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Case Report

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The Combined Effects of a Methacrylate Powder Dressing (Altrazeal Powder) and Photobiomodulation Therapy on the Healing of a Severe Diabetic Foot Ulcer in a Diabetic Patient: A Case Report

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Abstract

Weakened wound healing is a popular, severe complication of patients with diabetes which poses a risk for foot infection and amputation. Researchers have searched for new treatments for treating diabetic foot ulcers (DFUs) in recent years. In this case report, for the first time, we applied photobiomodulation therapy (PBMT) and Altrazeal powder together to treat a severe case of DFU in a 47-year-old woman who was suffering from type 1 diabetes. Along with the progress of combination therapy, we observed that the ulcer area was significantly reduced, and the wound healed within 16 weeks. Furthermore, dermatitis and purulent secretion were treated, and the pain was reduced. This reported case study indicated the beneficial effect of the combination of PBMT and Altrazeal powder for the healing of a severe DFU in a patient with type one diabetes. The combined application of PBMT plus Altrazeal powder demonstrated an additive effect. Further clinical trials in the clinical setting are suggested to validate the results further. Besides, more studies in preclinical models are suggested to find the mechanism of the action of combination therapy.

Keywords: Photobiomodulation therapy; Altrazeal powder; Diabetic foot ulcer; Wound healing; Diabetes mellitus.

Introduction

Diabetes mellitus (DM) is a chronic, demanding metabolic disease that affects individuals, their families, and society worldwide.[1] Approximately 463 million people suffer from DM in the world, and this number is expected to rise by 25% by 2030.[2] The patients suffering from DM account for almost 60% of all whole-limb amputations.[3] Leg amputations are almost always preceded by an infected diabetic foot ulcer (DFU).[4] Infected DFUs are primarily associated with *Staphylococcus aureus*.[5] A growth in drug-resistant microorganisms in terms of the abuse of wrongly administered antibiotics, particularly in patients with DFUs, is observed.[6] Foot deformities and DFU are caused by persistent and badly managed hyperglycemia, resulting in peripheral neuropathy hypoxia, inflammation, and ischemia. DFUs are regarded as a primary medical problem.[7]

Altrazeal powder, as a flexible methacrylate dressing, has recently been introduced to the medical community by pharmaceutical companies. The treatment with a methacrylate dressing has been administered for surgical wounds, slow-healing wounds, venous leg ulcers, exuding ulcers,[8] refractory venous leg ulcers, and chronic leg ulcers. When applied to the exudative wound bed, the powder interacts with the moisture, aggregates, and forms a porous, healing surface environment.[9] Positive

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results were reported with this therapy when used for a diabetic foot[8] and skin graft donor sites in patients with burns. Infection control was reported when using this methacrylate dressing.[10]

In diabetic wound healing, photobiomodulation therapy (PBMT) decreases inflammation, stimulates healing, and relieves pain, through the modification of cellular and molecular pathways.[11] Ischemic tissues treated with PBMT show an improvement in angiogenesis and nitric oxide release along with increasing the cells expressing vascular endothelial growth factor (VEGF) and hypoxia-inducible factor alpha (HIF-1).[12-14] Furthermore, PBMT may improve the survival rate of skin flaps via increasing the number of new vascular developments in the tissue, modifying VEGF discharge, matrix metalloproteinase-2 (MMP-2) stimulation, and HIF-1 expression. Recently, positive effects of PBMT plus stem cells on the delayed healing of diabetic infected wounds in types one and two in rats were shown.[15-17] Therefore, previous studies showed that using two therapeutic modalities simultaneously would be beneficial for the treatment of severe illnesses such as severe cases of DFUs. They may provide an addictive outcome and could advance treatments for DFUs.[17,18]

We surveyed the combined effect of Altrazeal powder with PBMT on the healing of a severe case of DFU in a 47-year-old woman with type one DM, unresponsive to previous treatments.

