Efficacy of Nd:YAG Laser 1064-nm in the Treatment of Onychomycosis

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ABSTRACT

Objective: To assess the effectiveness of neodymium-doped yttrium aluminum garnet (Nd:YAG) laser 1064 nm in the management of onychomycosis.

Study Design: Descriptive observational study.

Place and Duration of the Study: Department of Dermatology, PNS Shifa Hospital, Karachi, Pakistan, from December 2022 to May 2023.

Methodology: Thirty patients, of either gender, aged between 20 and 60 years, with a clinical diagnosis and a positive KOH test for onychomycosis. Long-pulsed 1064-nm Nd:YAG laser therapy was administered to patients. On the basis of nail plate thickness, laser therapy was given once a week for a month at a speed of 25 mm/sec and a spot diameter of 4 mm, with fluencies ranging from 40 - 60 J/cm^2. Before and six months' post-treatment, the patients' photos were taken and were evaluated based on dermoscopic results and clinical improvement.

Results: The patients' average age was 40.20 ± 15.85 years, and their average duration of disease was 3.0 ± 1.41 years. Six (20%) were males and 24 (80%) cases were females. The most prevalent clinical type was distolateral subungual onychomycosis 22 (73%). Fourteen (46.6%) cases showed excellent improvement, 6 (20%) cases showed good improvement, and 10 (33.3%) cases showed mild improvement.

Conclusion: Long-pulsed Nd:YAG laser is a safe and efficient option for onychomycosis because of its high clinical cure rates, lack of side effects, and clinical therapeutic efficacy.

Key Words: *Onychomycosis, Nd:YAG laser 1064-nm, Dermatology, Nail, Lasers in dermatology.*

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INTRODUCTION

Around 5.5% of people worldwide suffer from onychomycosis, which accounts for 20 to 40% of all onychopathies and roughly 30% of cutaneous mycotic infections.[1] The most frequent aetiologic agents are dermatophytes, however, a sizable portion of cases are also caused by yeasts and non-dermatophyte moulds.[2] Debris under-thickened, twisted, deformed, and discoloured nails, especially those with uneven and ragged edges strongly implies tinea obliging unguium.[3] Candidal onychomycosis primarily affects the fingernails and lacks severe deformation and accumulated debris. About 1.5 to 6% of cases of onychomycosis are caused by non-dermatophytic moulds, and they are typically seen in the toenails of older people who have experienced trauma.[4] Some Asian behaviours, such as biting one's nails, strolling barefoot, wearing poorly-fitting shoes, and using chemicals, can contribute to onychomycosis.[5]

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Numerous investigations have demonstrated that the incidence of onychomycosis rises with age, maybe as a result of impaired peripheral circulation, diabetes mellitus, recurrent nail injuries, extended exposure to pathogenic fungi, compromised immune system, and incapacity to appropriately clip toenails and take care of the feet.[6,7] Patients with onychomycosis may have serious psychological issues, especially if their fingernails are affected.[8]

Fluconazole, itraconazole, and terbinafine are common oral or external antifungal medications used to treat onychomycosis. However, topical antifungal medications rarely infiltrate into nail plates and do not reach up to the therapeutic level, and systemic oral antifungals are not appropriate for certain individuals who have impaired immune function or abnormal liver function.[9] There is, therefore, still an ongoing need for a relatively non-invasive and effective treatment modality with minimal toxicity and potential for drug interactions.

Neodymium-doped yttrium aluminium garnet (Nd:YAG) laser is a device that emits amplified light radiation using a Nd:YAG crystal. Nd:YAG laser has many applications in dermatology including hair removal, tattoo removal, and treating pigmentary disorders including exogenous ochronosis. Most laser systems use heat effects or work with the breakdown of fungal

structures and the production of toxic reactive oxygen species, thereby disrupting the mitochondrial membrane potential.[3] In the literature, there are onychomycosis treatment results with various laser types.[4-6] Carbon dioxide (CO_2) laser kills fungi by directly disrupting the tissues.[7] CO_2 laser is not a preferred choice due to its pain and trauma side effects on the area of application. In a study, it was shown that a long-pulse Nd:YAG laser with a wavelength of 1,064 nm could cure 52% of 154 infected nails in 33 onychomycosis patients.[8-10]

The various laser studies performed for onychomycosis have indicated a high safety profile of these devices although the efficacy rates have fluctuated. Laser treatment of onychomycosis is, therefore, still an attractive option, especially in subjects where systemic toxicity of oral antifungal agents prohibits their prolonged use. This research was conducted to assess the efficiency of Nd:YAG laser 1064-nm long pulse in the treatment of onychomycosis.

