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The effects of photobiomodulation therapy plus methacrylate powder dressing (Altrazeal powder) on the bacterial count in diabetic foot ulcer: A case report

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Abstract

Diabetes patients frequently experience a serious complication known as impaired wound healing, which increases the likelihood of foot infection and limb amputation. Investigators have been looking for novel methods to treat Diabetic Foot Ulcers (DFU) recently. In this case present case, we used Altrazeal powder and photobiomodulation therapy to treat and speed up the healing of a harsh diabetic foot ulcer in a 55-year-old man with type 1 diabetes and heart failure.

We observed that the ulcer area significantly decreased as combination therapy progressed, and Within 20 weeks, the wound was healed. The pain and microbial flora were also reduced. This revealed contextual analysis demonstrated the useful effect of the mix of photobiomodulation treatment and Altrazeal powder for recuperating a serious DFU in a diabetic patient with type 1. To confirm the findings, additional clinical trials in a clinical setting are recommended. In addition, it is recommended that additional research using preclinical models uncover the combination therapy's mechanism of action.

Keywords: Photobiomodulation therapy; Wet wound dressing; Diabetic foot infection; Wound remedy; Sareus.

Introduction

A metabolic disorder called Diabetes Mellitus (DM). which lasts a long time and is hard on the body. It affects people, their families, and society as a whole [1]. There are approximately 463 million people worldwide who have DM and this number is expected to rise by 25% by 2030 [2].

The body's metabolic activity is disrupted, resulting in a delay in wound healing, and this disease raises the risk of infection. DM patients account for nearly 60% of all amputations of the whole limb [3,4]. Leg amputations are almost always preceded by an infected Diabetic Foot Ulcer (DFU) [5]. Infected DFUs are primarily associated with Staphylococcus aureus [6]. Misuse of antibiotics, particularly in patients with DFUs, has been linked to an increase in drug-resistant microorganisms [7]. Diabetic Neuropathic Pain (DNP) is a frequent issue of both type 1 and type 2 diabetes, affecting more than 90% of diabetics [8]. Poorly managed hyperglycemia can lead to peripheral neuropathy, hypoxia, inflammation, and ischemia, which can cause foot deformities and DFU. DFUs are regarded as a major health issue [9].

During diabetic wound healing, Photobiomodulation Therapy (PBMT) reduces inflammation, stimulates wound healing, and reduces pain, through the modulation of cellular and molecular pathways [10]. PBMT-treated ischemic tissues demon-

strated enhanced angiogenesis and nitric oxide release as well as an increase in cells expressing Vascular Endothelial Growth Factor (VEGF) Hypoxia-Inducible Factor alpha (HIF-1) [11-13]. In addition, PBMT can improve flap survival by increasing the number of new blood vessels growing in tissues, altering VEGF release, stimulating matrix metalloproteinase-2 (MMP,-2) expressing the presence of HIF-1 [14].

It has recently been demonstrated that PBMT and stem cells can speed up the healing of diabetic-infected types one and two wounds in rats [15-17]. Therefore, previous related studies have demonstrated that the simultaneous use of the two treatment modalities is beneficial for the treatment of serious diseases such as severe cases of DFU. They can be addictive and are an advanced treatment for DFU [17,18].

Recently introduced a flexible methacrylate dressing (Altrazeal powder) [19]. A dressing made of methacrylate has been used to treat surgical wounds and wounds that take a long time to heal, vascular limb ulcers, edematous ulcers [19], refractory venous leg ulcers [20], and patients with chronic leg ulcers. The powder, when applied to the exudate wound, will interact with moisture, agglomerate, and form a porous, fast-healing surface environment [20]. When used for diabetic foot, this therapy has been shown to be effective [19] and burn patients' skin graft donor sites. Using this dressing has also been reported to improve infection control [21].

In the current study, we investigated the mixed impact of the Altrazeal powder with PBMT on the healing of a complicated case of DFU and CFU number in a 55 years old man with type one DM, unable to respond to routine treatments and at risk of having foot amputated.