Case Report

A 47-year-old woman who was suffering from type one DM was admitted to the outpatient clinic of the corresponding author. She had an extensive 35 cm^2 full-thickness cutaneous wound in the medial part of her right foot (Wagner Ulcer Grade Classification System: grade 4), which was not treated with the routine treatment of DFU (Irrigation with Saline, debridement, and Antibiotic therapy for 35 days) (Figure 1). During clinical examination, it was observed that the neuromuscular of the right lower extremity was intact, with considerable colliquative necrosis of the soft tissues and purulent discharges in the ulcer. The biochemical data revealed acute leukocytosis with a WBC count of 21×10^9 cells per liter, blood glucose levels > 300 mg/dL, and an HgBA1C of 11%. Due to the discharge of purulent secretion from the side of the foot, fever, pain, foul odor, and chills, routine procedures including antibiotic therapy, blood sugar control, and the offloading dressing were performed. However, a significant improvement was not observed.

Therapy began after the debridement of the necrotic tissue and cleaning with 0.9% sterile saline solution (Figure 2). PBMT was used once a week for 16 weeks. 35 points Over the ulcer surface and adjacent normal skin were exposed to laser radiation in each session (Figure 3). According to the following protocol and guideline, listed in Table 1, we used the Novin Tech laser machine (Novin Tech Co., Iran).

After PBMT, Altrazeal powder was topically used (Figure 3) to supply moisture control, decrease the need for dressing changes, and stimulate the wound healing process. The powder was applied with drops of saline on the surface of the ulcer. Moreover, the ulcer was dressed with a Vaseline dressing. Afterward, an offloading bandage was applied to relieve pressure from the weight-bearing portion of the foot, and dressing changes were

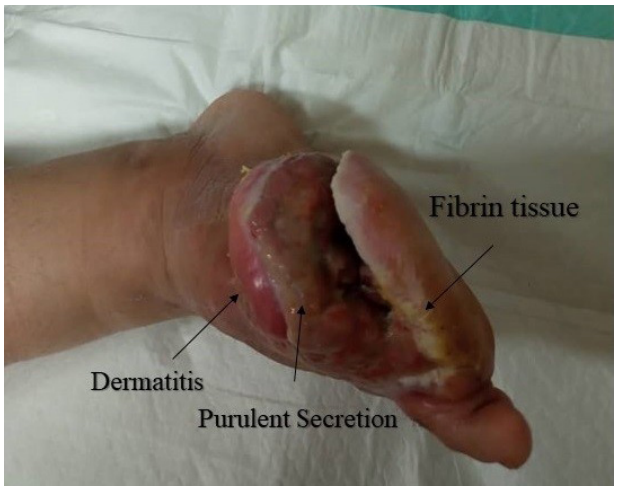

Figure 1. A Big Ulcer With Fibrin Tissue, Dermatitis and Purulent Secretion

Figure 2. The Ulcer After Debridement

Figure 3. A dressed wound with altrazeal powder

made at weekly intervals. Pain control with analgesics was done.

Every week, the clinical condition was assessed, and the results of the assessment indicated a decrease in the ulcer size and reduced inflammatory reaction, along with more structured tissue formation, hemostasis, and remarkable coagulation. Besides, the patient reported no pain. The most beneficial elements of the 16th week of follow-up were absolute remission of the lesions with a high level of healthy tissue (Figure 4). Furthermore, the absence of pain analyzed by the visual analogue scale (VAS) is shown in Table 2.

Discussion

In normal conditions, the inflammatory phase of the wound healing course is well-coordinated, lasting only a few days, and the wound healing stages progress normally. However, in DM, the inflammatory phase lasts longer and the entire damaged skin does not heal, resulting in slow healing.[19] Patients with DFU must endure various therapies during their life, which are expensive and place a significant financial strain on community and insurance organizations.[20] Chronic wound care costs have risen as the population has aged and the number of diabetic patients has increased. New treatment methods that increase the ability of patients against diseases can be beneficial.[21,22]

Table 1. Parameters of Photobiomodulation Therapy of the Current Study

Mode	Pulsed
Peak power (mW)	1000
Average power (mW)	400
Energy density (J/cm^2)	2
Frequency (number)	10000
Wavelength (nm)	870
Exposure time per point (s)	4
Spot area (cm^2)	1
Number of points	35

