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Evaluation of long pulse Nd: YAG laser therapy in treatment of onychomycosis

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BACKGROUND AND OBJECTIVE

Onychomycosis, a persistent fungal infection of the nail bed, matrix or plate, is the most common nail disorder in adults, accounting for one third of all fungal skin infections and up to 50 percent of all nail diseases [1-3]. There is a great need for a simple, effective, nontoxic procedure which does not allow for the development of fungal resistance.

The primary aim of this study was the evaluation of the efficacy and safety of a novel laser therapy in the treatment of onychomycosis. We have investigated the in vivo topical laser inactivation of the Trichophyton sp., Aspergilus niger, Candida sp. and molds with long pulse Nd:YAG laser light (Dualis SP, Fotona SLO). Long pulse Nd:YAG lasers employ a near infrared wavelength of 1064 nm which has very deep penetration in human skin and ability to create photothermal effects in the tissue.

MATERIALS AND METHODS

194 nails of 72 patients with clinically and mycologically proven onychomycosis were exposed to transcutaneous laser irradiation with the aim of deactivation and eradication of fungal infection.

Inclusion criteria: Toenail and/or finger nail fungal infection. Ages: between 18-45. Clinical types of fungal nail infection: total dystrophic form, distal subungual onychomycosis, proximal subungual onychomycosis and/or endonyx onychomycosis.
All patients signed written informed consent statements before beginning laser treatment.

Exclusion criteria: systemic antifungal therapy; usage of local antifungal therapy such as solutio Castellani, which change nail pigmentation; usage of nail coloring dyes which change nail pigmentation; usage of photosensibilisators; children under 12 years of age if using any of above mentioning drugs; existence of subungual hematoma or nevoid subungual formation; existence of bacterial nail infection which changes nail pigmentation; existence of concomitant nail disorders such as psoriasis of nail plate, lichen planus and atopic dermatitis. In addition, pregnant women were excluded.

Treatment procedure: Treatment was performed using a long pulse VSP 1064 nm Nd: YAG laser (Dualis SP; Fotona, Slovenia), with fluences in the range of 35 to 40 J/cm², a spot size of 4 mm diameter, and a pulse duration of 35 ms. The variations in fluence were selected based on the thickness of the nail to be treated, with thicker nails requiring higher fluence. The pulse rate was 1 Hz. The laser beam was applied to the entire nail plate by incrementally moving the beam in a spiral pattern as shown in Fig. 1. After the entire nail plate was irradiated a 2 minute pause was taken and then the treatment and pause were repeated twice more for a total of three passes. The total therapy consisted of four sessions with a one week interval between each session.
Follow-ups were done at 3, 6, 9 and 12 months. The patients were evaluated for clearance of fungal infection clinically by the physician executing the procedure and mycologically by analysis of the culture taken at 3 and 6 month follow-up visits made by independent microbiological laboratories.

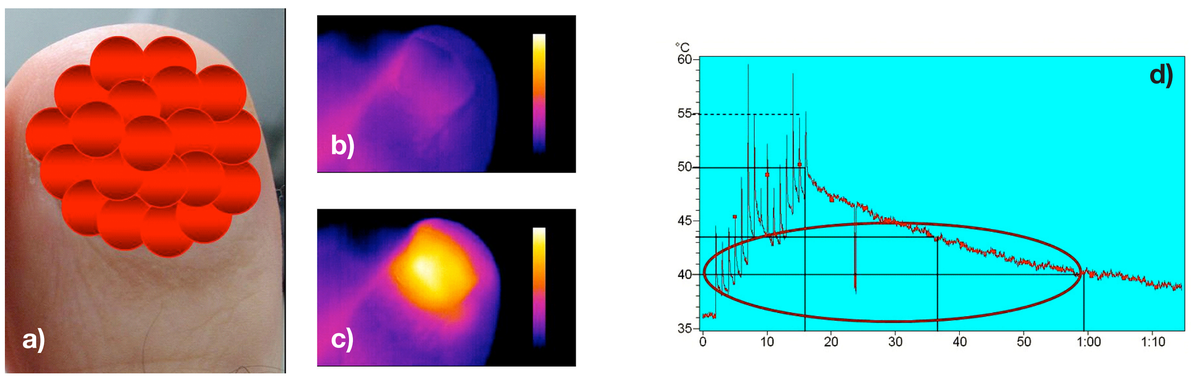

Fig. 1: Presentation of delivery of laser beam in spiral pattern on the nail plate surface (a), Thermal images of toenail surface before (b), and after (c) irradiation with VSP Nd:YAG laser beam. Temperature increase of the nail plate is clearly visible. Measured temperature at the nail plate during the laser treatment (d).

