

Short Communications

The Use of Ozone in High Frequency Device to Treat Hand Ulcers in Leprosy: a Case Study

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Abstract: Leprosy leads to chronic granulomatous inflammation in skin and peripheral nerves that can lead to sensory, motor and autonomic impairments. Autonomic dysfunctions may result in dryness and cracking of the skin. In this study, we present the use of ozone provided by a high-frequency device to treat hand ulcers (wounds) in an 80-year-old man who was diagnosed as multibacillary in 2007. In the first visit, the patient was evaluated and received verbal and written instructions about self-care. Treatment consisted of five sessions, once per week. The ozone provided by a high-frequency device seemed to be useful in the treatment of ulcers, thus, contributing to the healing process. Research that investigates the use of high frequencies in the treatment of ulcers associated or not with other interventions (self-care strategies, protective clothing, adapted tools and footwear adaptation) is strongly recommended.

Key words: leprosy, ulcer, ozone

INTRODUCTION

Peripheral nerve damage in leprosy may lead to loss of sensory and motor function [1–4]. The consequences of nerve damage may give rise to secondary disabilities that are mostly the consequences of the unprotected use of “anaesthetic” extremities, and include ulcerations of the feet and hands [5, 6]. In cases of important sensory loss, self-care is an essential component of preventing these significant complications [7, 8]. Indeed, self-care is the responsibility of the individual and might be difficult to implement in practice. In the presence of a plantar ulcer, some interventions, such as footwear adaptations, are recommended [5–10]. However, interventions to treat secondary disabilities in the hands, such as ulcers, are not common. The aim of this study is to present a case report about the application of a high-frequency generator in the treatment of hand ulcers due to sensory loss in leprosy. We believe that this research is important. First, because hand ulcers may contribute to infection and finger amputation and, consequently, more stigma and functional limitation; second, it is a non-pharmacological treatment; and third, this treatment may also be able to treat foot ulcers.

MATERIALS AND METHODS

This case report was conducted from November to December 2014. The study protocol was approved by the Human Research Ethics Committees of the Instituto Federal do Rio de Janeiro, and the patient was given oral and written information before he agreed to participate.

We present an 80-year-old Brazilian man who was diagnosed with multibacillary leprosy in 2007. He received multidrug therapy for one year, and was discharged in 2008. At the first visit, a clinical history, information regarding sensory and motor nerve damage, an assessment of the nose, eyes, hands and feet, and a cutaneous examination were performed by an experienced professional. There was no history of smoking or alcohol consumption, and there was no clinical history of any other condition that causes neuropathies. There was a history of a traumatic injury on the second finger of his left hand in 2008.

A physical examination followed the assessment protocol recommended by the Brazilian Ministry of Health, and all tests were performed by an evaluator (FJJR) who had 10 years of experience. The clinical nerve assessment included nerve palpation in sites of predilection, sensory impairment using Semmes-Weinstein monofilaments and

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motor function impairment assessed by manual muscle strength testing.

A palpation of the nerves, which aims to evaluate their tenderness, consistency (soft, hard, irregular) and size (enlarged, normal, small), was performed gently using the pulp of the fingers and included the main peripheral nerves (ulnar, median, radial, lateral popliteal and tibial). Left and right nerves were compared, and the result was defined as present or absent.

Semmes-Weinstein monofilaments (MF) (0.05 gm/0.2 gm/2 gm/4 gm/10 gm/300 gm) was used to assess light touch perception in skin areas related to the ulnar, median and tibial nerves.

Voluntary muscle testing was performed using a six-grade scale (0–5) in the following nerves by assessing the muscles to which they connect: ulnar nerve (abductor digiti minimi), median nerve (opponens pollicis), radial nerve (extensor carpi radialis longus, extensor carpi radialis brevis, extensor carpi ulnaris) and common peroneal nerve (extensor hallucis longus).

RESULTS

The patient presented no problems in his eyes or nose due to leprosy. During the palpation of nerves in the upper and lower limbs, no thickening or pain were perceived. There was sensory loss in both hands (4 gm, 10 gm and 300 gm), and feet were considered anaesthetic (no response with 300 gm) in all tested plantar points. Motor function of the hands was classified as grade five for all muscles except the left abductor digiti minimi, which was grade three. In the feet, the extensor hallucis longus was classified as grade five in the left foot and grade four in the right foot.

