Comprehensive Integration of the Operational Principles of Diabetic Foot Therapeutic Devices with Technological Innovations

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Abstract This paper offers a comprehensive overview of the operational principles of current therapeutic devices for diabetic foot management and further analyzes technological innovations and developmental trends, aiming to promote research and development in the field of technological convergence. The ultimate goal is to enhance the cure rate for diabetic foot conditions and to decrease the incidence of amputations. The paper discusses the novel applications of ultrasound and optical therapeutic devices within the field of physiotherapy, the numerous advantages of chitosan dressings in biotechnology, the ongoing advancements and broader combined use of vacuum sealing drainage techniques, and the distinctive effects and innovations associated with micro-oxygen diffusion techniques. It thoroughly examines various technological mechanisms that facilitate wound healing, highlighting the clinical applications of ultrasonic atomized medicinal solutions, novel dressing graft copolymerization, continuous hypoxia diffusion, and the functions of vacuum drainage. These advancements facilitate the integration of drainage and dressing changes, with the potential to enhance the therapeutic effects of diabetic foot treatment and provide valuable insights for clinical application.

Key words Diabetic foot therapeutic device, Operational principle, Technological innovation, Technological convergence

1 Introduction

According to the International Diabetes Federation (IDF), the number of individuals with diabetes worldwide reached 463 million in 2019, and this figure is projected to increase to 700 million by 2045[1]. Diabetic foot is a severe complication of diabetes mellitus, resulting from neuropathy and vasculopathy due to prolonged hyperglycemia. This condition leads to a loss of sensation in the foot, poor blood circulation, and a diminished ability to heal wounds. Consequently, it may result in serious complications such as infections, ulcers, and even amputations.

In the current context, the challenges of low cure rates and slow wound healing of diabetic foot ulcer (DFU) continue to persist, significantly impacting patients' quality of life. Therefore, enhancing the DFU cure rate and accelerating wound healing has become the primary objective of DFU treatment today. Currently, the primary clinical treatments for DFU include pharmacological therapy, surgical procedures to restore blood flow, and amputation. However, traditional treatments often yield suboptimal therapeutic outcomes, leading to a high rate of recurrence and an elevated incidence of amputation. There are also several new solutions to existing conventional treatments for DFU, including vacuum sealing drainage (VSD) combined with vacuum dressings and hyperbaric oxygen therapy. The diabetic foot therapeutic device is a multifunctional tool utilized in the treatment of diabetic foot conditions. It combines physical and biotechnological methods to accelerate wound healing, minimize the occurrence and progression of diabetic foot complications, and decrease the rate of amputations[2]. In recent years, advancements in science and technology have led to continuous innovations in the design of diabetic foot therapeutic devices, enhancing their functionality and providing improved treatment options for patients with diabetic foot conditions.

Further study and research on the operational principles and technological innovations of diabetic foot therapeutic devices are crucial for enhancing therapeutic effects, reducing costs, and improving patients' quality of life. Currently, existing therapeutic devices exhibit deficiencies, such as a limited scope of application. Therefore, it is essential to promote the further development and application of related technologies to meet clinical needs. This review summarizes the operational principles of existing diabetic foot therapeutic devices, analyzes the latest technological innovations and development trends, and investigates their therapeutic mechanisms. The aim is to provide a reference for the research and development of diabetic foot therapeutic devices that integrate various operational principles and technologies. Furthermore, as the number of diabetic patients continues to rise, the demand for efficient, cost-effective, and user-friendly therapeutic devices increases. Therefore, studying their operational principles and technological innovations holds significant academic and social value.

2 Physiotherapy

2.1 Ultrasonic therapeutic device Physiotherapy has introduced a novel approach to the treatment of DFUs in recent years, particularly through its application in wound care. Ultrasound therapeutic devices utilize the mechanical and thermal effects of ultrasound on foot lesions to enhance the metabolism of local tissues and stimulate cell regeneration. This method plays a significant role in repairing soft tissue damage associated with diabetic foot conditions. A study utilized low-frequency ultrasound irradiation at a frequency of 1 MHz and a sound intensity of 1 W/cm^2 to treat ulcerated wounds in diabetic rats. The findings indicated that low-frequency ultrasound irradiation could enhance neovascularization, stimulate fibroblast proliferation, and promote collagen fiber synthesis in the ulcerated wounds of diabetic rats[3]. Additionally, it facilitated the growth of granulation tissue and accelerated

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wound healing. This method is advantageous due to its safety, non-invasive nature, and effective therapeutic outcomes. Thereafter, Rastogi *et al.* [4] have found that a low-frequency, non-contact air ultrasound therapeutic device improves and accelerates the healing of chronic neuropathic DFUs when used in conjunction with standard wound care.