RESULTS

All four major clinical types of onychomycosis were treated: total dystrophic form, distal subungual onychomycosis, proximal subungual onychomycosis and endonyx onychomycosis. The distribution of onychomycosis types in the treated patients is given in Table 1.
The most frequent fungus found among treated patients was Trichophyton rubrum (in 37 patients or 51,4%), followed by Trichophyton mentagrophytes (22 patient or 30,5%). Table 2 presents the frequency of all the fungi which were found in the patients.
On 3 months follow up 95,83% patients were cleared of all fungal infections. On 3 patients (4,17%) with still present infection the complete procedure was repeated. On 6 and 12 months follow ups all patients (100%) were fully cleared of all fungal infections.

Table 1: Clinical types of fungal nail infection in treated group.

Type of onychomycosis	Number of patients (%)
Total dystrophic	6 (8.3%)
Distal subungual	38 (52.8%)
Proximal subungual	22 (30.5%)
Endonyx	6 (8.3%)

Table 2: Types of fungal nail isolates.

Type of fungal isolates	Number of patients (%)
Candida sp.	10 (13.9%)
T. rubrum	37 (51.4%)
T. mentagrophytes	22 (30.5%)
Aspergilus niger	3 (4.2%)

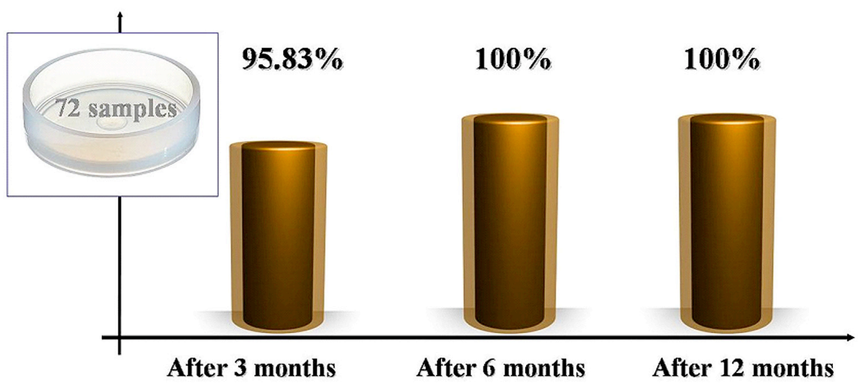

Fig. 2: Efficacy of laser treatment of onychomycosis, as observed from mycological cultures taken on 3 and 6 months and clinically evaluated on 12 months.

DISCUSSION

One of main advantages of laser surgery is its bactericidal effect. Laser light causes local hyperthermia, destruction of pathogenic microorganisms, and stimulation of the reparative process [16]. Statistically significant growth inhibition of T.rubrum was detected in colonies treated with the 1,064-nm Q-switched Nd:YAG laser at 4 and 8 J/cm² [17]. This laser produced a significant inhibitory effect upon the fungal isolate T.rubrum in an in-vitro study. Meral, Tasar at al. reported a strong bactericidal effect on Candida albicans suspensions after Nd:YAG laser irradiation [18]. The laser used in this study – Nd:YAG 1064 nm, penetrates through the nail plate and through photothermal effect produces heat deep within the dermis and nail tissue.

Desired average tissue temperature for laser irradiation of onychomycotic nails is about 43-51°C, at a treatment time of at least 2-3 minutes; these parameters provide an adequate therapeutic dose - the amount of laser energy that can deactivate 80-99% of the organisms present in an affected nail. That dose does not instantly kill the fungal colonies but results in their inability to replicate or survive through an apoptotic mechanism.

A number of reports have been published to demonstrate the induction of apoptosis by hyperthermia [10,11,12] as well as the generation of reactive oxygen species (ROS) and denaturation of cellular proteins contributing to apoptosis of fungal cell - a programmed cell death.

