

The Use of Aloe Vera after Infrared Therapy in the Treatment of a Diabetic Foot Ulcer: A Case Report

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Abstract

Background: Infrared radiation therapy and the use of aloe Vera have been independently suggested to enhance diabetic sensory neuropathy and diabetic foot ulcer. The current case study aimed at investigating the application of aloe Vera gel after the infrared radiation therapy on a diabetic foot ulcer. **Case Description:** The participant was a 62 year old male patient with a 10 year history of type 2 diabetes and 5 ulcers on both plantar parts of the feet (three ulcers on the left foot, and two on the right foot). The ulcers were graded 1 on Wagner Ulcer Classification. Initially, blood perfusion on both legs was evaluated by Doppler Ultrasound, and the foot with less perfusion (left) was selected as the case and the right foot as the control group, and both feet were washed daily with normal saline solution and draped for 5 weeks. First, the ulcers on the case foot were washed, then, radiotherapy was conducted for 20 minutes from 35 cm with infrared lamp, after that, aloe Vera gel was rubbed on the ulcer and then draped; but, the control foot was just radiated by a normal red lamp that was similar to the infrared lamps at a distance of 35 cm for 20 minutes.

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Thereafter, placebo gel was applied on the ulcer. Necessary instructions were given to the diabetic patient on diet and diabetes treatment, and the patient's laboratory tests were also monitored. **Outcomes:** The first ulcer of case foot healed in the third week, the second in the fourth week, and the third in the sixth week; while in the control group, the first ulcer healed in the fifth week and the second did not exhibit any significant change at the end of week 7. After changing the method, the second ulcer of the control foot was partially healed at week 13. **Discussion:** Applying aloe Vera gel after infrared radiation significantly decreased the time of ulcer healing in comparison with the control. Hence, more research studies in this area are recommended to be conducted.

Keywords: Diabetes, Foot ulcer, Aloe-Vera, Infrared.

Introduction

Diabetes is a chronic disease that occurs when the pancreas cannot produce enough insulin, or the body cannot efficaciously use insulin. Insulin is a hormone that regulates blood glucose level (Organization, 1999). Hyperglycemia or increased blood glucose is a common effect of uncontrolled diabetes, and in most cases induces serious damages to the body's systems, especially the nervous system and blood vessels (Organization, 1999). The number of people diagnosed with diabetes increased from 108 million in 1980 to 422 million in 2014, and its incidence among young people over the age of 18 increased from 4.7% in 1980 to 8.5% in 2014. In 2012, diabetes was directly responsible for 1.5 million deaths (Atlas, 2015; Ogurtsova et al., 2017; Organization, 2016). Diabetes and its complications have been one of the main concerns of health systems over the world (Unwin et al., 2012). The prevalent complications of diabetes include micro-angiopathy, which causes ulcers or delayed healing of ulcers (Papanas & Maltezos, 2011).

Studies have shown that peripheral vascular diseases can affect up to 50% of diabetic foot ulcers (Gregg et al., 2004). Singh et al., measured the probability of diabetic foot ulcers in diabetic patients to be more than 25% (Singh, Armstrong & Lipsky, 2005). Diabetic foot ulcer is one of the most prevalent complications of diabetes and the most common cause of hospitalization of these patients (Zareban et al., 2014). Diabetic patients with a history of foot ulcer had a higher incidence rate of mortality than other patients without a history of foot ulcer. After

the first amputation, they had an annual mortality rate of about 50% and a yearly rate of about 76%. Although chemical treatments and insulin can be employed to treat the disease to varying degrees; researches on the diagnosis of the disease as well as the introduction of natural medications for the disease is ever increasing (Papanas & Maltezos, 2011; Ibrahim, 2017).

In recent years, investigations on herbal medicines and their effects on microbial pathogens have been on the increase in herbal research centers around the world, especially in Iran (Bahmani et al., 2014). In traditional herbal remedies, aloe Vera extract and leaf have often been introduced as having antimicrobial and ulcer healing properties. The antimicrobial and ulcer healing properties of aloe Vera have been investigated and used for therapeutic purposes (Shamloo & Yavarmanesh, 2015; Daburkar et al., 2014; Coelho et al., 2015).