Ultrasound, as a therapeutic tool, can facilitate the repair of various injuries. Existing studies have demonstrated that low-frequency ultrasound can serve as an effective adjunct therapy for chronic wounds. However, relevant experimental and clinical investigations concerning the use of low-frequency ultrasound for treating diabetic wounds that are difficult to heal are still scarce. Additionally, optimal dosages, intensities, and irradiation durations of low-frequency ultrasound have not been thoroughly examined. Further research is necessary to elucidate these potential relationships.

2.2 Optical therapeutic device In the treatment of DFUs, optical therapy can be utilized alongside conventional methods, particularly through the application of infrared irradiation. This approach promotes local blood circulation, enhances the permeability of the vascular wall, increases leukocyte phagocytosis, and reduces the speed and extent of inflammatory exudate. Additionally, it alleviates congestion and edema, activates cell division, stimulates the formation of DNA and RNA, and fosters the growth of granulation tissue[5]. Existing studies have demonstrated that the penetration depth of long-wave infrared light, with a wavelength of 880 nm, ranges from 30 to 80 mm, making it more suitable for treating deep tissue conditions. In contrast, the penetration depth of short-wave infrared light, with a wavelength of 640 nm, is limited to approximately 10 mm, which is more advantageous for addressing superficial skin disorders, such as wounds, scars, and skin infections[6].

In addition, the infrared and red light therapeutic device combines the benefits of infrared (880 nm) and red (640 nm) LED lasers. It utilizes a specialized single-wavelength LED that emits infrared and red light to physically irradiate the affected areas of the body. This process can stimulate endothelial cells and hemoglobin in the blood to release nitric oxide (NO). Free NO is absorbed by body cells to achieve various physiological and therapeutic effects, including promoting capillary dilation, improving local blood circulation, relieving muscle spasms, exhibiting anti-inflammatory and analgesic properties, and facilitating tissue regeneration[7]. Thereafter, Zhang Jing *et al.* [8] compared the infrared light treatment group with the conventional treatment group and concluded that the ulcer healing rate in the former was significantly higher than that in the latter. This indicates that the use of infrared light-assisted treatment for DFUs is more beneficial for wound care. The application of infrared light-assisted treatment has demonstrated substantial advantages in the management of DFUs.

As the only therapeutic method that combines both bactericidal properties and tissue-repair-promoting physical factors, optical therapeutic devices positively impact the treatment of acute and chronic wounds. However, the dose-effect relationship for enhancing the healing of chronic wounds remains unclear. Currently, optical therapies have not been incorporated into clinical application guidelines for chronic wounds due to insufficient evidence from large sample sizes and high-quality clinical studies.

2.3 Ultrasonic atomization Ultrasonic atomization is a therapeutic method that utilizes ultrasound waves to convert medicinal liquids into microscopic droplets. Essentially, it serves as a localized fog particle diffusion therapy, aiming to achieve both local and partial systemic therapeutic effects. This technique differs from pharmacological wet dressing therapy; while wet dressings can provide some therapeutic benefits, they have a limited retention period for the drug solution, are prone to evaporation due to physiological temperatures, and exhibit reduced penetration efficacy[9].

Ultrasonic atomization technique is widely utilized in wound surface treatment due to its numerous advantages. Research has shown that ultrasonic atomization minimally affects the viscosity of the solution, is painless and non-irritating to the human body, and provides a warming effect on the atomized solution. This warming effect offers patients a sense of comfort and warmth, making the treatment more acceptable[10]. Related studies have also found that ultrasound transforms the drug solution into extremely fine mist particles, which are more readily utilized and absorbed by the body. Ultrasound can significantly enhance drug absorption in a short period by modifying the absorption medium and inducing mechanical disorders[11]. In addition, cavitation bubbles generated by liquids during cavitation can alter the permeability of cell membranes. This alteration may enhance the transport of substances and promote the body's metabolism, ultimately increasing the availability of beneficial compounds[12].

