# A clinical study on the use of the 1064 nm Nd:YAG laser with variable pulse width and spot size in the treatment of telangiectasias

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**Abstract**

*Treatment of telangiectasia is becoming a cosmetic demand, therefore a good outcome and lower incidence of side effects is crucial. Sclerotherapy had long been the mainstay treatment of telangiectasias and leg veins, other modes of treatment include intense pulse light, diode, pulsed dye and Nd:YAG laser. In this study we describe our clinical experience with the use of the 1064 nm Nd:YAG laser in management of face and leg telangiectasia. Our aim is to evaluate the clinical efficacy as well as the potential complications and put forward a protocol for effective treatment.*

**Introduction:**

Since treatment of telangiectasias is considered a cosmetic procedure therefore a good outcome and low incidence of side effects is essential. Leg telangiectasia and reticular veins affect a large segment of the population and are of significant cosmetic concern to both males and females. The mainstay of treatment remains sclerotherapy, but enthusiasm for an efficacious noninvasive treatment remains high. With sclerotherapy, multiple treatment sessions are usually required, and vessel clearance requires a minimum of 1 to 3 months post injection. Other drawbacks include patients' phobia of needles, post-treatment hyperpigmentation, telangiectatic matting, skin ulceration secondary to sclerosant extravasation, the remote possibility of deep venous thrombosis, and possible allergic reactions to the sclerosant.[1-3]

The conceptualization of the principles of selective photothermolysis and the development of the flash lamp-pumped pulsed dye laser in the 1980s revolutionized the treatment of capillary vascular malformations and facial telangiectasia by laser therapy, making it possible to obliterate fine, pink telangiectasia efficiently and safely, without damaging the surrounding tissue. Tremendous interest grew in modeling novel types of laser technology, based on these principles, to target leg veins. Although adequate vessel clearance was achieved, most of these studies were limited to the treatment of pink to red telangiectasia measuring less than 1.2 mm in diameter, and approximate clearance rates ranged from 50-80% after multiple treatment sessions (6-10 sessions). More recently, near-infrared wavelengths that provide more deep penetration light have been explored for the treatment of leg veins.[1-3]

Intense pulsed light (IPL) and visible light lasers are only effective in the treatment of small veins up to 1.0 mm in diameter.[2,3] Recently, long-pulsed Nd:YAG laser was introduced in the treatment of telangiectasia of the face and leg using variable laser parameters and with variable clinical outcome.[4-8]

The long pulse Nd:YAG (1064-nm) laser has gained increasing popularity during the past few years for treatment of disfiguring leg veins (blue venulectasia and reticular veins up to 4 mm in diameter) and more recently for the effective removal of unwanted body hair. Attractive aspects of this technology include deeply penetrating wavelengths and long-pulse options, which produce an "epidermal bypass" that targets the desired chromophore (hemoglobin for lower extremity vessels and melanin for pilosebaceous photoepilation) while protecting the epidermis. Haemoglobin absorption of the 1064 nm Nd:YAG wavelength offers the possibility to treat deep or thick lesions that are not accessible with shorter wavelengths as with the KTP, pulsed dye, IPL, and diode lasers. The 1064-nm wavelength also allows darker skin types to be treated with minimal risk to the epidermis because of decreased interaction with melanin, thus minimizing the potential for irregularities in epidermal contour and pigmentation.[9-12]

Sadick et al. (2001), examined the histologic and clinical effects of using a 1064-nm Nd:YAG laser system on lower extremity vessels. In their study, they performed a single treatment using the following parameters: Wavelength 1064 nm (multiple synchronized pulsing); spot size 6 mm; pulse duration 14 milliseconds (single pulse); and fluence 130 J/cm$^2$. The histological examination of treated areas revealed perivascular hemorrhage, thrombi, fragmentation and homogenization of elastic fibers, and eosinophilia of vessel walls. Expression of transforming growth factor ß was increased in the treated vessels which indicate healing. Vessel closure was defined by Doppler analysis. They stated that complete vein closure might be accomplished by induction of specific vascular injury secondary to heating, with consequent fibrotic closure of the abnormal vessels and maintenance of clearing was achieved for up to 6 months.[13]

In this study, we describe our clinical experience in the treatment of facial and leg telangiectasia using the 1064 nm Nd:YAG laser. Our aim is to evaluate its clinical efficacy as well as its potential complications and put forward a protocol for laser treatment of the disfiguring small and large veins up to 4 mm in diameter. Pulse durations were selected according to the estimated vessel size of each lesion: 40-45 msec for thin, and 45-50 msec for thick. Variable fluences (from 160-250 J/cm$^2$) were used. All the parameters were individually adjusted according to personal experience and immediate reaction (clearing or colour change of vessels).

