Ischemic diabetic foot ulcer when treated in association with photobiomodulation: Case report

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ABSTRACT

Introduction: Because ischemic diabetic foot has arterial lesions with micro and macroangiopathies, it is challenging successfully treat ulcers even now. This becomes especially true if limb revascularization is impossible due to the particularities of systemic pathology and/or local arterial disease. Case Report: A 61-year-old male patient with type II Diabetes mellitus, arterial hypertension, chronic arterial insufficiency, single limb, with ischemic calcaneal ulcer and posterior tibial artery occlusion that irrigates the angiosome of the lesion, but unfavorable to revascularization. Defined by conventional treatment with platelet antiaggregant, statin and vasodilator associated with laser photobiomodulation (PBM). Red laser, 660 nm, 108 mW, 2.7 W/cm², was used to irradiate the ulcer point by point, since the area of the laser beam was smaller than the area of the ulcer (laser beam = 0.04 cm²), in contact mode, 108 J/cm², 4.32 J, and 10 s per point once a week for 33 weeks. Arterial Doppler ultrasound examinations were performed twice, i.e., after three and six months of treatment. Results: Gradual improvement of blood flow in the ulcer bed with postocclusive flow after three months, and after six months, triphasic flow toward the calcaneus. Conclusion: Photobiomodulation proved to be effective for the formation of collateral circulation in the occluded vascular bed studied here, despite only partial ulcer healing. Randomized controlled trials should be performed to better understand the effects of PBM.

Keywords: Angiography, Angiosome, Doppler, Phototherapy, Wound

INTRODUCTION

The World Health Organization (WHO) defines diabetic foot (DF) as “the state of infection, ulceration, and/or destruction of the deep tissues, associated with neurological abnormalities and various degrees of peripheral vascular disease in the lower limbs of patients with diabetes mellitus (DM)” [1]. Diabetic foot ulcers are a challenge to fully treat even now. The situation becomes even more challenging if we are faced with an ischemic ulcer, since the pathophysiology of the DF brings us changes in the associated micro and
macroangiopathy. Thus, the need for improvement in the blood supply to the affected region becomes paramount for the healing of the lesion [1].

Considering the concept of angiosome (an anatomical unit of the tissue nourished by an artery) associated with the presence of micro and macroangiopathies in diabetic ischemic feet, it is clear that, in some cases, even with only one of the arteries of the leg being affected by significant stenosis or occlusion, if the ulcer is located in the irradiation angiosome for said artery, we will be faced with an ischemic ulcer to treat. Thus, it becomes necessary, for the healing process, to restore the blood supply to the affected angiosome area. This is the case because microcirculation anastomoses will certainly be occluded, which will prevent the irrigation of that region occurring through other leg arteries that are patent [2].

Photobiomodulation (PBM) demonstrates the ability of light to biomodulate the irradiated target, depending on the light parameters used and the characteristics of the tissue. Some studies report that PBM improves skin circulation in patients with diabetic microangiopathy [3]. Also, according to some clinical research, PBM, at certain wavelengths, may also improve tissue repair by releasing fibroblast growth factors and facilitating the healing process of diabetic wounds by modulating collateral circulation, increasing microcirculation, and relaxing the vascular smooth muscle [4].

CASE REPORT

After approval by UNINOVE and CHM Research Ethics Committee (CAAE 53351716.5.0000.5511), a 61-year-old male patient with type II DM (diagnoses 10 years ago), arterial hypertension (SAH), dyslipidemia (DLP), and chronic arterial insufficiency (CAI), with previous left lower limb amputation. He had a post-traumatic right calcaneal ulcer.

Upon physical examination he had palpable femoral, popliteal, and anterior tibial pulses, but showed an absence of a posterior tibial pulse. His ulcer was pale, with a lot of fibrin and an area of necrosis on the edges, with little secretion and without signs of infection.

It was possible to detect by arterial Doppler ultrasonography (US) an occlusion of the posterior tibial artery and preserved flow in the fibular and anterior tibial arteries; confirmed by arteriography (Figure 1).

Without the technical possibility of revascularization of the posterior tibial artery, ulcer treatment consisted of control of DM and SAH, antiplatelet agents (AAS 100 mg/day), statin (simvastatin 40 mg/day), and cilostazol 200 mg/day. Dressings once a week, primary coverage with cellulose membrane (Membracel®) and secondary coverage with gauze and a crepe bandage associated with PBM with laser was begun. Photobiomodulation was performed with laser (Therapy EC, DMC, Brazil), 660 nm, 108 mW, 2.7 W/cm². The ulcer was irradiated point by point, since the area of the laser beam was smaller than the area of the ulcer (laser beam area = 0.04 cm²), in contact mode, 108 J/cm², 4.32 J, and 10 s per point once a week, totaling 33 weeks. The entire edge of the ulcer was irradiated by 1 cm equidistant points. The posterior tibial artery pathway was irradiated from the beginning. The ulcer was irradiated from the fifth session. In total, there were 33 sessions on the posterior tibial tract and 28 sessions on the ulcer.