Cutaneous examination of his hands showed five hand ulcers (wounds) localised in the dorsal part of the third, fourth and fifth fingers of his left hand. According to the patient, these wounds occurred during cooking and car repair. The patient was unable to accurately estimate how long the wounds were present. However, he considered that the injuries exist for at least 4 months. The hand ulcers had not been treated previously. The patient reported that he uses only an oil lotion to avoid skin cracks due to skin dryness in hands and feet. There were no skin injuries on the right hand or on the feet. The area of each ulcer was measured using two software programmes (GIMP and ImageJ).

We performed five sessions (one evaluation and four treatments). At the first visit, the patient was evaluated and received verbal and written instructions about self-care management in order to avoid new injuries. At the first vis-



Fig. 1. Application of high frequency current - the technique of sparks.

it and after each treatment session, a photograph of his left hand was taken. The images were sent to be analysed by a blind evaluator (M.K.G) using ImageJ (version 1.48, National Institutes of Health, Bethesda, Maryland), a public domain Java image processing software programme (downloadable at <http://rsbweb.nih.gov/ij/download.html>), to estimate the area of the wound in square millimetres (mm²). This method has been used previously in studies to measure ulcers in diabetic patients [11] and can be considered reliable [12].

The patients' wound care protocol included the application of a high-frequency current (equipment Beauty Face[®], HTM Electronics, Brazil). We used the sparks technique (Fig. 1), with 80% amplitude and an electrode nozzle, bypassing the entire ulcer and its interior, moving away from the tissue to avoid contact and contamination. The patient received five applications in each ulcer per day, which varied in terms of the size of the lesions (one minute per cm²). The patient was treated once per week for a total of four weeks of intervention. Figure 2 shows the progression of ulcer healing, and Table 1 represents the areas measured in pre- and post-treatments. Despite it being possible to measure the area at the end of the fifth treatment session, the ulcers were considered clinically healed because they showed complete skin closure with no drainage and no sign of infection.

DISCUSSION

The main component of leprosy programmes has been the prevention of disability [5, 7, 9, 10]. Early diagnosis

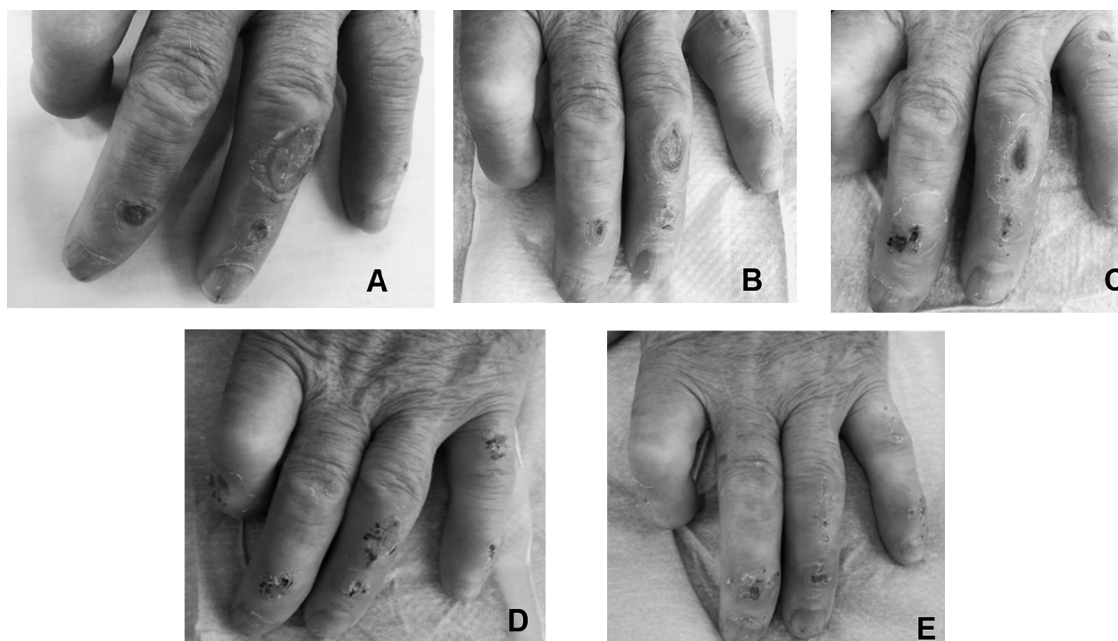


Fig. 2. The presence of hands ulcers (wounds). The patient's left hand in the assessment (A), first session (B), second session (C) third session (D) and in the fourth treatment session (E).

Table 1. The results of the measurements of each ulcer along treatment sessions.

