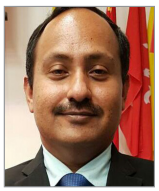
The use of photo biomodulation as an adjunct therapy to aid wound healing: a case series

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The alarming increase in the rate of chronic wounds has tremendous implications, at an individual level on the person's psycho-social wellbeing and on a much larger scale on the nation's healthcare economy (Dreifke et al, 2015). Chronic/hard-to-heal wounds develop when the phases of wound healing cease to advance in an orderly manner, thus resulting in delay in or failure of healing (Leyane et al, 2021). This case series is aims to demonstrate the beneficial effects of photo biomodulation as an adjunct therapy to wound management.

Key words:

- *Chronic wound*
- *Microcurrent*
- *Peripheral vascular disease*
- *Wound healing*

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Hard-to heal wounds pose a significant challenge to both patient and healthcare providers as their healing process is often prolonged with conventional treatment (Beckmann et al, 2014). The usage of light therapy is not new and goes back to the ancient Egyptians and Indians who use sunlight (heliotherapy) for curative intent and attaining good health (Mosca et al, 2019).

Photo biomodulation (PBM) formerly known as Low level laser therapy (LLLT) is a painless treatment modality of chronic wound with minimal side effects (Mosca et al, 2019; Chen et al, 2022). Photo biomodulation refers to a form of light therapy using non-ionising forms of light sources such as lasers, light emitting diodes (LEDs) and broad-band light, in the visible and infrared spectrum, involving a non-thermal process with endogenous chromophores eliciting photophysical (i.e., linear and nonlinear) and photochemical events at various biological scales (Mosca et al, 2019). The latter involves a photochemical reaction that happens after photon absorption by a chromophore in the cell. Cytochrome c oxidase (CCO) is the main chromophore which takes in red and near-infrared (NIR) light while light-gated ion channels and channel rhodopsin are chromophores stimulated by blue and green light. One of the central wound healing pathways in photo biomodulation therapy is extracellular activation of transforming growth factor beta (TGF-β), which potentiates haemostasis (platelet derived TGF-β), inflammatory cells (macrophage-derived TGF-β and extracellular matrix (latent TGF-β-binding protein-associated TGF-β sequestered in the matrix; Mosca et al, 2019). Hence, faster re-epithelisation and reformed connective tissue, lower inflammatory process and increased proliferation of myofibroblasts were observed in wounds treated with LLLT (Mosca et al, 2019).

Objective

To assess effectiveness of photo biomodulation as adjunct to wound healing.

Methods

Patients attending wound care clinic Hospital Kuala Lumpur were randomly selected during routine day care wound dressing from June to December 2022 (*Table 1*). The wounds were of varying aetiologies.

Before laser application, the wounds were cleaned and a primary dressing of either hydrogel, honey or silver alginate dressing were applied in accordance with the clinic's usual standard of care. The wound dressings were changed at least twice a week while large wounds were dressed three times a week. Compression dressings were applied on several VLU patients. However, adherence was a major issue owing to discomfort. Offloading was applied to less than 50% patients as these patients had to apply for financial support to purchase offloading shoes. After wound dressing, laser therapy (K-CUBE 4 PLUS, VBS Medical Ltd) with four different wavelengths, 660, 800, 907 and 970nm at 30kJ, was applied via a handpiece held above the wound area

Figure 1. **K-Laser cube 4**

Figure 2. K-Laser therapy being applied to patient's foot. The device is held like a pencil a few cm above skin and waved in a scanning motion following a structured pattern. An audible bip signals a phase change and wavelength within phase in nanoseconds, and this should be continued until the laser stops. For example, if each phase is pre-determined as 12 seconds, the operator should cover the whole wound in 12 seconds or less (picture courtesy of K-Laser, Australia)

for approximately three minutes The former was applied on each clinic visit (either every other day or twice a week) for three months. The wound size of each patient was measured at the beginning and end of the study.

Permission to use clinical images and case details for publication of this study were gained before the study.

