Utilization of laser therapy in dermal ulceration secondary to diabetes mellitus: A case profile

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Article points

1. Laser therapy, a Health Canada approved therapeutic technology, has been used for wound care in Canada for more than 10 years.
2. Laser therapy has been shown to improve microcirculation and expedite wound healing in patients with diabetic ulcers.
3. The authors report a case of a diabetic patient with a non-healing ulcer of the lower extremity that was successfully treated with laser therapy and exhibited rapid healing.
4. The authors present an approach for treating diabetic ulcers of the limbs utilizing laser therapy.

Key words

- Leg ulcer
- Low intensity laser therapy
- Phototherapy
- Therapeutic technology

Authors

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Laser therapy is a non-invasive technology that is available to clinicians involved in the management of diabetic ulcers. In the case described, the utilization of laser therapy to successfully treat a non-healing ulcer of the lower extremity is profiled. Prior to initiating laser therapy, this particular lesion had continued to increase in dimension. Laser therapy applied over a course of three weeks arrested wound progression, stimulated granulation tissue formation in the wound bed and re-epithelisation of the ulcer. Laser therapy can be a useful adjunct to best practice treatment for wounds that fail to progress.

The exploration of low intensity laser therapy as an effective therapeutic option for wound healing dates back over 40 years to Andre Mester, a Hungarian physician who first studied the biostimulatory effects of low-powered lasers (Mester et al, 1971). Since then, laser therapy has been extensively researched for its physiological effects in tissue structures. The therapeutic technology utilizes wavelengths in the red to infrared range (600–900 nm) with non-thermal power outputs of 5–500 mW. Both superluminous/light-emitting diodes (SLDs) and laser diodes have been used in pre-clinical and clinical studies (Chaves et al, 2014). Laser therapy is a non-invasive, pain-free therapy that is well tolerated by patients (Avci et al, 2013; Tuby et al, 2013).

In the case illustrated, the authors report the utilization of laser therapy in a non-healing diabetic ulcer of the lower extremity. The patient was an elderly man who presented with an ulcer that had continued to enlarge over a period of 4 months, despite intensive conventional wound care. The patient was increasingly apprehensive with this non-healing lesion and was concerned about the possibility of amputation of the extremity, which had been recommended to him.

Case report

Patient history

In October 2013, Mr F, an 88-year-old man, presented at the Meditech Wound Care Clinic in Toronto, Canada. After 4 months of conventional wound care, his lower extremity ulceration had continued to enlarge.

Mr. F had insulin-dependent type 2 diabetes and additionally was on several medications, including analgesics, metformin 500 mg and gliclazide 30 mg daily, and rantidine HCl 150 mg administered twice daily for stomach ulcer prevention. Solifenacin succinate 5 mg and tamulosin HCl 0.4 mg were being used to modulate urination. Mr F had undergone open heart surgery 10 years previously and was still taking a number of medications (tolterodine L-tartrate 4 mg, losartan potassium 25 mg, bisoprolol fumarate 5 mg, and acetylsalicyclic acid 325 mg daily).

Mr F reported severe pain in the lower extremity, which he attributed to the ulceration that had begun to develop 4 months prior to his visit to the Meditech clinic. He had received conventional best practice treatment via daily dressing changes provided by a nurse practitioner and surgical debridement periodically by a physician. Nevertheless the wound continued to increase in size over time. The lack of progress in wound healing and associated pain with the wound led Mr F to seek alternative options. His online search for wound care clinics in Toronto led him to the Meditech Laser Wound Care Clinic.

Physical examination

Marked edema and pigmentation of the distal portion of the tibia was present. An ulcer 4.3 cm in diameter and an area of 58.106 cm^2 was visible over the medial aspect of the lower tibia. Multiple deep erosions of the wound bed to a depth of 5–7 mm were predominant. There was extensive inflammation and deep pigmentation of the area beyond the wound, some purulent discharge from the central area and no evidence of epithelialisation at the margins. Peripheral arterial pulses were absent and only the femoral pulse was palpable. The patient did not have a fever but was monitored for possible infection over the next few visits.

Figure 1. Ulcer on medial aspect of Mr F's lower tibia immediately prior to the commencement of laser therapy. The area of the ulcer was 58.106 cm^2.

Diagnosis

Mr F was diagnosed with an ulcer of the lower left extremity secondary to atherosclerosis and diabetes.

Initiation of laser therapy

Following discussions with regard to compliance with the treatment program, a course of laser therapy was initiated.

The treatment regime was developed at the Meditech Laser Wound Care clinic based on a literature review of laser light parameters for wound healing along with clinical experience with the technology. The treatment consisted of a four step approach, including application of the red and infrared SLD arrays, followed by the red and infrared laser probes (BioFlex Laser Therapy System, Toronto, Canada).

1. Red light (660 nm) using a flexible GaAlAs 180 diode array of SLDs (750 mW), 6 minutes.
2. Infrared light (840 nm) using a flexible GaAlAs 180 diode array of SLDs (1500 mW), pulsed at 50Hz with a 70% duty cycle, 6 minutes.
3. Red laser probe (660 nm) using a single AlGaInP laser source focused on the basic pathology (75 mW), 6 minutes.
4. Infrared laser probe (830 nm) using a single GaAlAs laser source focused on the basic pathology (75 mW), 6 minutes.

The arrays and probes are applied in sequence directly over the wound which is covered by a sterile plastic film. Except for the protective plastic film, the contact is directly applied to the wound surface. The laser probes are applied for 5 seconds per point over the entire wound surface.