**Patients and methods:**

Long-pulsed 1064 nm Nd:YAG laser (Fotona, Slovania) was used in this study to treat 45 patients with telangiectasia. This device delivers pulse fluences up to 400 J/cm$^2$, pulse width up to 200 msec, spot size up to 8 mm, power of 25 watt, and frequency from 0.5-11.5 Hz. A Zimmer air cooling system -30ºC is also present for cooling aiming to minimize pain.

The study was performed at Cairo Cosmo Center. An informed consent for the study and medical digital photography was taken from each patient indicating the purpose and possible outcome of the study.

Patient inclusion criteria included those with leg veins up to 4 mm in diameter, patent saphenous vein and competent venous valves by examination and Doppler US, and absence of history of previous IPL, laser or sclerotherapy treatments. Exclusion criteria included pregnancy and lactation, patients on contraceptive pills or anticoagulants, patients with photosensitivity, history of poor healing or keloidal tendency, presence of local inflammation or Herpes simplex infection, darker skin types beyond IV, and refusal to sign the consent form. Patients with feeding reticular vessels demonstrated clinically by immediate refilling after release of finger pressure-induced blanching, were also excluded.

This study was performed on 45 patients with skin types II-IV. The patients were divided into two groups. First group included 5 patients with facial telangiectasia 0.5-1.5 mm in diameter and the second group included 40 patients with leg telangiectasia 0.5- 4 mm in diameters. Laser pulses were introduced in the form of 1-3 repetitive pulses followed immediately by finger pressure on the targeted area for a few seconds. This technique allows the biochemical transformation of haemoglobin into methaemoglobin. Methaemoglobin presents a much higher absorption coefficient against the elemental emission of 1064 nm Nd: YAG (a biochemical change, which in turn, results in better absorption and faster response). The end point for each laser session is venular clearance or disappearance following a maximum of 3 repitive pulses to avoid blistering. Laser parameters and the number of pulses are adjusted individually according to surgeon experience and patient reaction as shown in **Table(1)**.

*Table (1): Laser parameters for treatment of facial and leg telangiectasia.*

| Laser parameters | Facial telangiectasia | Leg telangiectasia |
|---|---|---|
| Fluence (J/cm$^2$) | 160-220 | 220-250 |
| Pulse width (m sec) | 40-45 ms | 40-50 ms |
| Spot size (mm) | 2 | 2-3 |
| Number of repetitive pulses | 1-2 | 2-3 |
| Number of sessions | 1-2 | 1-3 |

Topical anesthesia with 5% lidocaine (EMLA cream) was applied 30 minutes prior to treatment. The goal of the treatment session was to achieve blanching of the vessels without skin burn. The entire vessels were treated by 1-3 consecutive passes using multiple shots in an adjacent order. Surface cooling was achieved by -30ºC Zimmer air cooling system before, during, and few seconds after laser pulses and throughout treatment.

Post laser care included topical fucidin cream as an antimicrobial and sunblock application before outdoor activities. Patients were advised to drink plenty of water and wear crepe bandage or heavy sockets for 5 days post treatment in cases of leg telangiectasia.

Documentation was done by medical digital photography before treatment and at the follow up visits. The follow up period was at 2 weeks, one month and 6 months. Subjective evaluation was through patient satisfaction, ranked on a scale of 1-3 with 1 being minimum satisfaction and 3 being very satisfied **Table(2)**.

