filling, and unwillingness for skin grafting could opt for periodic disinfection and covering the wound with moist saline gauze to maintain moisture for spontaneous epithelialization and healing [7].

3. Outcome

After thorough debridement and application of artificial dermis combined with VSD technology, chronic wound granulation tissue grew well. Subsequent skin grafting or self-epithelialization resulted in satisfactory healing. Follow-up evaluations at 1 to 12 months postoperatively showed excellent survival of the skin grafts, which exhibited soft, flexible, and elastic texture. Compared to traditional skin flap repair, there was no significant bulging, and optimal restoration of limb function was achieved.

Typical Case

The 35-year-old male patient was admitted due to “skin ulcers with soft tissue infection on both lower legs for more than 3 months”. On examination, round skin ulcers of approximately 5 cm diameter were noted on the front and inner side of the right lower leg, extending to the muscle layer; and an irregular circular ulcer of about 4 cm with exposed tendons and purulent secretions on the dorsum of the left foot. Scars of previous ulcers and pigmentation were observed

on both lower legs. Treatment included debridement, application of artificial dermis to cover the exposed tendons, uniform perforation of silicone membrane, VSD dressing with continuous negative pressure. Postoperatively, routine anti-infection, pain management, and skin grafting were performed. The artificial dermis was removed after 3 weeks, revealing good granulation tissue growth, intact coverage of exposed tendons, and fresh epithelialization around the wound. A thick skin graft was then performed, which showed successful engraftment upon removal of stitches one week later, leading to discharge from the hospital.

The 53-year-old female patient presented with a crush injury to the left foot, resulting in fractures of the second and third metatarsal bones, contusions in the soft tissues of the left foot dorsal area, and a subcutaneous hematoma. Upon admission, appropriate examinations were conducted, and she was treated symptomatically with anti-swelling measures, pain management, and external fixation. Subsequently, necrosis of the skin on the dorsal area of the left foot developed. Once the extent of necrosis stabilized, debridement was performed revealing a 4 cm * 4 cm area of necrotic skin and tissue. After removal of the necrotic tissue, including exposure of tendons, the wound was covered with artificial skin, perforated silicone membrane, and VSD dressing with continuous negative pressure suction. The surgery was successful, and upon removal of the artificial skin two weeks post-operation, healthy granulation tissue was observed. Following discussion with the patient, she opted not to undergo skin grafting, choosing instead to manage wound healing at home with clinic visits for dressing changes. The patient was informed that if the wound did not heal adequately, skin grafting might be necessary upon her return to the hospital. At the 45-day follow-up appointment, the wound showed epithelialization with pigmentation, the tendons were not contracted, and toe movement in the left foot was preserved, resulting in a high level of patient satisfaction.

4. Discussion

4.1. Chronic Wounds

In contemporary China, industrialization and an aging population have led to a growing number of patients with chronic wounds caused by various traumas and age-related conditions, making chronic wound care a common issue in clinical practice. Chronic wounds are characterized by high treatment complexity, long healing periods, poor outcomes, and high recurrence rates. New treatment principles and methods have emerged over time. In 2000, Falanga introduced the concept of "wound bed preparation", and Schultz et al. proposed the "TIME" principle of wound bed preparation. This approach aims to promote orderly wound healing by thorough debridement, infection control, maintaining appropriate moisture levels, and removing the damaged wound edge epithelium. The rapid development of diverse treatment modalities such as holistic care, debridement therapy, negative pressure wound therapy, skin stretching therapy, growth factor therapy, platelet-rich plasma (PRP) therapy, oxygen therapy, silver dress-

ing therapy, skin substitutes, cross-sectional bone transfer therapy, vascular intervention therapy, gene therapy, among others, has led to improved treatment outcomes. In our study, we employed thorough debridement followed by the application of a bilayer artificial dermis combined with Vacuum Sealing Drainage (VSD) technology to facilitate the formation of the wound bed, thus enabling secondary skin grafting or spontaneous epithelialization for wound healing.

4.2. Bilayer Artificial Dermis

Bilayer artificial dermis is a novel synthetic material composed of a bilayer structure consisting of a lowly antigenic collagen sponge and a silicone membrane. It mimics the structure and function of the dermis, exhibiting excellent biocompatibility and mechanical properties [8] [9] [10]. It provides functions of cellular engraftment, support, and wound protection, effectively promoting wound healing, reducing the risk of infection, and minimizing the likelihood of rejection reactions. This material has been widely used in the treatment of burn injuries, wound healing, and skin repair due to its beneficial properties. The upper silicone membrane primarily serves to protect the wound and prevent excessive moisture evaporation. It is usually removed after 2 - 3 weeks, allowing the body's tissues to gradually replace the collagen sponge in the lower layer. In chronic wounds, granulation tissue is formed, replacing the deficient dermis and necessitating skin grafting on the surface as needed. Artificial dermis exhibits good tissue compatibility and low immunogenicity. The sponge-like dermal scaffold layer promotes the growth of endothelial cells and granulation tissue, resulting in the formation of dermis-like tissue to fill the dermal defect and inhibiting scar hyperplasia. Moreover, it reduces the frequency of dressing changes, facilitating wound healing, secondary skin grafting, and restoration of elasticity, flexibility, and aesthetic function of the wound [11] [12] [13] [14]. In our study, we treated patients with chronic refractory wounds by combining artificial dermis with vacuum sealing drainage (VSD) coverage, followed by secondary skin grafting or multiple dressing changes, which led to successful healing. Follow-up assessments at 1 month, 3 months, 6 months, and 1 year post-operation revealed minor pigmentation and no apparent scar hypertrophy, with no significant adverse reactions or local limb contracture deformities. The outcomes were positive, affirming the effectiveness of the treatment approach.

4.3. Vacuum Sealing Drainage

The VSD system comprises medical foam dressing, drainage tube, flushing pipelines, biofilm, and negative pressure source [15] [16] [17]. It functions to provide wound coverage and isolation, all-around drainage of secretions or pus, improve wound blood flow, reduce wound edema, minimize infections, and promote wound healing. Additionally, it alleviates patient discomfort during dressing changes and reduces the workload for healthcare providers in recent years, VSD technology has been widely used in the repair and treatment of chronic refractory wounds

in various medical specialties such as orthopedics, burns, endocrinology, plastic surgery, achieving favorable treatment outcomes [18] [19] [20].

In conclusion, the author suggests that in the repair treatment of chronic refractory wounds, the use of bilayer artificial dermis combined with VSD technology in the first stage promotes the formation of a wound bed. After the condition stabilizes, the second stage involves performing skin grafting to cover the wound or allowing it to epithelialize for wound healing. This approach, compared to traditional skin flap transplantation, significantly reduces surgical risks, increases the survival rate of the second-stage grafting, improves post-grafting appearance and functionality, enhances patient satisfaction, and effectively reduces hospitalization duration and treatment costs while conserving medical resources.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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