3 Biotechnology

Chitosan has a wide range of applications and demonstrates unique value in the field of medicine. Chinese scholars have proposed that chitosan is derived from chitin through the action of strong alkali, which removes part of the acetyl group. Chitosan exhibits several beneficial effects, including anti-infection properties, hemostasis, immunomodulation, tissue repair induction, and cell proliferation. Additionally, it possesses excellent biocompatibility and biodegradability. Furthermore, chitosan has a chemotactic effect on leukocytes and macrophages, enhancing macrophage phagocytosis. It can also stimulate neutrophils and macrophages to secrete interleukins and tumor necrosis factor, thereby promoting the self-cleaning of wounds[13].

In the contemporary medical field, a variety of polymeric wound dressings are currently available on the market. Comprehensive analyses have been conducted regarding the structure, function, chemistry, and essential characteristics of these polymeric wound dressings, particularly in relation to the potential of polymeric systems in the management of chronic wounds[14]. Currently utilized wound dressings exhibit several limitations, including inadequate antimicrobial properties, an inability to maintain moisture, weak mechanical capacity, poor biodegradability, and insufficient biocompatibility. In response to these challenges, Al-

ven et al. [15] incorporated bioactive agents and pharmaceuticals into chitosan-based wound dressings in 2022. The findings indicated that these modified dressings significantly enhanced therapeutic outcomes, demonstrating effective antimicrobial and antioxidant activities when employed in the treatment of diabetic wounds. Currently, the utilization of chitosan-containing dressings for the management of DFUs is extensively promoted in China. Zhang Quan *et al.* [16] have comprehensively summarized the experimental findings related to chitosan-based dressings, focusing on their bacteriostatic properties, *in vitro* coagulant capabilities, waterproof characteristics, breathability, and mechanical properties. Furthermore, they conducted an in-depth exploration of the application of these dressings in the treatment of DFUs and other medical conditions, ultimately affirming the numerous advantages associated with the use of chitosan-containing dressings for this purpose. Chitosan dressings have the potential to enhance the microenvironment of wounds, mitigate bacterial proliferation due to their antibacterial properties, decrease the risk of infection, and alleviate the inflammatory response in the treatment of DFUs. Furthermore, their excellent air permeability and moisture retention capabilities facilitate the maintenance of a moderately moist environment at the wound site, which is beneficial for cellular growth and metabolism, thereby promoting the development of granulation tissue. Chitosan has been shown to facilitate the healing of ulcers by promoting the synthesis of collagen and other components of the extracellular matrix by fibroblasts. Additionally, it enhances the strength and toughness of granulation tissue, provides an effective scaffold for the migration and coverage of epithelial cells, accelerates wound healing, reduces ulcer size, and diminishes the risk of severe complications, such as amputation. In the case of chronic DFUs that are challenging to heal, the use of chitosan dressings may play a crucial role in improving treatment outcomes.

Nevertheless, several challenges persist in the development of novel dressings utilizing chitosan. These challenges include the significant influence of external environmental conditions on the preparation process, the fact that certain mechanisms of action associated with chitosan remain in the preliminary stage, and the necessity for further enhancements in the application of chitosan.

4 Vacuum sealing drainage (VSD)

VSD is a technique employed to manage a range of complex wounds and facilitate deep drainage. It has gained increased application in the treatment of soft tissue injuries, ulcers, and various other medical conditions. VSD is an advanced therapeutic device that integrates medical polymer foam materials with vacuum suction devices. The medical polymer foam is affixed to the wound surface using a medical-grade film. The vacuum suction device operates continuously to maintain the foam area beneath the film in a vacuum state, thereby facilitating the removal of exudate and enhancing local blood circulation[17]. Thus, vacuum drainage serves a dual purpose: it facilitates the timely removal of leachate and liquefied necrotic tissue from wounds and cavities, while simultaneously preventing external contact with the wound. This mechanism effectively reduces bacterial proliferation and aids in the management of infection.