Objective evaluation was by assessment of the outcome of treatment 2 weeks, 1 and 6 months after the last laser session through comparison of the pre- and post-treatment photos, by two blinded plastic surgeons not involved in the treatment. Complications, even if minimal, were also recorded. The evaluation was recorded as the percentage of improvement on a quartile scale of 25% gradient. The result was considered excellent if there is 100-75% clearance of veins, good with <75-50% clearance, fair with <50-25% clearance, poor with < 25% clearance and no improvement if there was an associated exacerbation **Table(3)**.

**Results:**

The study was performed on two groups of patients with facial and leg telangiectasia. These patients were of Fitzpatrick skin types II-IV. Clinically, there was no correlation between the skin type, clinical response and the incidence of pigmentary changes.

Small veins tend to respond better and faster to treatment. However, redness was common with small veins <1mm in diameter. A pattern corresponding to the coagulated part stays longer with large veins more than 2 mm in diameter before spontaneous disappearance within a period of 2-3 weeks.

Subjective assessment showed high patient satisfaction rates with 60% of patients very satisfied in the first group, and 67% in the second group **Table(2)**.

Objective assessment through photography at 1 and 6 months indicated a good outcome with >50% improvement in 86% of patients in the first group, and 100% of patients in the second group **Table(3)**.

Complications were minimal as summarized in **Table(4)**. Pain associated with the procedure was deemed tolerable, yet still present, through the use of local anesthesia and air cooling routinely for all patients. All cases required a total number of sessions between 1-3 **Table(5)**.

*Table (2): Subjective assessment after accomplishing the laser sessions for treatment of telangiectasia.*

| Patient satisfaction | Facial telangiectasias | | Leg telangiectasias | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| Very satisfied | 3 | 60% | 27 | 67% |
| Somewhat satisfied | 2 | 40% | 7 | 17% |
| Unsatisfied | - | - | 1 | 2% |

*Table (3): Therapeutic efficacy of a single treatment for leg telangiectasias.*

| Improvement | Facial telangiectasias | | Leg telangiectasias | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| No improvement | 0 | 0 | 0 | 0 |
| Poor < 25% | 0 | 0 | 0 | 0 |
| Fair 25-50% | 0 | 0 | 0 | 0 |
| Good 50-75% | 1 | 20% | 14 | 34% |
| Excellent >75% | 4 | 80% | 26 | 65% |
| Greater than 50% | 5 | 100% | 40 | 100% |

*Table (4): Side effects of laser treatment of facial and leg telangiectasias.*

| Side effect | Facial telangiectasias | | Leg telangiectasias | |
|---|---|---|---|---|
| | Number | Percent | Number | Percent |
| Edema | 2 | 40% | 6 | 15% |
| Bruising | - | | 5 | 12% |
| Thrombosis | | | 3 | 7% |
| Matting | - | | - | |
| Blistering | 2 | 40% | 5 | 12% |
| Scab formation | - | | 2 | 5% |
| Shadow appearance | 3 | 60% | 30 | 75% |
| Scarring | - | | - | |
| Hyperpigmentation | 0 | 0 | 3 | 7% |

*Table (5): Number of sessions required by patients.*

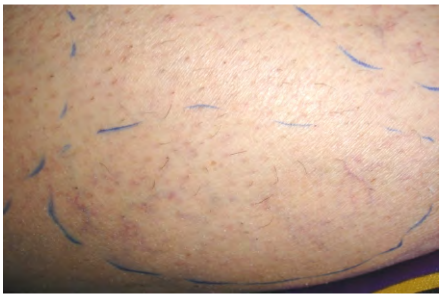
| | 1 session | 2 sessions | 3 sessions |
|---|---|---|---|
| Facial telangiectasia cases | 3 | 2 | |
| Leg telangiectasia cases | 7 | 28 | 5 |

*Case no.(1)*

*Preoperative*

*Postoperative*

*Case no.(2)*



*Preoperative*

*Postoperative*

*Postoperative .... one month*

*Case no.(3)*

*Preoperative*

*Postoperative*

*Postoperative .... one month*

*Case no.(4)*

*Preoperative*

*Postoperative .... six month*

**Discussion:**

Treatment of leg veins is considered problematic to both plastic surgeons and dermatologicalists. The difficulties inherent in treating leg veins with lasers relate to their relatively complicated anatomy and physiological features compared with facial telangiectasia. Most facial telangiectasia are monomorphic, thin-walled & small-diameter vessels with low venous pressures. In contrast, leg veins constitute a heterogeneous group of vessels, often with multiple diameters and depths within tissue. Even the small, red telangiectasia of the legs have larger diameters and thicker walls and are situated deeper in the dermis, compared with the average facial telangiectasia, and hydrostatic pressures are often elevated even in the absence of obvious signs of venous insufficiency.