METHODOLOGY

The observational study was conducted at the Department of Dermatology, PNS Shifa Hospital, Karachi, Pakistan, from December 2022 to May 2023. After obtaining ethical approval and written informed consent, patients visiting the outpatient department were examined clinically and by dermoscopy, revealing findings such as longitudinal striae, spike pattern, distal irregular termination, jagged, and linear edge. Wet Potassium hydroxide (KOH) preparations were made on the nail sample and the nail debri were sent to the microbiology department to confirm the diagnosis. Thirty patients tested positive for the KOH test of age range from 20-60 years of either gender, resistant to other treatments (anti-fungal agent), and patients who were not taking systemic antifungal drugs in the previous six months were included in the study. Patients taking oral anti-fungal treatments would give false results after Nd:YAG laser 1064 nm. Patients with subungual haematomas, subungual nevoid lesions, bacterial nail infections, concomitant nail disorders due to psoriasis, lichen planus, or atopic dermatitis, diabetes or hypertension, pregnancy, and those taking vasodilator medicine (due to uncontrolled heat transfer) were excluded. The non-probability sampling technique was used.

After taking demographic and clinical data, one week prior to the laser procedure, a chemical agent 10% urea cream was used as occlusion dressing for 12 hours daily to eliminate hyperkeratotic nail plate debris from patients with dystrophic onychomycosis. Subungual debri was removed mechanically by using a nail file and the patient was then started on the laser therapy programme.

The patients underwent two runs of long-pulsed, 1064-nm Nd:YAG laser therapy, with a one-minute break in between each pass. The laser was applied in a spiral pattern over the nail plate. On the basis of nail plate thickness, laser therapy was given once weekly for one month at a speed of 25 mm/sec and a spot diameter of 4 mm, with fluencies ranging from 40 - 60 J/cm^2.

There was no local anaesthetic used prior to the treatment. To reduce pain, a Zimmer Cryo 5 cold air chiller was employed for cooling during each laser therapy session. Following the procedure, no antiviral, antibacterial, or antifungal prophylaxis was carried out.

Before the laser application and six months' post-treatment, the patients' photos were obtained, and their clinical improvement and dermoscopic findings were evaluated. Clinical improvement was categorised as: Mild improvement (<30% normal nail), moderate improvement (31 - 60% appearing nail), and excellent improvement (81 - 100% normal nail).[12] Dermoscopic findings were categorised as distal irregular, spike pattern, jagged, longitudinal striae, and linear edge. During and after sessions, adverse effects were also assessed. The data were analysed using SPSS version 26. Mean ± SD were calculated to represent quantitative variables, whereas frequencies and percentages were used to report qualitative variables.

RESULTS

The demographic and clinical data are shown in Table I. Before treatment, distal irregular finding was observed in 11 cases (36.6%), spike pattern in 13 cases (43.3%), jagged in 8 cases (27%), longitudinal striae in 14 cases (47%), and linear edge in 1 case (3%). After treatment, these findings reduced to 6 (20%), 7 (23.3%), 3 (13%), 8 (26.6%), respectively and linear edge was observed in none of the cases, as shown in Table II.

Excellent improvement was observed in 14 cases (46.6%), good improvement in 6 cases (20%), and mild improvement in 10 cases (33.3%).

Table I: Demographic details of the patients (n = 30).

Demographic details	Frequency n (%)
Age groups (years) (mean ± SD)	40.20 ± 15.85
Duration (years) (mean ± SD)	3.0 ± 1.41
Gender	
Male	06 (20%)
Female	24 (80%)
Type of onychomycosis	
Distolateral subungual onychomycosis (DLSO)	22 (73%)
Proximal subungual onychomycosis (PSO)	01 (3.3%)
Total dystrophic onychomycosis (TDO)	05 (16.6%)
DLSO + TDO	02 (7%)
Location of infected nails	
Fingernail	03 (10%)
Toenail	27 (90%)

Table II: Dermoscopic findings before and after treatment.

Dermoscopic findings	Before treatment	After treatment
Distal irregular	11 (36.6%)	6 (20%)
termination	13 (43.3%)	7 (23.3%)
Spike pattern	08 (27%)	3 (13%)
Jagged	14 (47%)	8 (26.6%)
Longitudinal striae	1 (3%)	0 (0%)
Linear edge		

Figure 1: Images before and after the treatment of fingernail onychomycosis.