After 45 days (six sessions) the patient presented a secretory wound with a foul odor. Debridement of the lesion was performed as well as a deep tissue culture, which was positive for Escherichia coli, Morganella, and Enterococcus. It is necessary to emphasize that the patient, when perceiving an improvement in pain levels and reduction in the area of the lesion, failed to adequately care for the dressing, facilitating the appearance of infection. Thus, antibiotics were started, according to the antibiogram. The infection then improved along with granulation in the lesion (Figure 2).

Two arterial Doppler US examinations were performed during PBM treatment, in addition to the preliminary diagnostic examination. The first of which was performed after about three months of treatment and the second after six months.

In the arterial Doppler US exam after three months of treatment, the presence of distal flow was observed in the topography of the posterior tibial artery “Tardus Parvus,” compatible with postocclusive flow.

In the six-month arterial Doppler examination, a more prominent collateral network was observed, with flow present in the topography of the distal posterior tibial artery and in the triphasic calcaneal topography (Figure 3).

The patient only presented partial healing of the lesion during treatment with PBM, despite progressive improvements in blood supply to the region. At the beginning of the treatment, the deep-bed ulcer presented with 3.04 cm² of area, and at the end of 33 sessions the lesion was shallow presenting granulation and an area of 2.15 cm², a healing rate of 29.2% (Figure 4).

Figure 1: Angiography showing occlusion of the posterior tibial artery (highlighted by arrows) and patent anterior tibial and fibular arteries.
After this period, the participant presented with coronary insufficiency, and needed to leave the PBM treatment group.

**DISCUSSION**

Photobiomodulation makes use of nonionizing radiation both in the visible range of the electromagnetic spectrum (400–760 nm) and in the infrared (760–1000 nm). When a molecule absorbs a photon, the electrons in the molecule are led to a higher energetic state. This excited molecule needs to lose that extra energy and can do this by re-emitting a longer-wavelength photon in the form of fluorescence or phosphorescence, or it can lose energy by releasing heat or it can lose energy through photochemistry. Photobiological responses are the result of photochemical and/or photophysical changes produced by the absorption of nonionizing radiation, that is, there is no fluorescence or phosphorescence, nor warming of the biological target [5].

The word PBM demonstrates the ability of light to biomodular, both from point of view of stimulating or inhibiting, depending the light parameters used and the characteristics of the irradiated tissue [6].

According to Lipovsky et al., the effects of PBM on living tissues occur through the release of electrons that, upon reaching the mitochondria, enable the production of adenosine triphosphate (ATP) and the restoration of membrane potentials, normally altered in pathological situations [7]. Fortuna et al. report that PBM produces reactive oxygen molecules that are able to interact with body tissues, stimulating, or inhibiting chemical reactions inside cells [8]. In accordance with these authors, the objective of using PBM is to induce the recovery of cellular homeostasis and consequently favor healing of the tissue without causing a thermal effect.
Photobiomodulation has an effective indication in cases of tissue repair due to its ability to stimulate and proliferate fibroblasts, reduction of the inflammatory process, acceleration of collagen synthesis and its better organization, acceleration of the process of wound healing [9–11].

A recent systematic review and meta-analysis revealed that PBM was a potential method in the comprehensive treatment of DF ulcer. However, only seven randomized clinical trials met the inclusion criteria of the review, suggesting that PBM may play a role in treatment of DF ulcer by increasing ulcer healing rate, reducing ulcer area, forming granulation tissue, and relieving pain of DF ulcer [12].

It is important to consider the biphasic dose–response effect or Arndt–Schulz curve of PBM, which states that there are optimum parameters that provide a benefit to the particular disease. On the other hand, if these parameters were exceeded, the benefits disappear and can even lead to damaging effects [13].

About contraindications for PBM, only direct eye exposure remains forbidden for all applications. Other contraindications are inconsistent, inaccurate, and outdated, according to ref. [14].

The angiosome concept should always be considered when working with DF lesions, especially in ulcers with an ischemic component and in chronic ulcers not responsive to conventional clinical treatment, often, even in the presence of a palpable distal pulse [15, 16].

In the presence of DF ulcers associated with chronic obstructive arterial disease, the possibility of revascularization of the limb by vascular grafts or angioplasty is always the best option and should be considered [15–17]. However, there are cases in which revascularization is not the best option because it is a high risk to the patient and/or the vascular bed is unfavorable. In these cases, clinical treatment or amputation of the limb at the level at which the circulation proves adequate for surgical wound healing are the best therapeutic options available.

Therefore, the association of PBM with conventional treatment can be considered a coadjuvant treatment for the formation of a collateral network in the ischemic area, and in improving the topography of the nourishing artery of the affected angiosome, as well as for general healing of the lesion, especially in cases of DF [15, 18].

In the case reported, the initial diagnosis and the control of the blood supply of the affected limb were performed with Doppler ultrasonography, which proved to be effective for this purpose. Angiographies were only performed for clarity and for surgical planning.

It was observed that PBM proved to be effective for the formation of collateral circulation in the region of the lesion, initially, by the presence of postocclusive flow (Tardus Parvus) and then with normal triphasic flow detected by arterial Doppler US analysis, despite only partial healing of the lesion.

CONCLUSION

Photobiomodulation associated with conventional treatment for peripheral obstructive artery disease was able to promote collateral circulation in the occluded vascular bed, despite the fact that it only presented partial healing of the ulcer in the period evaluated.

REFERENCES


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