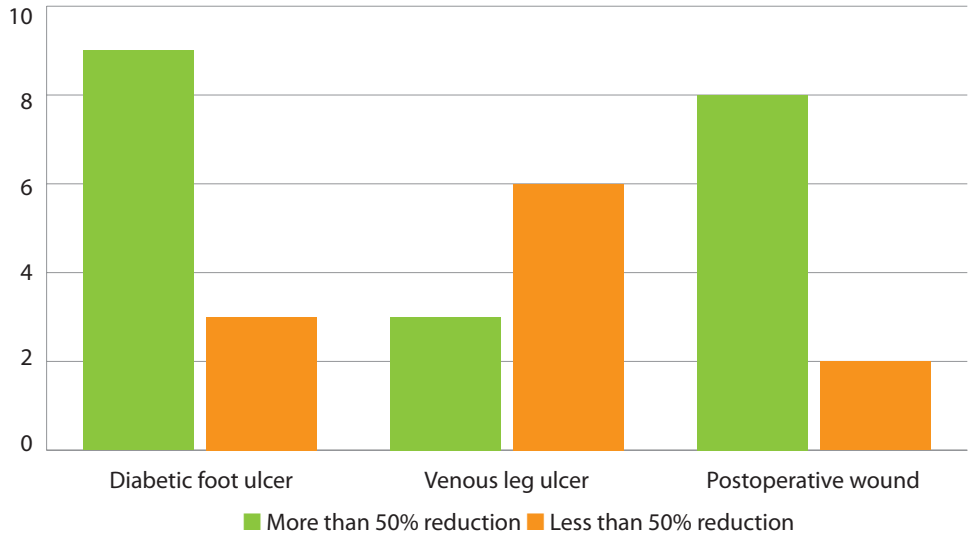
Results

A total of 30 patients attending wound care clinic Hospital Kuala Lumpur were randomly selected during routine day care wound dressing from June to December 2022 (*Table 1*). These wounds were of varying aetiologies, 12 were diabetic foot ulcers (DFU), nine were venous leg ulcers (VLU) and nine were postoperative wounds.

Table 1. Percentage of wound size reduction after K-Laser treatment

Patient number	Diagnosis	Initial wound size (cm^2)	Final wound size (cm^2)	Wound reduction (%)	Duration of observation
1	DFU	50	24	52	4 weeks
2	DFU from September 2022	28	0	100	6 weeks
3	DFU from 2018	1.5	0.25	83	12 weeks
4	DFU	25	9	64	6 weeks
5	VLU from May 2022	35	24	31	12 weeks
6	VLU from 2016	2.1	2	4.8	14 weeks
7	VLU from 2020	22.1	21.3	3.6	12 weeks
8	VLU from 2021	6	2	66.7	16 weeks
9	DFU from June 2022	18	0	100	16 weeks
10	Surgical wound – carbuncle	47.2	0	100	10 weeks
11	Postoperative wound – abscess	119	50	58	12 weeks
12	Postoperative wound (necrotising fascitis)	24	8	66.7	16 weeks
13	Postoperative wound (DFU)	24	0.4	98.3	16 weeks
14	Infected surgical wound (below the knee amputation in October 22)	40	10	75	4 weeks
15	VLU from 2018	51	48	6.25	4 weeks
16	Postsurgical wound since 2020	28	8	71	16 weeks
17	VLU from 2021	36	3	91.6	6 weeks
18	VLU from 2016	33	22	33.3	16 weeks
19	DFU from 2021	110	72	53.7	16 weeks
20	Surgical wound (post-below know amputation) from June 2022	76.5	0	100	10 weeks
21	DFU from 2019	60	48	20	14 weeks
22	DFU from 2021	132	80.75	38	12 weeks
23	VLU from 2020	67.5	63.75	5.5	16 weeks
24	VLU from 2020	32	0	100	12 weeks
25	Surgical wound breakdown	37.4	15	60	8 weeks
26	DFU	28	7	75	12 weeks
27	DFU	40	0	100	12 weeks
28	DFU from August 2021	18	12	33	12 weeks
29	Surgical wound (posttransmetatarsal amputation of right foot	36	16	55	10 weeks
30	DFU	28	7	75	8 weeks

Table 2. Percentage of wound reduction according to wound size



The VLUs were present for at least six months before presentation at wound clinic, the DFUs duration ranged from three months to three years, while the postoperative wounds presented as early as two weeks to wound clinic.