Aloe Vera is a durable plant with yellow flowers from the lily family; only the leaves of this plant have medicinal value. This herb is beneficial in the treatment and repair of ulcers, heat damage, inflammation, arthritis, asthma, chronic fatigue syndrome, indigestion, intestinal disorders, skin diseases, epilepsy, migraines, and so on. Aloe Vera gel is topically employed in the treatment of mild burns, skin lesions, diabetic foot ulcers, acne and oral mucositis (Daburkar et al., 2014; Baradaran et al., 2014; Zargari, 1997; Choi et al., 2001; Chithra, Sajithlal & Chandrakasan, 1998, 181(1-2); Chithra, Sajithlal & Chandrakasan, 1998, 59(3)). At the beginning of the 1930s, extensive scientific research was conducted on the compounds and properties of the plant. It was found that the gel has an enthralling effect on the treatment of ulcers and burns. This herb has been used in the treatment of inflammation and skin sensitization, lesions induced by leishmaniasis, chronic psoriasis, genital herpes in men, foot fungus infections, reduction of inflammation of the oral mucosa, skin and blood vessels, dermatitis, eczema, decreased blood sugar, increased body system immunity, stimulation of skin epithelial cell growth, rheumatoid arthritis, bed sores, asthma, chronic fatigue syndrome, indigestion and intestinal disorders. Many studies have demonstrated the antibacterial and antiviral effects of aloe Vera (Oliveira et al., 2008; Langmead et al., 2004; Maenthaisong et al., 2007; Takahashi et al., 2009; Khorasani et al., 2011). On the other hand, some studies have demonstrated the use of heat in the repair of diabetic ulcers, and argued that stimulation and use of infrared radiation can be a superior alternative in the development of future diabetic ulcer healing techniques (Armstrong, 1998; Petrofsky et al., 2007; Larijani et al., 2003).

In this regard, Hakim et al., in 2016 in a clinical trial study stated that infrared radiation with a tungsten bulb had a beneficial effect on the repair of diabetic foot ulcers (Hakim, Moghadam & Shariati, 2016). Some researchers believed that the best and the least expensive treatment for skin ulcers is the use of infrared radiation. In this regard, two researchers, Donald and Hayland, used infrared radiation to repair skin lesions and recorded favorable outcomes. They concluded that infrared radiation did not prolong chronic inflammatory process (Tavakoli et al., 2004; Hyland & Kirkland, 1980). Master et al.,

who studied the effect of infrared rays on chronic ulcers revealed that more than 70% of the ulcers responded to infrared radiation treatment (Mester, Mester & Mester A, 1985). Against this backdrop, the present study aimed at determining the use of aloe vera in the treatment of a diabetic foot ulcer after the application of infrared radiation therapy.

Case Description

The patient was a retired worker of a private company with a height of 172 centimeters and a weight of 70 kilograms. His body mass index was 23.7. The patient had 10 year history of diabetes, and a history of 2 years of 5 ulcers in both feet (three ulcers on the left foot: ulcer number one, 0.65 cm³, ulcer number 2 with volume of 1.1 cubic centimeter, and ulcer number 3 with volume of 2.55 cm³; the two ulcers on the right: ulcer number 4 was 0.57 cm³ and ulcer number 5 was 2.67 cm³), which were constantly degenerating. He has not had any care for his feet before the onset of the ulcers. He was referred to the doctor two years after the appearance of ulcers, but the treatments administered did not work well despite the fact that the patient was hospitalized for 10 days, and subsequent visits for 6 months did not improve the healing of the ulcers of the patient. On the last visit, about 6 months before the referral to the diabetic foot ulcer clinic at Dezful Hospital, the physician suggested that the patient should be informed of the need for amputation of one of the legs from the wrist. The patient had no history of any other chronic illnesses and surgeries. The patient did not consume any special medication other than insulin (6 units in the morning, 4 units in the evening and 8 units in the morning and 6 units in the evening). He also did not have a history of smoking and drugs. The patient lived with his wife and three children, and had two other children who were married and lived in their own house.

Examination

The patient was introduced to the ulcer healing center through an online notice, and was referred along with his wife. Fortunately, he did not use any crutches or wheelchairs, and despite the ulcers being on both sides of the foot, they went to the ulcer healing center on motorcycle. Vital signs were recorded at the time of entry into the center: pulse at entry; 76, respiratory rate, 16 minutes, pressure of the right hand 110/80 mmHg, left arm 80/141 mmHg, right systolic pressure 105 mmHg and left ankle systolic pressure 104 mmHg. The patient's fasting blood glucose was 60. In view of this, the patient's insulin dose was immediately corrected by the physician. The patient was alert and aware of time, place, and person, and communicated naturally and effectively with good listening and learning communication skills. Both blood vessels were checked due to swelling of the legs; distal pulses were palpable, and both legs had localized swelling of 2+ and Charcot disease. The ulcers on the patient's legs were also dirty and contaminated at the time of entry, and had infectious secretions.

