



Er:YAG Laser Therapy for Diabetes-Related Foot Ulcers: A Case Series with Hyperspectral Imaging Assessment

Flores-Escobar S¹, Álvaro-Afonso FJ¹, García-Álvarez Y¹, López-Moral M¹, Sanz-Corbalán I¹, Lázaro-Martínez JL¹

¹Diabetic Foot Unit. Universidad Complutense de Madrid. Madrid, Spain

INTRODUCTION

- Diabetic foot ulcers (DFUs)** impaired wound healing, and substantial morbidity. Effective local wound care is a fundamental component of management.
- Sharp debridement is the gold standard for local wound care; however, it is not always feasible in patients with poor vascular status, uncontrolled pain, or near delicate structures.
- Er:YAG laser** is a promising adjunctive therapy for the management of DFUs due to its combined ablative and biostimulation properties.
- Hyperspectral imaging (HSI)**, based on near-infrared spectroscopy (NIRS), is a non-invasive technique that allows for an objective assessment of physiological responses during wound healing.



AIM

To explore the feasibility and preliminary clinical and microvascular responses to adjunctive Er:YAG laser therapy in DFUs using HSI.

RESULTS

CLINICAL OUTCOMES

Clinical Outcomes	Patients (N=5)	p-value
Wound area week 1, mean ± SD, (cm ²)	5.90±5.42	.061
Wound area week 8, mean ± SD, (cm ²)	4.68±6.31	
Wollina wound score week 1, median [IQR]	5 [2 – 5]	.024*
Wollina wound score week 4, median [IQR]	6 [4.5 – 7]	
Wollina wound score week 8, median [IQR]	7 [5.5 – 7]	
Wound area reduction, mean ± SD, (%)	33.06±44.9	

Table 1. Clinical outcome measures during follow-up.