Table 1 shows the percentage of wound size reduction after K-Laser treatment and *Table 2* the percentage of wound reduction according to initial wound size.

Statistical analysis

Table 3 shows the initial wound size before the laser treatment has a mean value of 45.19cm^2 and a standard deviation of 33.653cm^2. Whereas, the final wound size after the laser treatment has a mean value of 20.94cm^2 and a standard deviation of 25.541cm^2.

Table 4 shows the paired samples correlations between initial wound size before laser treatment and final wound size after the laser treatment with the value of 0.733 at a *p*-value of 0.000.

Table 5 shows the paired samples T-Test. In the tests, the null hypothesis is that the average of the differences between the paired observations

Table 3. Descriptive Statistics of initial and final wound size

	n	Minimum	Maximum	Mean	Std. Deviation	Std. Error Mean
Initial wound size in – (before laser treatment)	30	2	132	45.19	33.653	6.144
Final. Wound size – (after laser treatment)	30	0	81	20.94	25.541	4.663

Table 4. Paired samples correlations

		n	Correlation	Sig.
Pair 1	Initial wound size (before - laser treatment) and final wound size (after laser treatment)	30	0.733	0.000

Table 5. Paired samples correlations

		Paired differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error mean	95% Confidence of the difference Lower	Upper			
Pair 1	Initial wound size (Before - laser treatment) & final wound size – (after laser treatment)	1.167	1.147	0.209	0.738	1.595	5.570	29	0.000

Case 1. Diabetic foot ulcer (patient 2)

- A 58-year-old Malay gentleman with underlying type 2 diabetes mellitus
- Presented with a diabetic foot ulcer over right foot, which was present for about five months
- Treatment: wound debridement in September 2022 followed standard of care with K-Laser was applied.

12 September 2022
A: 4.0cm x 7.0cm

25 November 2022
Wound healed

Case 2. Infected diabetic foot ulcer (patient 9)

- A 54-year-old Malay gentleman with underlying type 2 diabetes mellitus
- An infected diabetic foot ulcer, present for one months, which required Ray's amputation of left 2nd toe
- Treatment: standard of care, a hydrogel dressing and K-Laser was applied.

4 August 2022
A: 3.5cm x 5cm

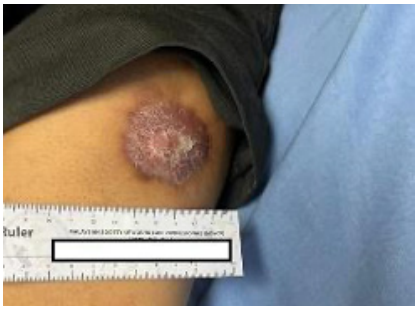
29 December 2022
Wound healed

Case 3. Right thigh carbuncle (patient 10)

- A 51-year-old Malay gentleman with underlying type 2 diabetes mellitus
- Presented, in May 2022, with a right thigh carbuncle present for the past 2–3 months, which required saucerisation
- Standard of care, a hydrogel dressing and K-Laser was applied.

4 August 2022
A: 3.5cm x 5cm

29 December 2022
Wound healed



Case 4. Infected below the knee amputation (BKA) stump (patient 20)

- A 52-year-old Indian lady, with underlying Type 2 diabetes mellitus
- Presented with infected below the knee amputation (BKA) stump with wound breakdown in July 2022
- Treatment: bedside desloughing, along with hydrogel and K-Laser was applied.

