# The use of polarised polychromatic non-coherent light alone as a therapy for venous leg ulceration


• **Objective:** This study assessed the effectiveness of polarised, polychromatic, non-coherent light therapy in the treatment of venous leg ulcers. Investigators in previous studies have advocated the use of light as an adjunct to other proven therapies or on its own.

• **Method:** This was a pilot prospective case-series study. We enrolled 25 patients with venous leg ulcers. All were treated with light only. Phototherapy (light therapy) treatments were given once a day over four weeks.

• **Results:** All ulcers except one (99%) had a positive value for the change in healing area at the end of the four weeks. The total number of 73 leg ulcers recorded at the beginning of the study was reduced to 51 at the end of the four weeks ($p<0.01$). The decrease in wound surface area following the treatment was statistically significant (mean: 57.15%; SD: 31.87%; $p<0.01$).

• **Conclusion:** Polarised, polychromatic light therapy applied as a monotherapy was associated with positive healing rates in patients with venous leg ulcers. It is a simple and non-invasive treatment. However, a well-designed randomised controlled study is needed to confirm the efficacy of this form of phototherapy and to objectively evaluate recommendations for its routine use in clinical practice.



• **Declaration of interest:** This research was supported by Bioptron AG, Switzerland, which supplied the Bioptron 2 light therapy system used.

venous leg ulcers; light therapy; visible light; infra-red light


Most leg ulcers are venous, making up 54–81% of all lower-extremity ulcerations.[1-3] Overall incidence of venous leg ulcers ranges from 0.06% to 2.2%,[4,5] with a tendency to increase as the population ages.[6] About 1–4% of patients aged 70 have a venous leg ulcer.[7]

Healing can take years, and recurrence is a serious problem.[8,9] Many patients experience pain and some have problems with sleep and mobility.[10,11] Venous ulcers impair quality of life,[12,13] with not only economic but also social and psychological costs.[14,15]

Many studies in the past 20 years have investigated the effect of light therapy on wound healing. The results have been equivocal, particularly in relation to low-power laser light.[16,17] The role of light therapy as a stand-alone treatment or as an adjunct to other proven therapies remains unclear.

This pilot study aimed to assess the effects of polarised, polychromatic, non-coherent, low-energy light (Bioptron 2, Bioptron AG, Switzerland) on wound healing in patients with venous leg ulcers. The manufacturer's explanation of how Bioptron works is given in Table 1.

## Method

The research ethical committee at the Clinical Centre, Belgrade, Yugoslavia, approved this study. Twenty-five patients were enrolled and all gave informed consent. To increase compliance, all were hospitalised at the Institute of Dermatovenereology, Clinical Centre, University of Belgrade. All patients received the same care and lifestyle regimen in order to reduce potential bias. The inclusion and exclusion criteria used in the recruitment stage are given in Table 2.

### Light source

The equipment used was a non-invasive optical device, with patented technology based on the biostimulative effects of polarised, non-coherent light in the visible and infrared spectrum. Physical parameters of the output of this light unit were:

- Wavelength: 480–3400nm
- Spot size: 254cm$^2$
- Average power density: 40 milliwatts/cm$^2$, applied at a distance of 10cm from the skin surface.

At each treatment session a patient received a energy density (dose) of 19.2 jules/cm$^2$.

### Intervention

All 25 patients were treated with light only. Treatments were given once daily for eight minutes for four weeks, making a total of 28 sessions.

No other therapies that could enhance ulcer healing were permitted. No control group was used as it would have been difficult to distinguish the benefit of the light therapy from that of compression


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**Table 1. Manufacturer's explanation of how Bioptron's light works**

| | |
|---|---|
| **Polarised** | Its waves move on parallel planes. In this device polarisation reaches a degree of approximately 95% |
| **Polychromy** | Polychromatic light contains not just one wavelength (like laser light), but a wide range, including visible light and a part of the infrared range. The wavelength of this device's light ranges from 480nm to 3400nm. This electromagnetic spectrum does not contain ultraviolet radiation |
| **Incoherency** | In contrast to laser light, this device's light is incoherent or out-of-phase light. This means the lightwaves are not synchronised |
| **Low energy** | This device's light has a low-energy density (fluence), which has biostimulative effects. This means the light can stimulate various biological processes in the body in a positive way |

Source: www.bioptron.com/characteristics/index.php

daily rinsing of ulcers with saline, followed by a simple sterile dry dressing.