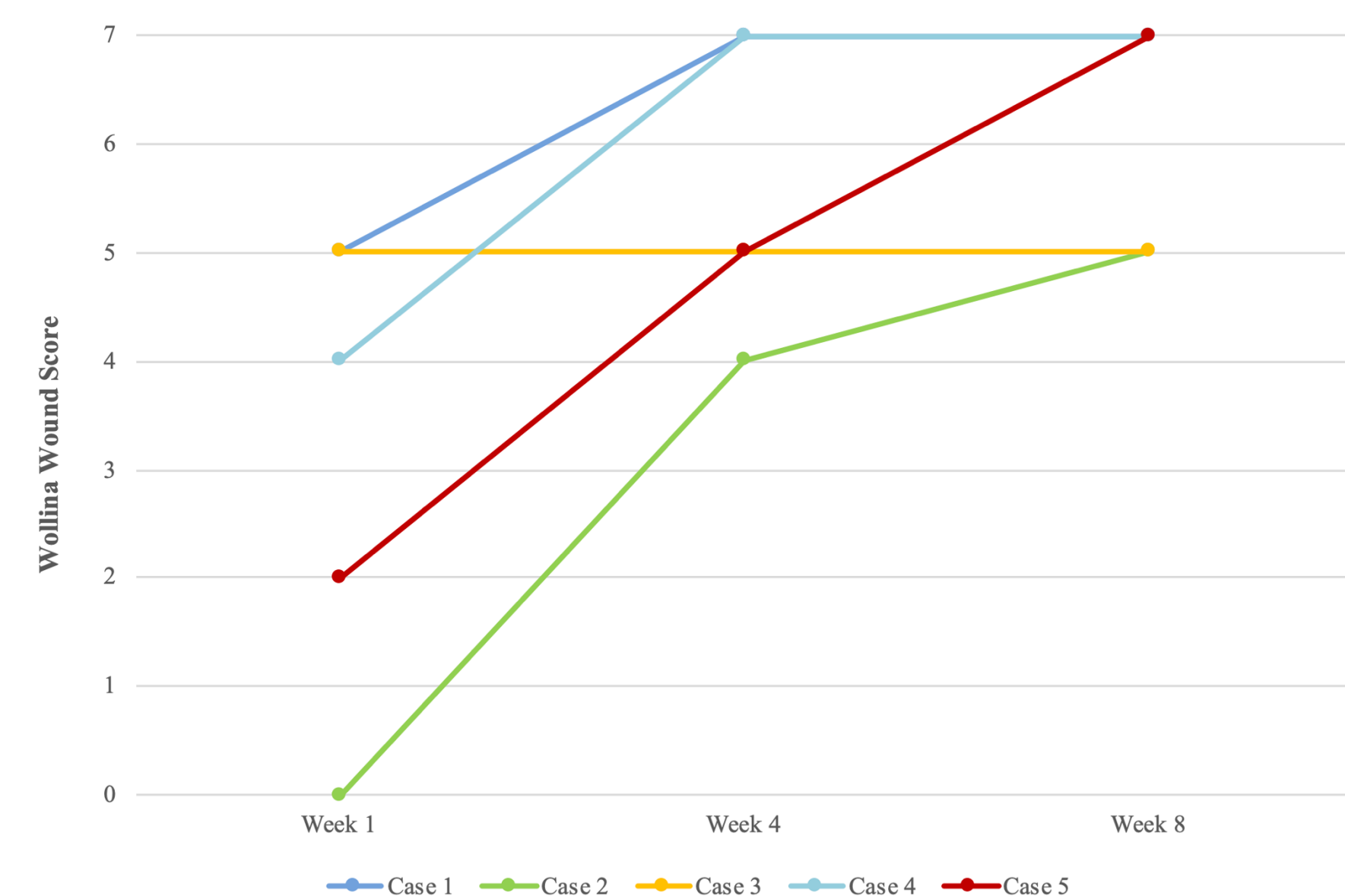


Figure 1. Individual evolution of the Wollina Wound Score throughout the study period.

PHYSIOLOGICAL OUTCOMES

Physiological outcomes HSI	Week 1 (Before)	Week 4 (After)	Week 8 (After)	p-value (W1 vs. W8)
StO ₂ , mean ± SD, (%)	74.8±5.49	78.2±3.83	75.5±2.64	0.318
DeoxyHb, mean ± SD	0.30±0.03	0.35±0.07	0.39±0.08	0.052
THb, mean ± SD	1.31±0.42	1.61±0.25	1.62±0.35	0.009*
OxyHb, mean ± SD	1.01±0.39	1.26±0.22	1.23±0.28	0.004*

Table 2. Physiological outcome measures obtained with HSI

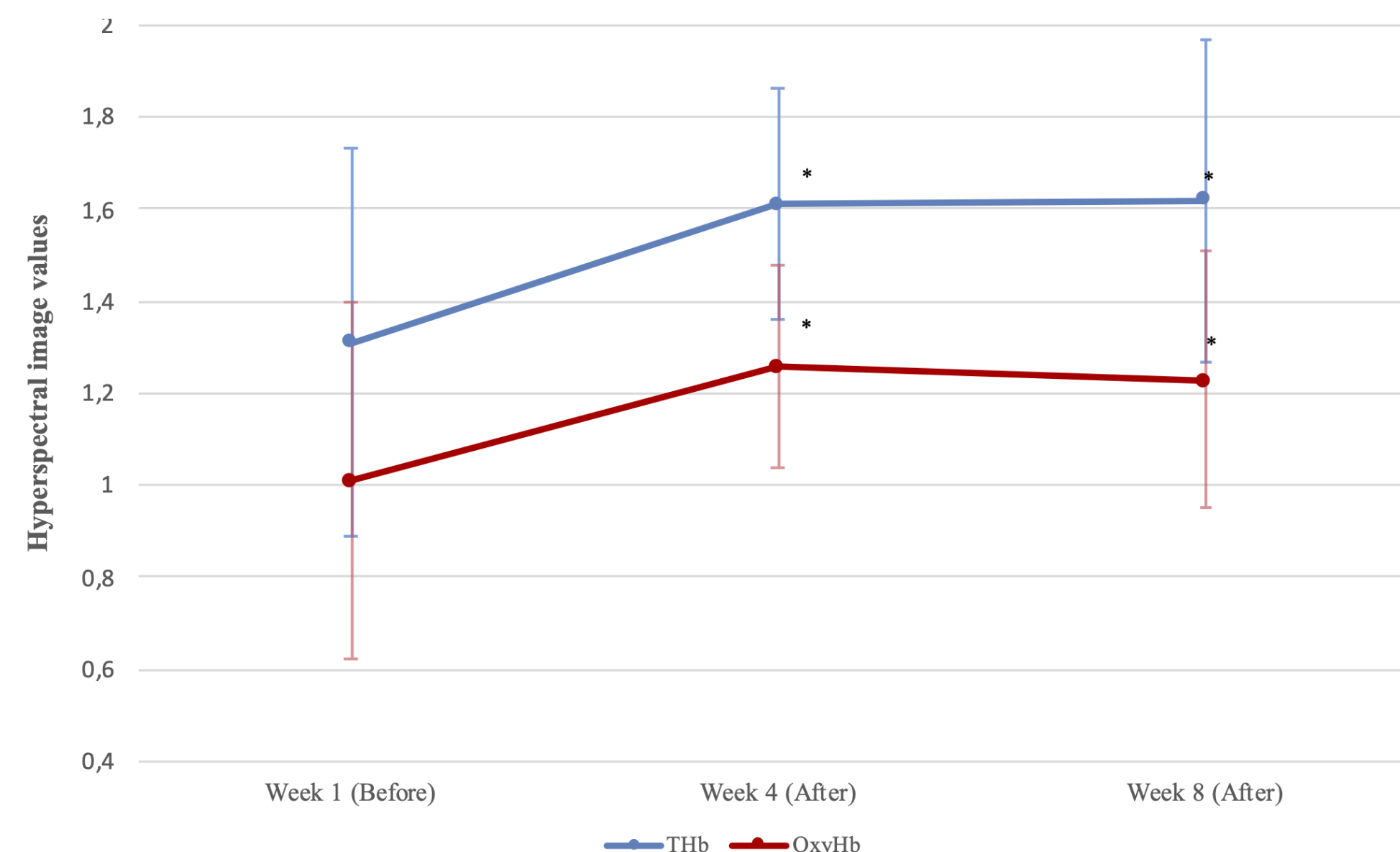
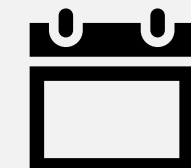