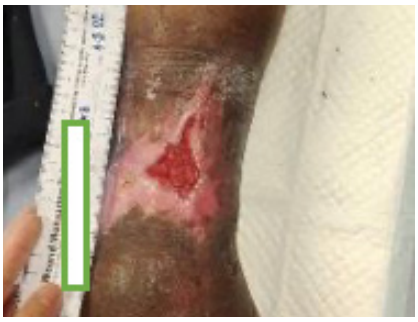
1 August 2023
A: 8.5cm x 9cm

8 October 2023
Wound healed

Case 5. Chronic venous right leg ulcer (patient 24)

- 53-year-old, Malay gentleman with underlying type 2 diabetes mellitus
- Presented with chronic venous leg ulcer of right leg, present for approximately one year with multiple visits to private GP clinic for dressing
- Treatment: hydrogel dressing and a foam secondary dressing with K-Laser applied each appointment.

4 August 2022
A:4cm x 8cm



24 November 2022
Wound healed

Case 6. Diabetic foot ulcer over the left leg (patient 27)

- A 30-year-old Malay gentleman, with underlying Type 2 diabetes mellitus and Ray's amputation of 4th and 5th toe,
- Presented with diabetic foot ulcer over the left leg, which was present for three months
- Treatment: Hydrogel dressing with barrier dressing at the periwound area, followed by K-Laser.

7 June 2022
A: 5cm x 8cm

2 December 2023
Wound healed

Case 7. Chronic wound over left plantar aspect of foot (patient 13)

- A 40-year-old Malay gentleman with underlying type 2 diabetes mellitus
- Presented with chronic wound over left plantar aspect of foot for past 7 months
- Treatment: Hydrogel dressing, changed three times a week alongside laser therapy

17th August 2022
A:6 cm x 4cm

3rd November 2022
A: 0.2cm x 2cm

Case 8. A wound over right plantar foot (patient 17)

- A 75-year-old Malay gentleman, with underlying type 2 diabetes mellitus
- Presented with a wound over right plantar foot for approximately two years
- Treatment: Hydrogel dressing, foam dressing and laser therapy
- After approximately two months the wound was 90% reduced in size.

16 August 2023
A: 6cm x 6cm

13 October 2022
A: 2.5cm x 1cm

Case 9. Infected wound over left big toe (patient 12)

- A 72-year-old Malay gentleman, with underlying type 2 diabetes mellitus
- Presented with an infected wound over left big toe present for three weeks, following which he underwent Rays amputation of left big toe.
- Treatment: Wound debridement for left foot necrotising fasciitis, in wound clinic, his wound required multiple bedside desloughing and application of honey and hydrogel dressing. K-Laser was applied after wound was cleaned.

29 August 2022
A: 6cm x 4cm

29 December 2022
A:4cm x2cm

Case 10. Chronic venous ulcer over left leg (patient 8)

- A 68-year-old Chinese gentleman with underlying hypertension
- Presented with chronic venous ulcer over left leg for over 18 months
- Treatment: Hydrofibre dressing with and K-Laser was applied.

11 August 2022
A: 1.2cm x 5cm

1 December 2022
A: 2cm x 1cm

Case 11. Diabetic foot ulcer of the left foot (patient 30)

- A 41-year-old, Malay gentlemen with underlying type 2 diabetes mellitus
- Presented with left foot diabetic foot ulcer, required Ray's amputation of 2nd, 3rd, 4th and 5th toe
- Treatment: The wound was cleaned and a hydrogel dressing was applied with laser therapy.

1 August 2022
A: 10cm x 2.8cm

4 November 2022
A: 2cm x 3.5cm

in the two samples is zero. Conversely, the alternative hypothesis assumes that the true mean difference between the paired samples is not equal to zero. If the calculated *p*-value is less than 0.05, the conclusion is that, statistically, the mean difference between the paired observations is significantly different from 0.

Discussion

From this study, 66.7% patients (20 out of 30 patients) achieved at least 50% wound healing with six patients achieving 100% wound healing. The latter consisted of three DFUs, one VLUs and two postoperative wounds.

In terms of wound aetiology, DFUs accounted for half of the 20 patients achieving at least 50% wound reduction while only 8 postoperative wounds and three VLUs showed this similar outcome. Approximately half of the VLU patients achieved at least 30% reduction in wound size with K-Laser therapy. This is similar to the latest study findings by Rajhathy et al (2022), which reports 30% as basal healing rate for wounds managed with compression bandaging and advanced dressings.