Sclerotherapy used to be the gold standard for treatment of telangiectasia. When sclerotherapy is performed, the sclerosant solution is injected into all of the vessels within a given patch of telangiectasia, inducing an inflammatory response throughout the affected endothelium. However, it is associated with pain during injection with possible allergic reactions and an incidence of postsclerotherapy hyperpigmentation or telangiectatic matting.[7] Facial veins treatment with sclerotherapy is not recommended because of the documented possible ulceration and loss of vision.[8] Leg veins were found to respond better and in fewer sessions to sclerotherapy compared to Nd:YAG laser. Sclerotherapy in the treatment of leg veins is less expensive but requires more experience than laser and laser therapy was selected for patients with telangiectatic matting, needle phobia or allergy to sclerosant material.[9]

Due to the limitations of sclerotherapy, other therapeutic modalities were described for treatment of telangiectasia including diode laser, pulsed dye, KTP, and Nd:YAG laser, as well as the none coherent intense pulse light.[1,4,5,10,11] According to the theory of selective photothermolysis, short pulse duration can limit heat transfer within the blood vessel but this can be associated with vessel rupture due to sudden vaporization of the RBCs, leading to purpura and hyperpigmentation. Therefore, the ideal pulse duration should be long enough to damage the vessel wall but not too long to damage the perivascular tissues and induce scarring.[4]

Because of limitations in light penetration or fluence delivery, laser treatment of a patch of telangiectasia often produces segmental photocoagulation of the most superficial vessels in a network of telangiectasia, followed by subsequent vessel repair and recanalization. This may explain the sometimes unpredictable response of leg telangiectasia to laser therapy. This finding occurs most with short wavelength lasers. For effective laser treatment of leg veins, sufficiently long wavelengths are necessary to provide adequate photon penetration and absorption by these larger, deeper vessels. Millisecond duration pulses best match the thermal relaxation time of such vessels. Infrared wavelengths provide the necessary tissue penetration, but the absorption coefficient for hemoglobin drops, and higher fluences are required for effective photocoagulation. With greater risk to the epidermis posed by high-fluence treatment, with such techniques selective epidermal cooling must be used.[14]

Dierickx et al.,[1] studied an 800-nm diode laser with a water-cooled sapphire tip (Star Medical Tech Inc, Pleasanton, Calif) for the treatment of leg telangiectasia. Telangiectasias less than 0.4 mm in diameter were treated with a 20-millisecond duration pulse at a fluence of 40 J/cm$^2$. Approximately 25% of telangiectasia cleared after 1 treatment, 50% after 2 treatments, and 75% after 3 treatments, with vessels greater than 0.4 mm in diameter demonstrating better clearance than smaller ones. In a preliminary study, Weiss and Weiss[2] found 75% improvement in vessels 0.5 to 3.0mm in diameter with the use of a long-pulsed Nd:YAG laser (Vasculight; ESC) at fluences up to 130 J/cm$^2$ and single-, double-, or triple-synchronized pulses of 10- to 16-millisecond durations.

McDaniel and associates[3] used a long-pulsed alexandrite laser (Photogenica; Cynosure Inc, Bedford, Mass) to treat leg telangiectasia. These treatments were performed with the 755-nm, 5-millisecond laser, with a 10-mm spot size at a fluence of 20 J/cm$^2$, single pulse, at 4-week intervals, and resulted in a 23% improvement in telangiectasia less than 0.4mm in diameter. Veins of 0.4 to 1.0 mm in diameter improved by 48%, and veins greater than 1.0 mm in diameter responded by 32% after 3 treatments, using a fluence of 20 J/cm$^2$, double pulsed.