Figure 2: Images before and after the treatment of toenail onychomycosis.

DISCUSSION

A fungal infection of the nail called onychomycosis can be either non-dermatophytic (1%) or dermatophytic (99%), and it grows slowly until the nail plate is destroyed if treatment is not received. Long-pulsed YAG laser therapy is a promising modality for safe and cost-effective treatment of mycotic nails, in comparison to oral antifungal treatment that is given as 3 – 6 months therapy. Long-pulsed YAG laser with a 1,064 nm wavelength heats the fungal substance by penetrating the nail plate and into the nail bed. Fungi that are exposed to high temperatures experience cell damage and death in addition to growth inhibition.[11,13] In addition to instances where traditional oral medication for onychomycosis cannot be started, such as when there is drug-resistance or hypersensitivity in a systemic condition, laser therapy can also serve as a backup plan in case the oral therapy is unsuccessful.[14] According to the current study, the incidence of onychomycosis was found to be 8:2 being higher in women. A previous study comprising 35 participants, 18 women and 17 men, reported similar women prevalence.[15]

The present research showed excellent improvement in 14 (46.6%) cases, moderate improvement in 6 (20%) cases, and mild improvement in 10 (33.3%) cases at the end of sessions (Table II). El-Tatawy *et al*. evaluated the results of randomly assigning 40 individuals with disease to groups receiving topical terbinafine and long-pulsed Nd:YAG lasers. At six months, every patient in the group treated with Nd:YAG laser showed remarkable improvement, while 50% of patients treated with topical treatment exhibited mild-to-moderate improvement. They proposed that patients with liver disease, ageing, and impaired immune systems would benefit most from laser therapy.[16] Moon *et al*. conducted treatment sessions at 4-week intervals using a long-pulsed 1064-nm Nd:YAG laser on 13 patients. Of the 43 nails, 4 (9.3%) achieved full recovery, 8 (18.6%) had excellent treatment outcomes, and 31 (72%) had good treatment outcomes. Other than a slight inflammation, no unfavourable events were noted.[17] Noguchi *et al*. observed a 27.6% improvement in turbidity in the lesion region following the application of a 1064-nm Nd:YAG laser.[18]

When 1064-nm Nd:YAG laser was administered, Carney *et al*. employed an onychomycosis severity index (OSI) scoring system to assess therapy response. They found that while none of the eight patients who underwent treatment experienced a mycologic or clinical cure, all of them saw mild clinical improvement. This result was linked to study's strict scale, as well as the utilisation of different procedures, fluence levels, and pulse duration settings.[19]

The authors' purpose in this research was to assess the effectiveness of long-pulsed Nd:YAG laser therapy for onychomycosis. In the current investigation, no symptoms other than some pain and discomfort were noticed following the laser treatment. One of the most crucial aspects of onychomycosis laser therapy outcomes is the interval between treatments. One significant weakness of the current study is that all participants had laser therapy once weekly for a month. The study's small sample size of patients is another limitation. More large-scale investigations will provide more conclusive answers regarding the effectiveness of the long-pulsed Nd:YAG laser. According to Ortiz *et al.*, although the results that are currently available are encouraging, more research is required because the previous studies' limited sample numbers and subpar designs were problematic.[20]

CONCLUSION

In this study, the authors assessed the effectiveness of using a 1064-nm long-pulsed Nd:YAG laser for treating onychomycosis. The current study showed excellent to good results in 66.6% cases which conclude that long-pulsed Nd:YAG laser therapy is an effective therapy. This study's findings indicate that this laser therapy is both safe and boasting high clinical cure rates and therapeutic efficacy. Notably, no significant adverse effects were observed and patients expressed satisfaction with the treatment outcomes. This modality may be particularly beneficial for individuals with systemic diseases or those who are reluctant to use antifungal agents. However, to solidify these findings, further extensive studies on a larger scale are imperative.

ETHICAL APPROVAL:

Ethics Committee of PNS Shifa Hospital gave its approval to the study [ERC/2023/DERM/19].

PATIENTS' CONSENT:
Informed and written consent was obtained from the patients.

COMPETING INTEREST:
The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:
AK: Concept of the study, design of the study, data collection, drafting of the manuscript, and data interpretation.
SK: Concept of the study, data collection, and critical analysis.
NA: Data collection, critical analysis, and manuscript review.
MA: Data collection and drafting of the manuscript.
All authors approved the final version of the manuscript to be published.

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