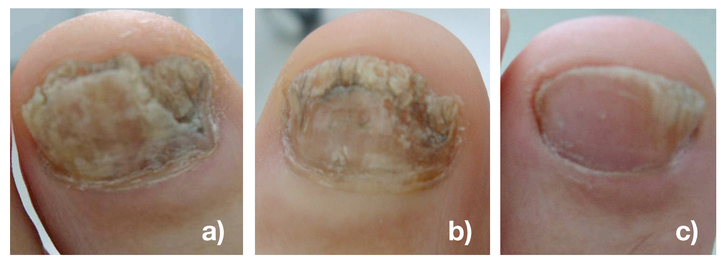

Fig. 3: Trichophyton rubrum treated with VSP Nd:YAG laser: before a), 6 months after b) and 12 months after c)

Fig. 4: Trichophyton mentagrophites treated with VSP Nd:YAG laser : before a) and 12 months after b)

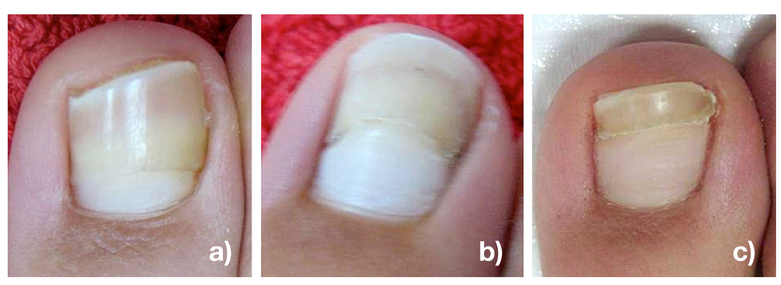

Fig. 5: Candida species treated with VSP Nd:YAG laser: before a), 6 months after b) and 9 months after c)

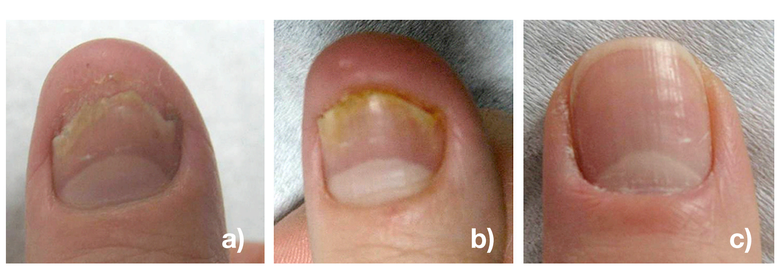

Fig. 6: Candida species treated with VSP Nd:YAG laser : before a), 3 months after b) and 9 months after c)

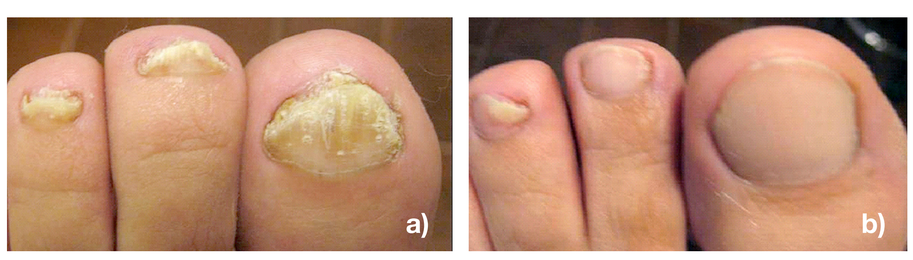

Fig. 7: Trichophyton rubrum treated with VSP Nd:YAG laser: before a) and 12 months after b)

CONCLUSION

Nd:YAG 1064 nm laser irradiation was found to be well suited for the task of eradicating nail fungal infection. This wavelength photo-inactivate fungal pathogens to a depth below the nail tissue surface leaving the surrounding tissue intact, using safe energy densities at physiologic temperatures.
The procedure is simple and quick with no noticeable side effects and complications. Nd: YAG laser therapy of onychomycosis is safe and very efficient method for treating all types of onychomycosis caused by various fungal species.
This method is useful for the broadest range of patients and is specially beneficial in elderly, compromised and hepatopathic patients for which other alternative treatments could present some risks.

References:

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