Tests and actions

The computed value of the ABPI index for this patient was 0.95 on the right side and 0.92 on the left side, indicating no arterial

disease in the patient (Al-Qaisi et al., 2009). In the interpretation of this index, it was stated that ... the normal range was between 0.8 and 1, and less than 0.8 represented moderate to very severe disease (Wagner, 1981). (ABPI= Dividing the systolic blood pressure measured in the arterial conduits at the level of the ankle by the systolic blood pressure measured in the brachial artery).

The patient's neurological sensation was performed on the left leg trachea employing 10 g monofilament at the points of 4.6-10, and in the right leg at 2-7 and 10.9.

The sensory test with the 10 g monofilament showed a reduction in the function of the large neuronal fibula of both legs, indicating the complications associated with the development of DFU (diabetic foot ulcer).

Bilateral dorsalispedis and posterior tibia distal pulses were not palpable in both legs, and Doppler ultrasonography showed a significant decrease in the elasticity of the blood vessels of both legs.

Measles of both feet were measured using the Table *Guelph General Hospital Congestive Heart Failure Pathway*; and the left leg and right foot edema were measured to be +3 and +2; respectively.

Table 1: Assessment of Pitting Edema

Assessment of Pitting Edema			
2mm or less = 1 + Edema	2-4mm = 2 + Edema	4-6mm = 3 + Edema	6-8mm = 4 + Edema
Slight pitting	Somewhat deeper pit	Pit is noticeably deep	Pit is very deep
No visible distortion	No readably detectable Distortion	May last more than 1 Minute	Lasts as long as 2-5 Minutes
Disappears rapidly	Disappears in 10-15 seconds (2-4 mm indent)	Dependent extremity looks fuller and swollen (4-6mm)	Dependent extremity is grossly distorted (6-8mm)

Assessment Chart for Pitting Edema adapted from the Guelph General Hospital Congestive Heart Failure Pathway

Evaluation and planning

Since the patient's morale was very high for treatment and on the other hand, was eagerly ready to follow the treatment regimen, the prognosis seemed very good. The patient's ulcers were first graded based on Wagner classification criteria (Wagner, 1981). Based on the physical therapy guidelines for this type of ulcer, two types of targeting were performed (Association APT, 2001).

The short-term goal was to search, manage, and remove infections from the ulcers, remove dead tissues and hyperkeratosis, maintain ulcers' moisture and close small ulcers, and induce healing in at least half of the major ulcers in 8 weeks. In addition, in the long term, it was asserted that, all the patient's ulcers were completely healed, the full epithelization occurred for the patient's ulcers, and the patient was encouraged to take care of

himself and to come for follow-up visit on relapse of the disease in less than 4 months.

Intervention

The subject gave his informed consent for inclusion before his participation in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of XXX (Project identification code).

The left foot, which had less blood flow, was selected as the case foot in the intervention stage, and the right foot was assigned as the control. In the first visit, the patient's legs were washed with sterile gas and normal saline serum to remove the mechanical surface debris and as far as possible, the skin was dead and exposed to necrosis. The ulcers' infectious remnants continued their invasion until they reached the surface of healthy skin and alive muscle. Thereafter, the ulcers were washed with 0.9% normal saline solution for 5 minutes. Debris was removed from the ulcer, and the ulcers were dried with sterilized gas. Daily dressing and washing were done for each foot. Each day, after the rupture of the foot, 20 minutes of radiotherapy was performed at a distance of 35 cm with a 250 watt infrared bulb, and then a layer of aloe Vera gel with a thickness of 0.5 cm was applied to the ulcer; thereafter, the dressing was carried out with six layers of ulcer gas of 0.5 centimeters and closed with two normal bands in the case foot; but in the control foot, after being dislodged for 5 minutes by a non- infrared bulb of 1 watt that looked like an infrared lamp, radiotherapy was carried out at 35 centimeters for 20 minutes and then, the prepared placebo was administered in accordance with the previous method of dressing. The person who performed the dressing was not aware of the type of drugs and rays used as they were all confidential information. The necessary written and verbal training was provided to the patient and his wife who accompanied him, and daily follow-up was done in compliance with the requirements. In addition to a visit in every two days by an intern and a weekly visit to the endocrinologist, systemic antibiotic therapy was prescribed by the physician for the patient, and the diet and treatment of the diabetic patient was monitored daily. All trials conducted on the patient (including daily FBS and Hba1c) were monitored and controlled.