Case presentation

A 55-year-old man (addicted, heavily smoked) who suffered from type one DM and heart failure has been admitted to the ZAKHM NOOR outpatient clinic. He had an extensive 37 cm^2 full-thickness cutaneous wound in the plantar part of his right foot (Wagner Ulcer Grade Classification System: grade 3) (Figure 1) that have previously undergone unsuccessful standard of care wound therapy. During clinical examination, it was observed considerable colliquative necrosis of the soft tissues and discharge of pus in the ulcer. The biochemical data revealed an acute leukocytosis with a WBC count of $22x10^9$ cells per liter, blood sugar levels >320 mg/dl, and an HgBA1C of 12%.

Microbial sampling was done in the first and last session of treatment (Mueller-Hinton agar) (Figures 2 & 3).

PBMT was used once a week for 20 weeks and performed 37 shootings of the laser over the ulcer surface and adjacent to normal skin in each session and finally the wound was constricted (Figure 4). According to the following protocol and guideline, which is listed in Table 1, we used the Novin Tech laser machine (Novin Tech Co., Iran).

After PBMT, Altrazeal powder was topically used 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. And ulcer was dressed with Vaseline dressing. Afterward, the offloading bandage was applied to relieve pressure from the weight-bearing portion of the foot, and dressing changes were made over weekly intervals.

Table 1: Parameters of photobiomodulation therapy of the current study.

Mode	Pulsed
Peak Power (mW)	1000
Average Power (mW)	400
The energy density (J/cm^2)	3
Frequency (number)	10000
Wavelength (nm)	870
Exposure time per point (s)	6
Spot area (cm^2)	1
Number of points	37

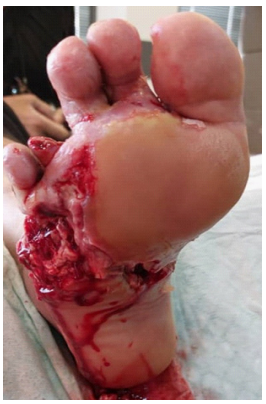

Figure 1: A extensive ulcer in right plantar (Wagner Ulcer Grade Classification System: grade 3).

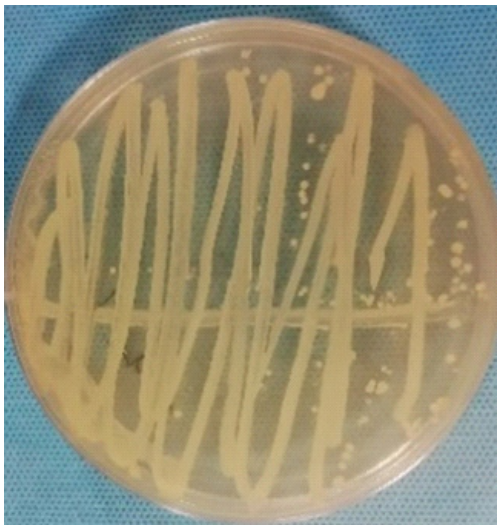

Figure 2: Microbial sampling on the first day.

Every week, the clinical condition was assessed, which indicated a decrease in the ulcer size, pain, and reduced inflammatory reaction, along with more structured tissue formation, hemostasis, and remarkable coagulation. The absolute remission of the lesions with a high level of healthy skin was the 20th week of follow-up's most beneficial aspects. And absence of pain analyzed by the Visual Analogue Scale (VAS) in Table 2.

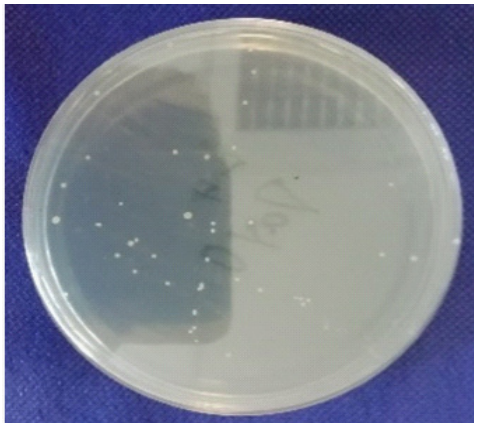

Figure 3: Microbial sampling on the last day.