The distinctive benefits of VSD technique in the management of DFU wounds have led to its increased application in this context. Research indicates that vacuum sealing treatment demonstrates greater efficacy and safety compared to conventional wound debridement and dressing changes in the treatment of complex diabetic foot wounds. This approach has been shown to enhance the rate and speed of wound healing while simultaneously decreasing the likelihood of surgical intervention for these wounds[18]. The implementation of a fully sealing vacuum environment effectively isolates the wound from external contact, thereby significantly reducing the risk of bacterial invasion and minimizing the incidence of cross-infection. Relevant studies have demonstrated that the VAC technique can markedly enhance the microcirculation of blood flow at the wound surface and promote the dilation of microvessels by providing continuous auxiliary support for blood supply to the wound. This subsequently increases blood supply to the wound and mitigates the inflammatory response, ultimately facilitating accelerated wound healing[19]. The VSD technique has been shown to enhance the proliferation of wound fibroblasts, thereby facilitating neovascularization and accelerating the proliferation of granulation tissue[20]. Consequently, the application of the VSD technique will help to the gradual rejuvenation of DFU wounds following debridement, thereby establishing favorable conditions for subsequent skin grafting or other surgical interventions. The research conducted by Li Tiancheng *et al.* [21] demonstrates that the VSD technique significantly enhances the healing process of DFU wounds. Furthermore, it establishes a foundational basis for subsequent implant repair, serving as an effective adjunctive treatment modality during the transition from wound care to surgical interventions.

Despite its advantages, the VSD technique presents several limitations. Its application is challenging in cases of ulcerated wounds that involve exposed tissues, including tendons, blood vessels, and bones. Additionally, there exists a risk of local re-infection, and the prolonged treatment duration contributes to an increased economic burden on patients. At present, VSD is often utilized in conjunction with other therapeutic modalities for the management of DFU wound repair[22].

In recent years, the combination of vacuum drainage and pharmacological interventions for the treatment of DFUs has demonstrated a promising medical outlook, as evidenced by an increasing number of clinical studies. In 2019, Liu Jiali *et al.* [23] demonstrated that the combination of Shengji Yuhong plaster and VSD significantly reduced the healing time of DFU wounds. This treatment not only facilitated wound repair but also enhanced vascular neovascularization in ulcerated areas and improved the body's oxidative stress levels. The underlying mechanism of action may be associated with the regulation of factors such as VEGF and bFGF. In 2021, a clinical study conducted by Guo Yuanxue *et al.* [24] demonstrated that the VSD technique, when used in conjunction with Kangfuxin solution, yielded superior outcomes compared to the control group. Specifically, the study reported improvements in preoperative and postoperative VAS scores, quality of life assessments, and patient satisfaction. Consequently, the combination of the VSD technique with pharmacological intervention is anticipated to emerge as a novel approach in the management of DFUs.

Simultaneously, Da Xiangdong *et al.* [25] investigated the clinical efficacy of employing metronidazole and chitosan solution for intermittent irrigation during the repair of DFUs utilizing VSD technique. In 2020, 406 patients with DFUs, admitted between May 2010 and December 2019 and classified with a Wagner grade of 2 – 3, were allocated into an observation group and a control group for the experiment. The observation group received treatment with VSD technique combined with metronidazole and chitosan antibacterial solution for intermittent irrigation of DFUs. The results indicated that the wound healing time in the observation group was significantly shorter than that in the control group, thereby further substantiating the efficacy of VSD technique in conjunction with chitosan for the treatment of DFUs. To investigate the clinical efficacy of negative-pressure wound therapy combined with the instillation of carboxymethyl chitosan bio-glue in the treatment of DFUs, Li Chuang *et al.* [26] conducted a study involving 60 diabetic foot patients at Dongzhimen Hospital Affiliated to Beijing University of Chinese Medicine, between February 2019 and March 2020. The researchers employed a random number table method to assign the patients to experimental and control groups. The findings indicated that negative-pressure wound therapy with the instillation of carboxymethyl chitosan bio-glue significantly promoted the healing of DFUs.

5 Micro-oxygen diffusion therapy

At present, the primary clinical application of micro-oxygen diffusion technique in the treatment of DFUs in China involves the integration of debridement with continuous oxygen diffusion therapy[27]. This method entails the continuous delivery of pure oxygen to the wound site at a low flow rate. This method has the potential to enhance the oxygen supply to the wound and facilitate the healing process. Luo Ai *et al.* [28] selected patients with DFUs classified as Wagner grade 2 – 4 as study participants. The experimental group received treatment with a micro-oxygen wound therapeutic device in conjunction with a comprehensive treatment and standardized wound care plan. The findings indicate that the micro-oxygen wound therapeutic device is effective in reducing exudate volume, enhancing the response of ulcer wounds, accelerating patient recovery, and improving the overall quality of life for patients. Li Ke *et al.* [29] conducted a clinical trial involving patients with DFUs, comparing the efficacy of the wet healing wound management method with that of the continuous micro-oxygen penetration wound management method. The findings indicated that the continuous micro-oxygen penetration method effectively regulated inflammatory factor levels, enhanced the wound microenvironment, and facilitated the healing process. Patients treated with this method exhibited greater wound reduction rates, shorter healing duration, and improved rates of bacterial clearance from the wounds. Yi Cailan *et al.* [30] conducted a study involving patients with DFUs classified as Wagner grade 2 – 4. The participants were divided into four groups: a conventional treatment group, a negative pressure therapy group, an oxygen therapy group, and a combined treatment group. The combined group received VSD in conjunction with micro-oxygen penetration technique. The findings indicated that this combined approach enhances the removal of bacteria and inflammatory factors by improving the oxygen supply in the microenvironment, thereby promoting the healing of DFUs. Additionally, the recurrence rate was found to be low, suggesting a favorable prognosis for patients receiving this treatment.