Region	AREA (mm ²)				
	Assessment	Day-1	Day-2	Day-3	Day-4
III finger (distal)	2130,6	495,3	264,9	176,1	111,7
IV finger (proximal)	12564,9	1427,8	1200,9	937	142,8
IV finger (distal)	1477,8	519,9	468	211,9	178,6
V finger (proximal)	1321,6	1038	609,5	417,8	46,1
V finger (distal)	1145,9	498,3	247,4	147,3	109,9

and treatment, and adequate management of nerve damage, combined with effective health education to prevent limb damage is strongly recommended as the main intervention to prevent disabilities in leprosy [5, 9, 10]. When nerve damage occurs, it is important to develop strategies to prevent it from worsening and/or to treat impairments such as deformities and ulcers [5]. However, the best way to prevent or treat skin damage is not clear.

The majority of studies on skin damage in leprosy are related to plantar ulcers and recommendations on footwear [9, 10] A systematic review [8] suggested that topical ketanserin as an effective treatment in the healing process of plantar ulcers. Topical phenytoin (two studies) may be more effective than saline dressings regarding ulcer healing. In our study, a conservative and non-pharmacological treatment option was presented in the management of hand ulcers due to nerve damage in leprosy. The use of ozone provided at a high-frequency may be beneficial in healing

processes with a short period of treatment.

The high-frequency generator operates on alternating currents (high voltage and low intensity) and uses glass electrodes with air or gas (Neon, Argon or Xenon). It is advocated that the electric field generated by the device and the passing of the current through the body can produce thermal effects (heat production) and the ozone effect due to the sparking produced by the current passing through the electrode. The thermal effects contribute to peripheral vasodilation, increasing blood flow and oxygen delivery. The ozone has been used to treat chronic wounds such as in diabetes [12]. Healing process promoted by ozone might be promoted by the decrease in bacterial infection, fibroplasias activation and keratinocyte proliferation [12–16].

Ozone is a powerful oxidant; contact with body fluids results in the formation of reactive oxygen molecules and biochemical events. Those events influence cellular metabolism and provide tissue repair and antimicrobial effects

[16]. The ozone exposure promotes the activation of transcription factor NF- κ B (regulating inflammatory responses) [17–19] and the release from platelets of platelet-derived growth factor (PDGF) and transforming growth factor β 1 (TGF- β 1) [20–22].

The clinical use and the physiological effects have been presented previously in the literature. In a study by Kim et al., using an acute cutaneous wounds in guinea pig model, the authors found an increased intensity of collagen fibres and a greater number of fibroblasts in the ozone group [12]. In a small sample controlled clinical trial, found that a high-frequency generator caused an improvement in healing and a decrease in pain in pressure ulcers when compared with the control group [16]. A systematic review [22] of the therapeutic use of ozone in wounds; it was discovered that most of the studies analysed found a stimulation of the healing process (62.2%), followed by improvement in wound appearance (43.5%) and a decrease in pain (17.4%). The author concluded that ozone could be an important treatment option for wounds and may bring numerous benefits to patients.

The measurement of areas using a photographic method was previously used and showed good inter- and intra-reliability [23]. The availability of computers and the popularisation of digital cameras made the use of this technology as a precision instrument possible [24–26].

We recognise that the major limitation of this study was the lack of comparison with other treatments. It is also possible that the results could be different in plantar ulcers, especially concerning the time of healing. Plantar ulcers may be more difficult to heal due to the contact of the foot with the ground and the presence of deformities such as claw toes or drop foot. Another limitation of this study was the difficulty to investigate the influence of self-care practice. We provided verbal and written instructions, and self-care was evaluated only by the absence of new wounds during the period of the study.

The ozone provided by a high-frequency device seemed to be useful in the treatment of ulcers contributing to the healing process. However, it is important to highlight that this intervention can be considered as adjuvant in skin damage treatment. We recommend that this modality be used in combination with self-care strategies, protective clothing, modified tools and footwear adaptation.

This study sheds light on the treatment of one important complication after multidrug therapy discharge. Research that investigates the use of high frequencies in the treatment of plantar ulcers associated or not with other interventions is strongly recommended.