Compression therapy is considered the treatment of choice for leg ulcers throughout most of Yugoslavia, although in many centres it is not used because of its high cost.

### Wound assessment

Wounds were assessed by two independent observers before the light therapy was first given and then every week for four weeks. The wound surface area (ulcer size) was measured using computerised planimetry (Planix 7 Digital Planimeter, Tamaya Techniques, USA) which was performed on

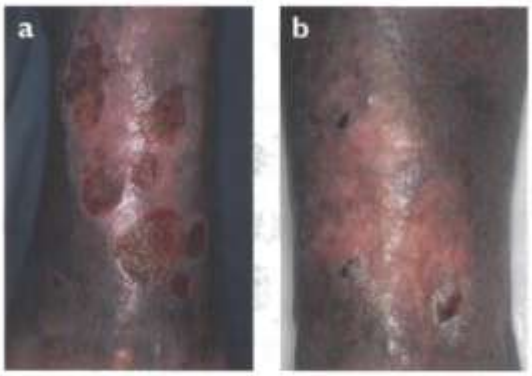


**Fig 1. Patient 6: (a) Venous leg ulcer (wound surface: 20.95cm²) before treatment; b) Significant decrease in the wound surface area (14.52cm²) after four weeks of light therapy**

tracings of the patients' leg ulcers. All measurements were made three times and a mean value of ulcer size was calculated.

Photographs were taken during each assessment to provide an additional record. A qualitative description of the wound was recorded on a standardised assessment sheet.

Healing was related to the initial ulcer size. The ulcer was defined as healed when the epidermis was intact and the skin no longer produced exudate.

### Histologic evaluation

As this was a pilot study, we wanted to evaluate changes on a cellular level and the most appropriate analysis for this was immunohistochemistry. Skin biopsy specimens were obtained from the wound bed before the first treatment session and then after three weeks of light therapy in all 11 patients from whom this was requested. Due to ethical considerations, patients whose wounds had completely epithelialised or who had a small wound surface were not approached for this.

Sections from formalin-fixed paraffin-embedded tissue blocks were resected and then stained with haematoxylin-eosin. The wound tissue was evaluated for Masson's trichrome, factor VIII-related antigen and alpha-smooth muscle actin (α-SMA) using immunohistochemistry. The main para-

**Table 2. Inclusion and exclusion criteria**

| Inclusion | Exclusion |
|---|---|
| Age over 40 years | Ulcers of infectious, pressure or postoperative origin |
| Either sex | Patients with uncontrolled diabetes and diabetic sensory neuropathy, cellulitis, vasculitis or collagen vascular disease and any concomitant illnesses |
| One or more venous ulcers larger than 1cm² in area | Patients taking any medication that may affect wound healing, including corticosteroids and chemotherapy |
| No evidence of arterial disease of the legs (ankle brachial pressure index >0.8)[41] | Active or suspected carcinoma |
| Patient not currently receiving any other form of treatment or dressing for the ulcer | |
| Ability to give written consent | |

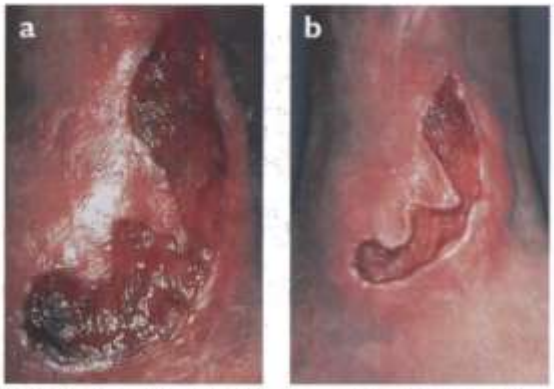


**Fig 2. Patient 10: a) Multiple venous leg ulcers (total wound area: 35.59cm²) before treatment; b) Evident wound epithelialisation (total wound area: 5.1cm²) after three weeks of light therapy**

meters for comparing the wound-healing process at the cellular level were:

- Epithelialisation
- Cellular content
- Granulation tissue
- Collagen deposition
- Neovascularisation.