Using the paired sample T-Test, the mean difference between paired observations (before and after laser treatment programme) is significantly different from 0. The finding

from the results indicates that there is a mean difference between the two groups and the *p*-value is less than 0.05. Hence, the wound size of patients has reduced after the laser treatment.

The device used in this case series is K-Laser with Class IV laser system which emits light with wavelengths of 660, 800, 905 and 970nm. The energy delivered by this device can be tailored according to chronicity, skin shade, and depth of penetration (Nair et al, 2021).

Laser therapy accentuates wound repair in the preliminary stages of wound healing i.e. faster proliferation phase indicated by intensive fibrillogenesis and angiogenesis, as well as better regulation of intricacies of wound healing by cytokine regulation (Pavlovet al, 2020). Other beneficial effects associated with photo biomodulation include enhancing tissue renewal, controlling inflammation, reducing pain and oxidative stress. This can be explained by its ability to stimulate mitochondria, increasing adenosine triphosphate (ATP) production and the downstream release of growth factors. These growth factor bind to cell surface receptors and induce transcription of genes for increased cellular proliferation, viability, and migration in numerous cell types, including stem cells and fibroblast (Nair et al, 2021). K-Laser therapy significantly increases the formation of new capillaries, therefore increases tissue oxygenation and accelerating healing processes (Nair et al, 2021).

Limitations

One limitations of this study was that a certain degree of selection bias was present as most patients had undergone surgical debridement before wound care visit. Furthermore, venous leg ulcer patients were mostly non-concordant with wearing compression bandaging due to the discomfort, which will affect the healing rates.

Conclusion

This case series has demonstrated that usage of photo biomodulation as adjunct to wound healing resulted in significant reduction in wound size ($p<0.05$). This can be explained from its effects in enhancing proliferation, tissue renewal, controlling inflammation and oxidative stress. Hence, more high-levelled trials i.e randomised study should be conducted to incorporate K-Laser in clinical protocols of wound management (Mosca et al, 2019). WAS

Declaration of interest

The authors have no conflict of interest to declare. This was a wound care investigator initiated study.

References

Beckmann KH, Meyer-Hamme G, Schröder S (2014) Low level laser therapy for the treatment of diabetic foot ulcers: a critical survey. *Evid Based Complement Alternat Med* 2014:626127.https://doi.org/10.1155/2014/626127

Chen Q, Yang J, Yin H et al (2022) Optimization of photo-biomodulation therapy for wound healing of diabetic foot ulcers in vitro and in vivo. *Biomed Opt Express* 202213(4):2450–66. https://doi.org/10.1364/BOE.451135

Dreifke M B, Jayasuriya A A, Jayasuriya A C (2015) Current wound healing procedures and potential care. *Mater Sci Eng C Mater Biol Appl* 48: 651–62. http://dx.doi.org/10.1016/j.msec.2014.12.068

Leyane TS, Jere SW, Houreld NN (2021) Cellular signalling and photobiomodulation in chronic wound repair. *Int J Mol Sci* 22(20):11223. https://doi.org/ 10.3390/ijms222011223

Mosca, Crespo R, Ong A A et al (2019) Photobiomodulation therapy for wound care: a potent, noninvasive, photoceutical approach. *Adv Skin Wound Care* 32(4):15–67. https://doi.org/10.1097/01.asw.0000553600.97572.d2

Nair HKR, Chong SSY, Selvaraj DDJ (2022) Photobiomodulation as an adjunct therapy in wound healing. Int J Low Extrem Wounds 22(2):278–82.https://doi.org/10.1177/15347346211004186

Pavlov S B, Babenko N M, Kumetchko M V (2020) The influence of photobiomodulation therapy on chronic wound healing. *Romanion Reports in Physics* 72:(609). https://rrp.nipne.ro/2020/AN72609.pdf

Rajhathy EM, Murray HD, Roberge VA, Woo KY (2020) Healing rates of venous leg ulcers managed with compression therapy: a secondary analysis of data. *J Wound Ostomy Continence Nurs* 47(5):477–83. https://doi.org/10.1097/won.0000000000000693