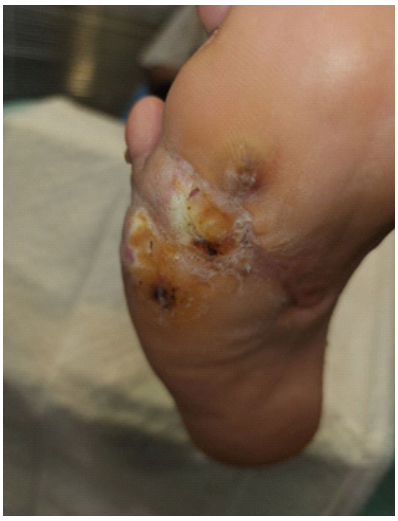

Figure 4: Wound healing in the 20th week.

Table 2: Assessment of VAS pain levels during the follow-up period.

Week 1	Week 6	Week 12	Week 20
7	5	3	0

Discussion

Under typical conditions, inflammatory phase of wound healing process is correlated, lasting only a few days, and the healing phases progress normally [4]. However, in DM, the inflammatory phase lasts longer and the entire damaged skin does not heal, resulting in slow healing [22]. Patients with DFU endure a variety of treatments throughout their lives, which are costly and place a significant financial strain on communities and insurance organizations [1,23]. The cost of chronic wound care has increased as the population ages and the number of diabetics increases. New treatment procedures that improve patients' ability to cope will benefit them [24,25].

The current case study reveals a special and complementing approach in which both modalities (Altrazel dressing and PBMT) were chosen to promote healing and provide patient comfort. Reduces healing time of ulcerated areas.

Present day, nano science plays an essential role in promoting wound healing. Altrazeal uses nanoparticles that can be modified to give the best-wound dressing. This sterile mixture of 85% poly-2-Hydroxyethyl Methacrylate (pHEMA) and 15% poly-2-hydroxypropyl methacrylate (pHPMA) is suitable for operative wounds, acute peripheral leak wounds, including grafts of donor and second-degree burns, as well as chronic wounds, slow-healing sores [26]. When the sterile nanoparticle powder is put on a wet injury bed, it joins with ionized liquids like exudate, saline, or blood to shape a clustered, exudate-controlling injury dressing. The flexible wound gauze adjusts to the region of the injury bed once amassed, filling vulnerable sides and containing wound edges. The permeable construction of the polymer produced by actuation takes into account superb oxygen and fume happening, immovability, and consistency, all of which help to safeguard the injury during healing [19]. This dressing also assists to seal the wound margins and this is a bacteria-resistant, reducing the possibility of additional bacterial contamination [19].

In consumed wounds, it was also proposed to use pHEMA in conjunction with various admixtures, such as polyethylene glycol-400 (PEG), including antimicrobial added substances like silver sulfadiazine, silver nitrate, gentamicin, or nitrofurazone [27]. Studies show adding the antimicrobial compounds to a pHEMA base reduce the number of bacteria in burn wounds and relieved pain in patients, according to experimental and clinical studies [28,29]. PBMT has an inhibitory impact on S. aureus growth by stimulation of ROS (Reactive Oxygen Species) synthesis. consistent with this finding, the combination of the PBMT and Altrazeal have synergic impacts in reduction of CFU number in the wound.

It appears to be stimulating a variety of cell types and actions, particularly in the wound bed, and angiogenesis was the focus of PBMT [6]. PBMT is also a non-interfering treatment that relieves pain through analgesic and anti-inflammatory effects [30,31]. The release of neurochemical agents like endogenous endorphins (-endorphin), a reduction in C-fiber and bradykinin activity under the influence of PBMT, and a shift in pain threshold are thought to be some of the factors that contribute to the analgesic effect [31,32]. In the past and current studies, the patient's pain decreased during therapy and was analyzed by the VAS method [32]. PBMT can also stimulate the growth of epithelial, endothelial, and mesenchymal cells while also increasing tissue oxygenation and microcirculation [33].

Our limitation in the study: The 3D camera was not available, so the depth of the wound was not evaluated.

Conclusion

The positive impact that the mixture of photobiomodulation therapy and Altrazeal wound dressing had on the colony-forming unit of a diabetic foot ulcer was demonstrated in this present case report. To validate our results, further clinical trials are suggested. moreover, it is recommended that additional research using preclinical models uncover the mechanism of action of the combination of PBMT and Altrazeal powder.

Declarations

Competing interests: The authors declare that they have no competing interests.

Availability of data and material: Not applicable.

Authors contributions: EM, LAY collected patient data, HA wrote the manuscript.

Consent to publication: The patient gave written informed consent to publish this manuscript.

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