Figure 2. Changes in perfusion-related HSI parameters. THb, Total Hemoglobin; OxyHb, Oxyhemoglobin. Values were obtained before treatment at week 1 and after treatment at weeks 4 and 8.

METHODS

Study design → A prospective case series



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5 patients with DFUs



8-week follow-up

- Er:YAG laser** (Multiline™, LINLINE Medical Systems Ltd)

1. Ablation: Removal devitalized tissue and biofilm from the wound bed.

□ Energy density: 5 to 10 J/cm² - Repetition rate: 3 Hz.

□ Endpoint: Capillary bleeding

2. Biostimulation (RecoSMA® technology): Microablation and acoustic stimulation promote biological responses involved in wound healing.

□ Energy density: 2 to 4 J/cm² - Repetition rate of 3 Hz.

□ Wound bed and and the area 3–5 cm²surrounding the DFUs.

- Standard of Care**

Sharp debridement / Moist wound dressings / Removable knee-high device off-loading.

Hyperspectral Imaging Procedure

- HSI was performed using the **SnapshotNIR®** system (Kent Imaging Inc.), a NIRS-based hyperspectral camera for the non-invasive assessment of tissue oxygenation and perfusion.
- HSI was conducted at baseline and at weeks 4 and 8, before and after Er:YAG laser therapy.
- The camera was positioned perpendicular to the wound surface at a fixed distance in accordance with the manufacturer's recommendations.
- DFUs area was manually delineated, and the software calculated quantitative values of: **StO₂**, **OxyHb**, **DeoxyHb**, and **THb**. It also generated colorimetric maps of perfusion and oxygenation patterns.