After 7 weeks, for control and maintenance of the side that was treated with routine and placebo treatment, only daily washing with a normal saline solution and dressing was done, and then from the eleventh day, aloe Vera gel and infrared radiation were employed to induce healing on the ulcer of the desired foot. It should be noted that the temperature of the infrared rays and ordinary red light bulbs were recorded every 5 minutes using a thermometer. The peak temperature at the surface of the infrared radiation was 42°C, but the temperature at the surface of the conventional bulb was up to 37°C, and if the temperature at each leg was higher than these values, the lamp was pulled backward.

Outcome

First foot ulcer at the end of the third week and second leg ulcer at the end of the fourth week as well as the third leg ulcer at the

beginning of the seventh week were completely healed. In the other foot, the smaller ulcer was completely healed at the end of the fifth week, and the second ulcer did not change until the 7th week. After 8 weeks, ulcer healing started in the second ulcer.

The second ulcer was healed at the onset of week 13, but unfortunately at the end of the 13th week, the patient's control foot was burnt with hot water in their house bathroom and its ulcer could not heal completely. (Figure 1)

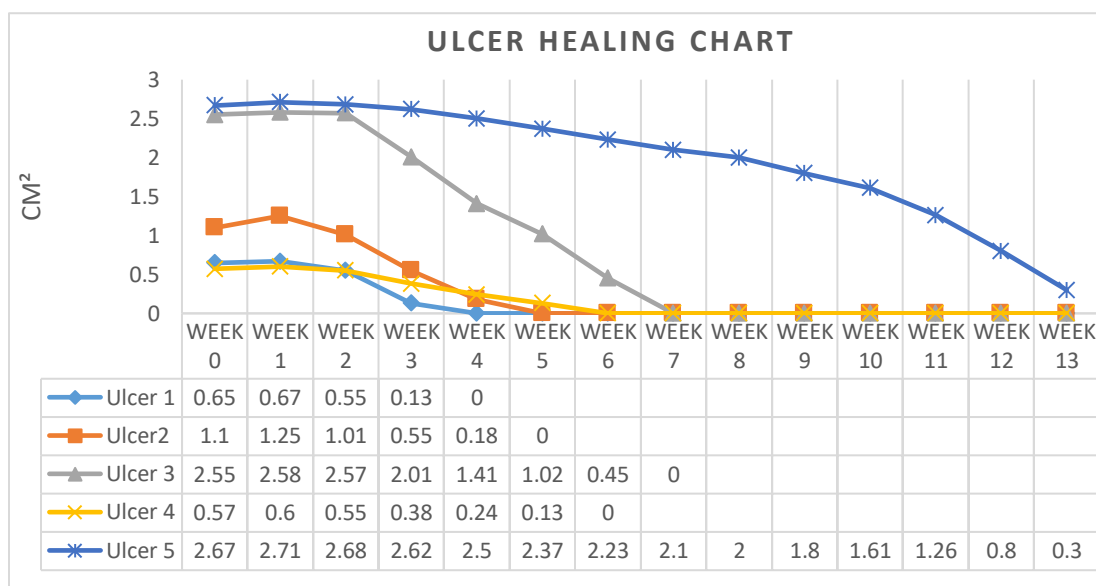


Fig. 1: ulcer healing chart

Discussion

Evidences from this study showed that the duration of treatment for a patient's ulcer using aloe Vera gel after treatment with infrared radiation decreased compared to the routine method for the treatment of ulcers. This type of treatment has been a combination of two distinct, almost new methods that have been used over the last decade to treat diabetic ulcers alone or in combination with other drugs in order to induce repair in diabetic ulcers and other ulcers. For the first time, a large clinical trial study was conducted at the Dezfoul Medical Diabetic Foot Ulcer Treatment Center, approved by the Research Council and Ethics Committee; this case report has been one of the fascinating examples of this type of trial. In addition to the effects of infrared radiation on diabetic foot ulcers, the study of Hakim et al (2016) ($p < 0.05$), Mahmoudi in 2004 ($p = 0.08$) and Gerald Petrofsky (2007) also showed similar results ($p = 0.05$). Cliff in 2005 also reported in a double-blind study that infrared radiation could have a significant effect on improving the sensation of patients with diabetic neuropathy. Some other studies have also described the effect of infrared radiation on sensory restoration (DeLellis, Carnegie & Burke, 2005; Harkless et al., 2006; Powell, Carnegie & Burke, 2004).