Wang Shuo *et al.* [31] conducted a randomized study to investigate the mechanisms by which local oxygen therapy facilitates wound healing in DFUs, utilizing RNA sequencing technology. The findings indicated that local oxygen therapy primarily enhanced wound healing through the tumor necrosis factor signaling pathway and the apoptosis pathway, resulting in a reduced healing time and an increased healing area. Lawrence *et al.* [32] conducted a comprehensive evaluation of the study design, rationale, and outcomes associated with continuous oxygen diffusion therapy (CDOT) for the treatment of DFUs within the framework of a double-blind, placebo-controlled randomized clinical trial. The results indicated that, in both per-protocol and intention-to-treat analyses, a greater proportion of DFUs healed in the CDOT group, and ulcers in the CDOT group exhibited a faster healing rate than those in the sham treatment group ($P = 0.026$).

Micro-oxygen diffusion technique plays an important role in the treatment of DFUs. In addition to its well-documented effects on promoting ulcer healing, this technique also improves local tissue hypoxia, regulates the inflammatory response, enhances antimicrobial activity, and facilitates angiogenesis.

6 Conclusions and prospects

In conclusion, the integration of physiotherapy, biotechnology, VSD, and micro-oxygen diffusion techniques in the management of DFUs offers a comprehensive technical framework for treatment. Furthermore, these approaches present novel options for enhancing patient prognosis. However, the majority of the techniques discussed are utilized individually in treatment protocols. Given the benefits associated with the four primary techniques outlined above, and drawing inspiration from the synergistic application of these treatments, it is proposed that these four major approaches can be integrated and applied concurrently to the wound surface. This combined application is anticipated to enhance the healing process of the wound. This proposed treatment option represents an innovative and comprehensive approach that is anticipated to substantially enhance the outcomes for patients with DFUs. In this context, a thorough examination of the characteristics associated with the application of each technology in wound treatment, the interaction mechanisms involved in their combined use and the resultant therapeutic effects is undertaken, with particular emphasis on the synergistic relationships between the techniques. The objective is to identify more targeted and effective methods of wound treatment that address the therapeutic needs of various wound types and patients, ultimately aiming to accelerate the wound healing process.

Firstly, with regard to physiotherapy, the emphasis was placed on the mechanisms and practical operational processes involved in ultrasonic atomization. This technique utilizes ultrasonic waves to atomize the drug solution into minute particles, thereby enhancing the permeability of the drug, prolonging its efficacy, and facilitating both absorption and local blood circulation. In the field of biotechnology, the utilization of chitosan is investigated due to its anti-infective, hemostatic, and immunomodulatory properties, which facilitate tissue repair and enhance cell proliferation. These characteristics render chitosan a crucial component in the treatment of DFUs. The VSD technique enhances the local microenvironment by establishing a negative-pressure environment that facilitates the drainage of wound exudate. This process not only accelerates the rate and speed of healing but also diminishes the risk of infection and the necessity for surgical intervention. Furthermore, the technique promotes hematopoiesis and microcirculation, thereby expediting the proliferation of granulation tissue and creating optimal conditions for skin grafting or other surgical treatments. Nevertheless, VSD is not appropriate for certain specific types of wounds and frequently requires adjunctive therapies. In the domain of micro-oxygen diffusion technique, the provision of a continuous micro-oxygen environment to the wound has been shown to significantly decrease the volume of exudate. This approach not only facilitates the healing of ulcers but also ameliorates tissue hypoxia, modulates inflammatory responses, enhances antimicrobial efficacy, and promotes angiogenesis.