REPRESENTATIVE CASE

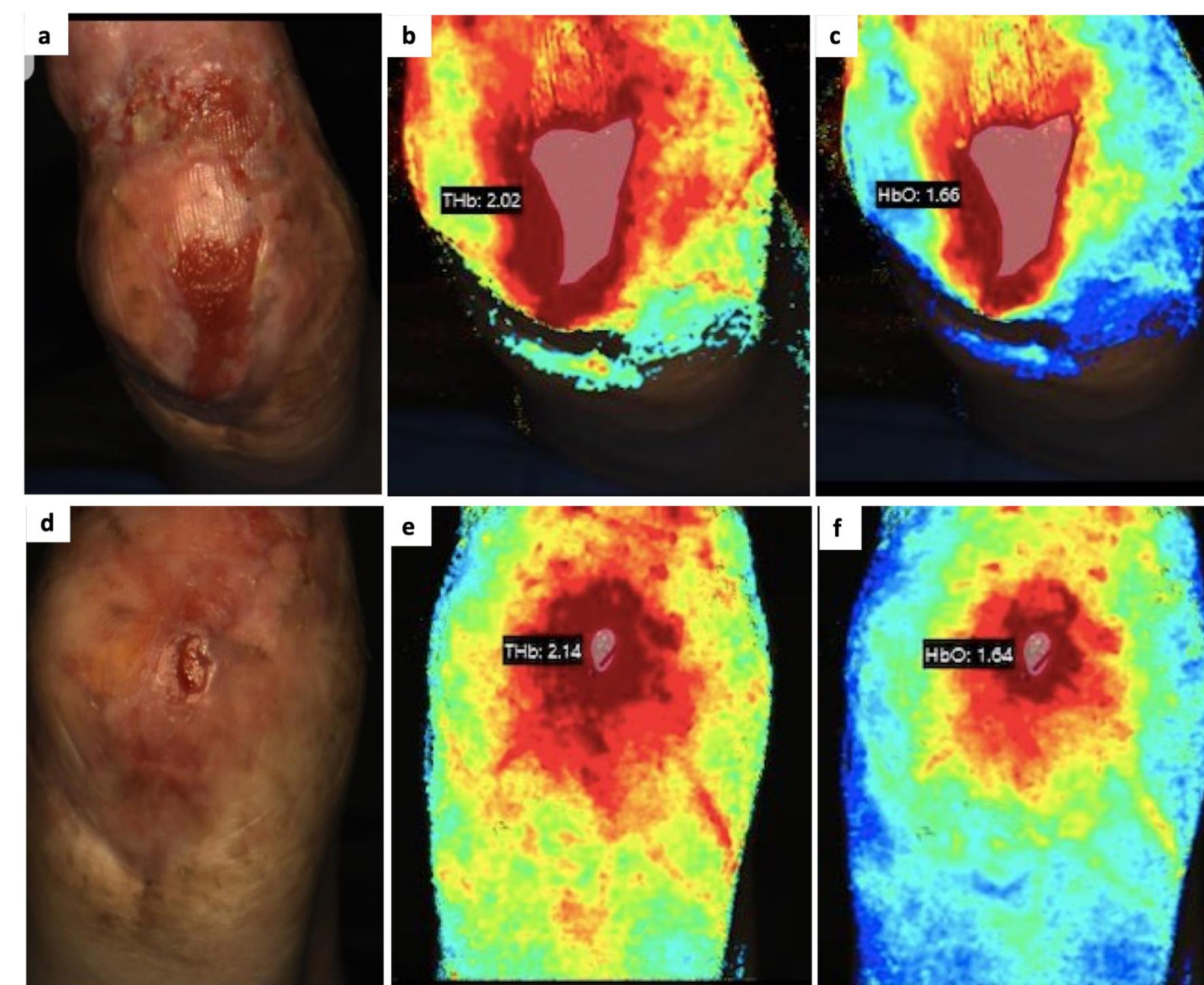


Figure 3. Representative clinical image and corresponding HSI maps obtained at week 1 and week 8 following Er:YAG laser therapy.

In the HSI maps, warmer colors (red/orange) indicate higher perfusion and oxygenation values, whereas cooler colors (blue/green) indicate lower values. THb, Total Hemoglobin; OxyHb, Oxyhemoglobin

A, Clinical image at week 1; b, THb map at week 1; c, OxyHb map at week 1; D, clinical image at week 8; e, THb map at week 8; f, OxyHb map at week 8.

CONCLUSION

- ✓ Er:YAG laser was associated with improved wound-bed quality, wound-area reduction, and increased perfusion-related parameters, particularly THb and OxyHb.
- ✓ HSI showed potential as an objective tool for early assessment of wound response to therapy.
- ✓ Larger controlled studies are needed to confirm the potential role of Er:YAG laser and determine whether early HSI-derived changes can predict long-term healing outcomes.

References

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- Alcolea JM, Hernández E, Martínez-Carpio PA, et al. Treatment of chronic lower extremity ulcers with A new Er:Yag Laser technology. Laser Ther. 2017;26(3):211-222.
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