The treatment program also includes the following measures:

1. Dressings are removed for the duration of the laser therapy treatment.
2. There are gradual reductions in analgesic medications over the course of treatment as needed by the patient.
3. Elevation of the limb is maintained as much as possible, particularly if edema was present
4. Direct contact with all objects was avoided.
5. Debridement is accomplished with a 5% hydrogen peroxide solution for 1–2 minutes at each visit until devitalized tissue no longer exists.
6. Patients are instructed on the application of saline compresses using soaked cotton pads and recommended to apply daily for 20–45 minutes per day. If the patient cannot change the dressing, a caregiver, attending nurse or family member is instructed in the application of the compress.
7. Laser therapy treatments are administered daily in the first five days of treatment, 3 times per week for the next 2–4 weeks, then reduced depending on the clinical response.

After seven treatments over 12 days (*Figure 2*) following the initiation of treatment, Mr F had reduced edema on the left foot and distal half of the tibia. The surface area of the ulcer was reduced to 18.285 cm^2 and re-epithelialisation was noted at the margins of the lesion. Upon physical examination, there appeared to be a reduction in inflammation as palpation along the outer diameter of the wound

Page points

1. At the time of presentation at our clinic, on 4 October 2013, Mr F's ulcer of 4 months duration, had not responded to conventional wound care and continued to increase in size.
2. A course of laser therapy was recommended and the first treatment was applied that day.
3. Complete healing had occurred by 25 October 2013. All symptoms had disappeared and the patient was discharged.

Figure 2. Mr. F's ulcer following seven laser therapy treatments over 12 days. There appeared to be a reduction in edema and re-epithelialisation at the margins of the lesion upon physical examination. Dimension of the ulcer was reduced to 18.286cm^2.

edge was not deemed painful. Peripheral arterial pulse was now palpable in addition to the femoral pulse. The patient reported that the pain in his foot had disappeared completely and total mobility was restored. He also reported that he was sleeping better since initiating treatment.

The foot showed complete re-epithelialisation after 11 treatments over 21 days following the initiation of treatment. No inflammation, pigmentation or edema was observed at this point. No symptom recurrence has been reported in the 9 months post-treatment.

Discussion

It has been demonstrated that red and infrared light (600–900 nm) can increase cellular metabolism and adenosine triphosphate (ATP) production through absorption by cytochrome C oxidase, a key component of the electron transport chain in *in vitro* studies (Tafur and Mills, 2008).

Laser therapy has been shown to accelerate the inflammatory process and facilitate faster healing, with an increase in fibroblast activity and promotion of collagen synthesis in experimental cutaneous wounds (Medrado et al, 2003; de Araújo et al, 2007).

De Araújo et al (2007) confirmed that laser therapy can increase the thickness of the epithelial cell layer formation in the treatment of wounds. Laser therapy has also been demonstrated to increase angiogenesis in a model of ischemic skin flap in rats (Cury et al, 2013).

Collectively, the biological implications of laser therapy are well aligned to resolve the pathology of the diabetic ulcer.

While there are no detrimental effects to using laser therapy, we recommend the following precautions:

1. Do not shine laser in eyes.
2. Do not treat directly over a pregnant uterus.
3. Do not treat directly over a malignant carcinoma.
4. Do not treat if patient is taking photosensitizing drugs.

This Health Canada approved technology does not have any additional contraindications.

Laser therapy for diabetic ulcers

The applications of laser therapy for diabetic ulcers have been explored in a number of clinical trials.

Kajagar et al (2012) showed that diabetic ulcers were significantly reduced in size following 15 consecutive days of laser therapy treatments, as compared to a control group (40.24% vs 11.87%, $P<0.001$). Kaviani et al (2011) showed that laser therapy could accelerate the healing process of diabetic ulcers when compared to a sham control

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"Collectively, the biological implications of laser therapy treatment are well aligned to the pathology of the diabetic ulcer."

group. Minatel et al (2009) demonstrated that chronic diabetic leg ulcers responded significantly better to laser therapy as compared to a sham control group with 56% more granulation and 79.2% faster healing by day 30 of treatment.

Furthermore, in over 1500 studies done on laser therapy, there has been no evidence of significant short or long-term negative effects from laser therapy. Therefore, laser therapy has been classified as a safe and non-toxic modality (Pontinen, 1992; Baxter, 1994; Avci et al, 2013; Tuby et al, 2013).

The Canadian Association of Wound Care estimates the cost of treating a chronic wound at $10 376. This includes the cost of dressings, medications and hospital or community care visits. At the Meditech Laser Wound Care Clinic, the cost of treatment ranges from $50–$100 per visit, depending on the extent of the wound and the time needed to treat the area. Chronic wounds can take from 10 to 40 treatments over 1 to 10 months for complete closure, resulting in an estimated cost of $500 to $4000, a saving of 60–95%.

Conclusion

Neuropathy, ischemia, poor vision, limited joint mobility and accidental trauma frequently accompany diabetes and render individuals vulnerable to ulcer development. Abnormal wound healing processes exacerbate the signs and symptoms of diabetic ulceration often producing a non-healing wound that may necessitate amputation. If used appropriately, laser therapy offers a safe and effective adjunct therapy for non-healing diabetic ulcers.

In the case described, 11 treatments over a 3-week period induced clinically significant improvement in wound size, epithelialisation and pain control. The utilization of laser therapy generated significant improvement in the healing of the wound and in the patient's quality of life.

The benefits of laser therapy suggest that its use earlier in the treatment of chronic diabetic leg ulcers could expedite the wound healing process in these compromised patients.

While there is a growing body of preclinical and clinical research to support the use of laser therapy for chronic wounds, there is a need for larger clinical trials to confirm efficacy and establish optimal parameters for wavelength, dose and frequency of treatment. ■

Figure 3. Mr. F's ulcer after 11 treatments over 21 days. Note the complete re-epithelialisation of the ulcer.

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