An independent pathologist who was unaware of the study design examined the specimens.

No adverse effects in the healing process were observed in the 11 patients following the biopsies.

### Statistics

Data were analysed using Excel and STATA (Stata Corporation, College Station, Texas, USA). Statistical significance between means was calculated using the Student's paired t-test.

## Results

### Clinical findings

A total of 25 patients — 21 men (84%) and four women (16%) — were enrolled into the study. Their mean age was 61.9 years (range: 46–84). The total number of leg ulcers recorded at the start of the study was 73. The mean initial ulcer size was 26.45 cm² (SD: 24.6; range: 1.45–94.66cm²). All patients completed the study.

All ulcers except one (99%) had a positive value for the change in healing area at the end of the four weeks; 22 ulcers (30%) healed completely. Mean ulcer size after four weeks of treatment reduced to 12.79cm² (SD: 18.2; range: 0–84.5cm², t=4.09, p<0.01), which was statistically significant. The decrease of the wound surface area after the treatment period was statistically significant (mean: 57.15%; SD: 31.87%).

The total number of ulcers remaining after four weeks was 51 (t=3.77, p<0.01).

Mean overall healing rate was 3.53cm²/week (SD: 4.1; range: 0.052–19.34). No adverse side-effects were observed, as is evident from two randomly selected patients (Figs 1 and 2). Results for all patients are given in Table 3.

**Table 3. Leg ulcer healing rates among the study patients**

| Patient no. | No. of ulcers | Reduction in ulcer size after 4 weeks (%) | Healing rate (week/cm²) |
|---|---|---|---|
| 1 | 4 | 84.4 | 7.41 |
| 2 | 1 | 57.9 | 0.53 |
| 3 | 6 | 71.7 | 19.34 |
| 4 | 6 | 81.2 | 3.51 |
| 5 | 2 | 100 | 1.09 |
| 6 | 6 | 42.2 | 4.89 |
| 7 | 4 | 15.1 | 0.88 |
| 8 | 3 | 20.6 | 0.89 |
| 9 | 2 | 1.7 (+)* | -0.05* |
| 10 | 7 | 86.3 | 9.51 |
| 11 | 2 | 20.2 | 1.94 |
| 12 | 2 | 14.9 | 1.14 |
| 13 | 2 | 75.6 | 2.99 |
| 14 | 1 | 25.8 | 0.25 |
| 15 | 1 | 51.9 | 0.97 |
| 16 | 2 | 32.8 | 4.25 |
| 17 | 2 | 6.9 | 1.55 |
| 18 | 1 | 95.8 | 8.39 |
| 19 | 2 | 91.7 | 0.33 |
| 20 | 1 | 52.3 | 2.83 |
| 21 | 1 | 79.0 | 2.01 |
| 22 | 4 | 82.8 | 3.82 |
| 23 | 5 | 91.5 | 3.42 |
| 24 | 3 | 65.1 | 2.69 |
| 25 | 3 | 60.4 | 0.77 |

*Patient has an increase in ulcer size and a negative healing rate

### Histological findings

Standard histologic study (haematoxylin-eosin staining) of all 11 biopsy specimens taken before the light therapy showed complete epidermal and dermal necrosis, with pronounced inflammatory infiltrate and poor granulation.

All 11 tissue specimens showed significant histologic changes after three weeks of treatment. Re-epithelialisation, and proliferation of the granulation tissue containing new blood vessels and moderate to extensive new collagen deposition were noted.


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Results of the immunohistochemical analysis of all the tissue specimens taken three weeks after the treatment began were qualitatively impressive. Sections stained by Masson's trichrome showed significant proliferation of fibrotic tissue. All of these sections were immunohistochemically positive for factor VIII, demonstrating extensive neo-angiogenesis and increased vascular density. All sections also contained α-SMA positive myofibroblasts that resembled pericytes.