In light of the aforementioned advantages, a comprehensive treatment plan has been proposed that integrates ultrasonic atomization, chitosan application, VSD, and micro-oxygen diffusion techniques. By optimizing the synergistic effects of each of these methods, it is anticipated that the treatment efficiency for DFUs will be significantly enhanced, helping to bring about a reduction in healing time and a decrease in the amputation rate.

The review indicated that the preparation process of chitosan dressings is significantly influenced by external environmental conditions. To optimize the utilization of chitosan properties, we opt not to employ the traditional preparation method. Instead, the raw chitosan solution is transferred to an ultrasonic atomization device, where it is converted into an atomized liquid through atomization. This atomized liquid is then directly sprayed onto the wound surface to create a layer of drug coverage. This approach aims to enhance the contact area with the wound and improve the durability of the treatment, thereby increasing its bioavailability and therapeutic efficacy. To enhance its atomization capabilities, the ultrasonic atomization device is meticulously calibrated to increase its maximum atomization volume from the conventional 200 to 600 mL/h, and to elevate the maximum liquid viscosity from the standard 2 cps to a range of 30 – 50 cps[10]. This adjustment aims to improve the device's atomization function and facilitate the atomization of a diverse array of liquids with varying viscosities, thereby enabling its application in a broader range of contexts. Simultaneously, an additional liquid pump is incorporated to deliver the liquid in order to achieve a precise and instantaneous quantity of atomization. This, in conjunction with the design of various gas flow pathways, facilitates a uniform and directional distribution of the atomized liquid droplets. Prior to the application of the chitosan atomized solution for wound treatment, the negative pressure of the VSD technique is employed to facilitate the drainage of wound exudate from the body. This process effectively removes wound secretions while simultaneously preventing external contact with the wound, thereby minimizing bacterial proliferation and establishing an optimal environment for the direct application of the chitosan atomized solution. The integration of VSD with an atomized chitosan solution creates an optimal healing environment for ulcerated wounds that involve exposed tendons, blood vessels, and bones. This approach may also alleviate the financial burden on patients requiring prolonged treatment for recurrent infections. During the treatment process involving drainage, debridement, atomization, and dressing changes, micro-oxygen diffusion technique is employed to deliver a continuous low-flow supply of oxygen to the wound. The sustained application of micro-oxygen diffusion effectively addresses microcirculation disorders at the wound surface, facilitates the restoration of blood circulation, and mitigates tissue edema in the affected area, thereby promoting wound healing. The innovation is characterized by the integration of four key functions: VDS, ultrasonic atomization, the application of chitosan, and micro-oxygen diffusion. This comprehensive approach enhances the efficacy of the treatment for DFUs, eliminates the need for patients to transition between various treatment devices, and improves both the efficiency and convenience of the treatment process. Furthermore, it facilitates the operation and management tasks for healthcare personnel. The implementation of this integrated multifunctional treatment solution is anticipated to establish a standard model for the treatment of DFUs in the future. However, it also encounters several challenges that require resolution. A significant challenge lies in maintaining the stable operation of various functional modules, including VSD, ultrasonic atomization, and micro-oxygen diffusion, within a single device. It is essential to prevent interference among these components, particularly regarding the effects of pressure fluctuations during vacuum aspiration on the effectiveness of ultrasonic atomization. Additionally, it is crucial to assess whether the airflow produced by micro-oxygen diffusion disrupts the proper functioning of the other modules. Furthermore, it is important to note that, currently, research on the selection of pharmaceutical agents suitable for atomization in the treatment of DFUs is limited, with chitosan being the primary focus and few alternative options available. It is essential to identify additional pharmaceuticals that possess antibacterial and wound healing properties and are suitable for atomization administration. This approach aims to improve the selection of medications for atomization treatment while minimizing the risk of drug allergies and the lack of available options. Concurrently, it is essential to take into account various factors, including particle size distribution, stability, and the deposition and penetration effects of the drug on the wound surface following atomization, in order to ensure that the medication can effectively target the affected tissue. In conclusion, it is imperative to conduct a comprehensive examination of the technical compatibility among various modules in the future. Additionally, optimizing the overall structural design of the device and its control system is essential to ensure the stability and reliability of its functions during prolonged operation. Furthermore, it is anticipated that future research will explore additional techniques that can be integrated into the diabetic foot therapeutic device, thereby enhancing its therapeutic efficacy and improving the quality of life for individuals with diabetes.

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