In addition, Mak (2012) also reported that infrared radiation could increase microcirculation and could be considered as a reason for the improvement in repair of diabetic ulcers. However, there was no significant difference in the effect of infrared radiation on the repair of diabetic foot ulcer in the study of Korzendorfer in 2008. The most natural radiations from human viewpoint have been infrared rays, which have been permanently released and absorbed by humans. Therapeutically, short

wavelengths of infrared were used. Consequently, when infrared radiation was absorbed, in addition to producing heat, the visible part of the red light induced some chemical changes along with heat. Physiological changes caused by infrared radiation included: 1- Increase in metabolic rate 2- Reduced viscosity 3- Increased collagen fibrousness 4- Sensory nerve stimulation 5. Consequential vascular changes (Robertson et al., 2006; Low & Reed, 2000). Some other references have also suggested that the use of infrared radiation has been very effective in ulcer healing, and it has been believed to accelerate repair, and reduce the risk of common bacterial infections of ulcers (Tavakoli et al., 2004; Robertson et al., 2006; Wadsworth & Chanmugam, 1983).

The effect of infrared radiation on ulcer healing included the reduction of inflammation; in other words, modulating the inflammation and accelerating the healing stage of the ulcer. On the other hand, it increased the blood supply and oxygenation to the site of the ulcer through vasodilatation, which affected the capacity of fibroblasts, increased the synthesis of collagen fibers and the resistance of the ulcer due to the increased collagen content (Tavakoli et al., 2004; Griffin et al., 1991). In some studies, the effect of infrared radiation on collagen fibers showed that this variable was significantly higher on the 10th day after the injury. This finding has been one of the most significant findings of the research on infrared radiation. Collagen fibers caused the ulcer location to return to its original state before the appearance of ulcer and prevented the formation of a white and ugly scar (Tavakoli et al., 2004; Hyland & Kirkland, 1980). In addition to the effect of aloe Vera gel on the repair of diabetic foot ulcers, many studies have shown that the aloe Vera concentrated and cleared the various gel containing vitamins, glucosamine polysaccharides, carboxy peptidase, and glucose had

anti-oxidant, anti-inflammatory, antifungal and antimicrobial properties that accelerated ulcer healing (Choi et al., 2001; Visuthikosol et al., 1995; Hamman, 2008; Moghbel, Ghalambor & Allipanah, 2007; Olaleye & Bello-Michael, 2005; Abraham et al., 2012; Hamid & Soliman, 2015; Hashemi, Madani & Abediankenari, 2015; Avijgan et al., 2016; Panahi et al., 2015 Garcia-Orue et al., 2017; Athavale et al., 2017; Hekmatpou et al., 2018) and prevented skin ulceration (Maenthaisong et al., 2007; Shahzad et al., 2009).

In this regard, Najafian et al. 2018, in a study to investigate the effect of aloe Vera gel on chronic ulcer repair, stated that this gel could efficaciously influence the repair of chronic ulcers and accelerate the growth of ulcer healing cells (Najafian et al., 2018). In addition, Hashemi et al in 2015 also stated in a review study that aloe Vera could induce a positive ulcer healing process (Hashemi, Madani & Abediankenari, 2015).

Avijgan in 2016 suggested that aloe Vera gel would enhance the treatment process of old and chronic ulcers (Avijgan et al., 2016).

Therefore, considering the effects of infrared radiation and aloe Vera gel on healing the ulcers, the combination of these two treatment methods could have a positive and profound effect on the healing of diabetic ulcers.

Conclusion

The findings of this study showed that the use of aloe Vera gel after the use of infrared radiation in the treatment of diabetic foot ulcers could have a positive effect on the repair process of diabetic foot ulcers. Consequently, it has been recommended that a larger clinical trial to be conducted on this treatment method, which is a completely non-chemical treatment technique, low-cost and usable at home. In addition to examining the efficacy and reliability of this type of treatment method, a clinical trial on the use of aloe Vera or radiation alone should be carried out.

Study limitations

The lack of clarity of the contribution of each of the independent variables (aloe Vera gel, infrared radiation) to ulcer healing was the most important limitation of this study.

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Author Contributions:

For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The

following statements should be used “HA, ASM and MM. conceived and designed the experiments; HA, HK, MM. KF and NA performed the experiments; HA, MK and OZ. analyzed the data; HA, HK, MM. KF and NA contributed reagents/materials/analysis tools; LK, HA, MM wrote the paper.” Authorship must be limited to those who have contributed substantially to the work reported.

Conflicts of Interest:

The authors declare no conflict of interest.

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