## Discussion

Following the use of Bioptron light therapy, there was a significant decrease in wound surface area (an average of 57.16%), as evidenced by the percentage of wound closure and histological evaluation. This source of light therapy, applied as a monotherapy for wound healing, was associated with the start of complete wound closure.

Light therapy has been widely used to treat wounds of diverse aetiologies since Mester et al. reported that low-power laser treatment had a stimulatory effect on wound healing.[18,19] Like laser therapy, Bioptron is also a low-power light sources, but differs from it in that it is polychromatic (has a wide range of brandwith) rather than monochromatic.

Some *in vivo* and *in vitro* studies have demonstrated that light therapy treatments with different optical sources of low-energy photons improved wound healing.[20-26] Others, however, were unable to show that low-power laser light therapy promoted wound healing.[27-29]

These inconsistent results suggest controversy still surrounds the effectiveness of low-power laser therapy on wound healing. The main reasons for these conflicting results are significant methodological biases in the studies and the use of optical devices with different physical characteristics.

A systematic review of four randomised controlled trials[30-33] into the effectiveness of low-power laser therapy in the treatment of venous leg ulcers showed no benefit *per se*.[34] One of the trials evaluated[32] in the review suggested that combining helium neon laser and infrared light may promote healing. Further research is required. Moreover, the trials analysed contained significant biases and pooling that may have been inappropriate, leading to the unreliable conclusions. Therefore, there is no clear evidence that low-power laser therapy benefits wound healing.

Bioptron combines visible light at a wavelength of 480–700nm and infrared light at a wavelength of 700–3400nm. Our hypothesis of why this is better than laser light is presented below.

The mechanism of action of polarised, polychromatic light is unknown. A variety of mechanisms are responsible for the photobiostimulating effects of both parts of the electromagnetic spectrum present in the polychromatic light source used in our study: visible and infrared. These lead to the same final photoresponse, but start the cascade of metabolic events at different cellular levels.

One proposed mechanism of action of photobiostimulation is the absorption of visible light energy by the mitochondria.[35] This may cause a chain of molecular events, leading to an increase in cell energy and activation of nucleic acid synthesis, which is essential for wound repair.

The second mechanism is obtained by the infrared portion of the light spectrum. This initiates the response at the membrane level, probably through photophysical effects on $Ca^{++}$ channels.[36]

Low-power laser light therapy has been shown to stimulate release of growth factors from irradiated cells. Growth factors stimulate angiogenesis, extracellular matrix production and degradation, and cytokine release.[37-39] The key cells in skin ulcer contraction and collagen synthesis are fibroblasts and keratinocytes. Several studies have demonstrated their activation and proliferation in response to low-energy laser/photon stimulation.[40,41]

Another mechanism that might be responsible for the light therapy's therapeutic effect is the local peripheral vasodilation, which may enhance skin blood flow and the delivery of oxygen to the ulcer area, facilitating the transport of nutrients needed for ulcer healing.

## Conclusion

This study shows that polychromatic polarised light therapy, applied as a monotherapy, enhanced wound healing in patients with venous leg ulcers and is a simple and non-invasive treatment. However, a well-designed randomised controlled study conducted by a multidisciplinary team is necessary to confirm the efficacy of this form of phototherapy in patients with venous leg ulcers and to objectively evaluate recommendations for its routine use in clinical practice. Preparation for such a randomised controlled trial is now in progress. ■

### Box 1. Summary of the main findings

Twenty-five patients with 73 venous leg ulcers between them were recruited into this study, which tested the effect of polarised, polychromatic, non-coherent light on healing over four weeks

Previous studies into light therapy have had mixed results, with some showing successes and others inconclusive

In this study all the ulcers except one improved after four weeks of treatment. The total number of 73 leg ulcers at the start of the study was reduced to 51, and in the other ulcers a statistically significant average decrease of wound surface area occurred (mean: 57.15%; SD: 31.87%; $p<0.01$)

A randomised controlled study is now being conducted. This is required before this non-invasive treatment can be introduced into clinical practice


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