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REFERENCES

- Rodrigues LC, Lockwood DN. Leprosy now: epidemiology, progress, challenges, and research gaps. *Lancet Infect Dis* 2011; 11(6): 464–470.
- Graham A, Furlong S, Margoles LM, et al. Clinical management of leprosy reactions. *Infect Dis Clin Pract* 2010; 18(4): 235–238.
- White C, Franco-Paredes C. Leprosy in the 21st Century. *Clin Microbiol Rev* 2015; 28(1): 80–94.
- Bhat RM, Leprosy PC. An Overview of Pathophysiology. *Interdiscip Perspect Infect Dis* 2012; 2012: 181089. doi: 10.1155/2012/181089.
- Brandsma J. Prevention of disability in leprosy: the different levels. *Indian J Lepr* 2010; 83(1): 1–8.
- Srinivasan H. Nerve damage, surgery and rehabilitation in leprosy. *Trop Med Parasitol* 1990; 41: 347–349.
- Cross H. The prevention of disability for people affected by leprosy: whose attitude needs to change? *Lepr Rev* 2007; 78(4): 321–329.
- Reinar LM, Forsetlund L, Bjørndal A, et al. Interventions for skin changes caused by nerve damage in leprosy. *Cochrane Database Syst Rev* 2008; 16(3): CD004833. doi: 10.1002/14651858.
- Anonymous. Consensus statement on prevention of disability. *Lepr Rev* 2006; 77: 387–395.
- van Veen NH, McNamee P, Richardus JH, et al. Cost-effectiveness of interventions to prevent disability in leprosy: a systematic review. *PLoS One* 2009; 4(2): e4548.
- Miot HA, Mendaçolli TJ, Costa SV, et al. Chronic ulcers in lower limb: assessment by digital photography. *Rev Assoc Med Bras* 2009; 55(2): 145–148.
- Kim HS, Noh SU, Han YW, et al. Therapeutic effects of topical application of ozone on acute cutaneous wound healing. *J Korean Med Sci* 2009; 24(3): 368–374.
- Valacchi G, Bocci V. Studies on the biological effects of ozone: 11. Release of factors from human endothelial cells. *Mediators Inflamm* 2000; 9: 271–276.
- Travagli V, Zanardi I, Valacchi G, et al. Ozone and ozonated oils in skin diseases: a review. *Mediators Inflamm* 2010; 2010: 1–9.
- Bocci VA, Zanardi I, Travagli V. Ozone acting on human blood yields a hormetic dose-response relationship. *J Transl Med* 2011; 9(66): 1–11.
- Korelo RIG, de Oliveira JJJ, Souza RSA, et al. High frequency generator as treatment in scar pressure ulcers: pilot study. *Fisioter Mov* 2013; 26(4): 715–724.
- Valacchi G, Fortino V, Bocci V. The dual action of ozone on the skin. *Br J Dermatol* 2005; 153: 1096–1100.
- Janic B, Umstead TM, Phelps DS, et al. Modulatory effects of ozone on THP-1 cells in response to SP-A stimulation. *Am J Physiol Lung Cell Mol Physiol* 2005; 288:

- L317–325.
19. Valacchi G, van der Vliet A, Schock BC, et al. Ozone exposure activates oxidative stress responses in murine skin. *Toxicology* 2002; 179: 163–170.
 20. Bocci V. Biological and clinical effects of ozone. Has ozone therapy a future in medicine? *Br J Biomed Sci* 1999; 56: 270–279.
 21. Valacchi G, Bocci V. Studies on the biological effects of ozone: 10. Release of factors from ozonated human platelets. *Mediat Inflamm* 1999; 8: 205–209.
 22. Oliveira, Juliana Trench Ciampone de. Systematic Literature Review about the therapeutic use of the ozone in wounds [dissertation]. Sao Paulo: University of Sao Paulo, Escola de Enfermagem; 2007 [Accessed 2015-02-16]. Available: <http://www.teses.usp.br/teses/disponiveis/7/7139/tde-20122007-094050/pt-br.php>.
 23. Reis FJ, de Barros ESV, de Lucena RN, et al. Measuring the Pain Area: An Intra- and Inter-Rater Reliability Study Using Image Analysis Software. *Pain Pract* 2014; 10. doi: 10.1111/papr.12262.
 24. Cutler NR, George R, Seifert RD, et al. Comparison of quantitative methodologies to define chronic pressure ulcer measurements. *Decubitus* 1993; 6: 22–30.
 25. Solomon C, Munro AR, Van Rij AM, et al. The use of video image analysis for the measurement of venous ulcers. *Br J Dermatol* 1995; 133: 565–570.
 26. Rajbhandari SM, Harris ND, Sutton M, et al. Digital imaging: an accurate and easy method of measuring foot ulcers. *Diabetes Med* 1999; 16: 339–342.