Figure 4. Complete Healing and Re-epithelialization of the Ulcer With No Necrotic Tissue, Dermatitis and Purulent Secretion

Table 2. Assessment of VAS Pain Levels During the Follow-up Period

Week 1	Week 4	Week 8	Week 16
6	5	2	0

The present case report revealed a unique and adjunct method in which both (Altrazeal powder and PBMT) modalities were chosen to improve healing, offer patient comfort, and shorten the period of ulcerative region recovery. Today, nanotechnology serves a crucial function to promote the process of wound healing. Altrazeal uses nanoparticles which can be modified to deliver the best moist wound dressing qualities. This sterile mixture of 85% poly2-hydroxyethyl methacrylate and 15% poly-2-hydroxypropyl methacrylate is appropriate for surgical wounds, leaking acute superficial wounds, including donor graft sites and second-degree burns, along with chronic, slow-healing ulcerations.[23] When the sterile nanoparticle powder is placed on a wet wound bed, it is linked with ionized fluids like exudate, saline, or blood to form a clumped, exudate-controlling wound dressing. A nanoflex wound dressing adapts to the area of the wound bed once aggregated, filling blind spots and closing wound edges. The porous structure of the polymer generated by activation allows for excellent oxygen and vapor transpiration, firmness, and compliance, all of which help protect the wound during healing.[8] Following aggregation, capillary with a diameter of about 7 nm draw exudate off the wound surface at a sharp moisture evaporation rate of around 12000 mL/m^2/24 h, while supporting a moist wound base for healing.[24] This dressing assists with sealing the wound margins and is bacteria-resistant, reducing the possibility of additional bacterial contamination.[8] After discharge, the patient resumed using the Altrazeal wound dressing, and the wound was examined every week when the bandage was replaced. We noticed a decrease in dead space in the wound region while the improvement process progressed, and we conclude these improvements have happened because of improved wound reepithelization and granulation tissue formation under the influence of Altrazeal powder. Because of the qualities described, it seems Altrazeal is a beneficial dressing alternative in DFU.

It seems bio-stimulating various types of cells and actions, especially in the wound bed, and angiogenesis (ideally by the visible wavelength of 870 nm/red light) was the focus of PBMT. PBMT is a non-invasive treatment that relieves pain through analgesic and anti-inflammatory effects.[25,26] The analgesic effect of our treatment is believed to be triggered in part by the release of neuropharmacological substances such as endogenous endorphins (-endorphin), a decrease in C-fiber and bradykinin activity under the influence of PBMT, and a shift in pain threshold.[26] The patient's pain decreased during therapy in our study, which was analyzed by the VAS method. PBMT can increase tissue microcirculation and oxygenation while stimulating epithelial, endothelial, and mesenchymal cell growth.[27]

Untreatable chronic wounds, such as pressure sores,

arterial and venous ulcers venous, and DFU, stay in a state of inflammation indefinitely.[28] One of the most consistent effects of PBMT is a decrease in general inflammation, which is critical for wound healing. It has been indicated that PBMT diminishes M1 phenotypic indicators in activated macrophages. M1 macrophage in DFUs is pro-inflammatory and contributes to impairment.[29] Many studies have indicated that PBMT reduces prostaglandins and reactive nitrogen substances in several animal models of inflammatory conditions and reduces their destructive effects.[30]

Our study limitation was as follows: unfortunately, we were not able to perform the microbiological examination of the ulcer during the study.

Conclusion

This reported case study indicated the beneficial effect of the combination of PBMT and Altrazeal powder for the healing of a severe DFU in a patient with type one DM. The combined application of PBMT plus Altrazeal powder showed an additive effect. To validate our results, we suggest further clinical trials. Besides, more studies in preclinical models are suggested to find the mechanism of action of the combination of PBMT and Altrazeal powder.

Conflict of Interests

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

Ethical Considerations

Written informed consent was obtained from the patient for publication of this report

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