Pulsed dye and frequency-doubled Nd:YAG laser as well as IPL were found to be effective only for ectatic red vessels <1 mm in diameter.[15,16] A bimodal approach to treat leg veins was described where shorter wavelengths (600-800 nm) were used to treat class I superficial, reddish oxygenated telangiectasia and longer wavelengths (800-1100 nm) were used to treat class II and III venulectasia and reticular veins.[17] However, this approach requires the use of two laser devices or a laser device and an intense pulsed light device.[18] The use of long-pulsed 1064 nm Nd:YAG laser in treatment of facial and leg telangiectasias has been recently described.[3]

The 1064 nm wavelength of Nd:YAG laser lies in the near infrared part of the spectrum. This relatively long wavelength allows deep penetration to the veins with minimal effect on the epidermis.[3,18] The main light-absorbing chromophores in the skin are epidermal melanin and hemoglobin in the dermal blood vessels. Melanin has a wide absorption spectrum ranging from 250-1200 nm.[19] Poor absorption of the 1064 nm Nd:YAG by melanin allows safe use in darker skin types and decreases the incidence of pigmentary changes.[16] Nd YAG laser produces better results with large leg veins and less pigmentary changes when compared to 755 nm alexandrite lasers and the 810 nm diode laser, because of the poor absorption by melanin.[16] Hemoglobin also has a broad band of absorption ranging from 500-1100 nm.[7]

Incomplete absorption of the 1064 nm Nd:YAG by hemoglobin and minimal scattering allows full-thickness affection of both small superficial and large deep vessels.[4] The 1064 nm laser energy acts non-specifically by coagulating proteins of the blood and vessel wall. These effects last for at least 6 months.[2] It was postulated that a non-uniform pulse sequence with the Nd:YAG laser produces methemoglobin by the first pulse that changes the optical condition of blood absorption and increases the thermal effectiveness of subsequent pulses.[20]

The energy density, pulse duration, and spot size are important parameters for efficient results as well as protection of the epidermis from thermal damage. Surface cooling may be alone inefficient in counterbalancing the collateral heat generated in the dermis by the laser pulse.[21] The most important variant in laser parameters was the fluence ranging from 80-130 J/cm$^2$,[2] to 180-210 J/cm$^2$,[7] up to more than 350 J/cm$^2$.[22] Long pulse widths up to 50 m sec should theoretically increase treatment efficacy. Long pulse duration may theoretically produce uniform heating and less acoustic damage to the vessel wall that leads to deposition of hemosiderine and hyperpigmentation.[23] Post-laser cooling may decrease epidermal damage secondary to heat generated in the dermis.[13] It can be done by chilled forced air,[2] dynamic cooling device,[6] or surface cooling by contact hand piece at 4ºC.[18] The number of laser sessions ranged from 1-2 sessions,[7] up to 3-5 sessions.[2]

Progressive improvement from 3-6 months after end of the laser sessions is attributed to continued vascular disruption and denaturation of the vascular endothelium.[18] It was observed that immediate hemorrhage is followed by thrombosis and up regulation of cytokines after 1064 nm laser treatment of leg veins.[22]

Treatment of small leg veins responds well to low parameters. But when using the Nd:YAG for clearing leg veins reaching up to 4 mm, higher fluences were used reaching up to 250 J/cm$^2$ and long pulse width 40-50 msec. The effectiveness of these parameters was more satisfactory than those used by Sadick et al.,[13] and Trellers et al.,[24] who did not exceed 130 J/cm$^2$ . Voegeli (2005) used variable spot sizes (3, 5, 7 and 10 mm), highly-variable pulse duration (0.1-300 ms) and high fluences (up to 300 J/cm$^2$) in his series.[25] The use of multiple repetitive pulses and cooling also improved the results and lowered the incidence of side effects which were all reversible in all cases. In other studies of Suthamjariya et al.,[26] and Coles et al.,[27] fluences up to 350 J/cm$^2$ were used but the pain associated with the single pulse mode and high fluences of their studies, makes treatment unpleasant, and according to our experience, sometimes even unbearable for the patient. It is possible that the fact that larger spot sizes used with relatively lower fluences, led to much better and deeper distribution of energy, reducing negative laser thermal effects in the epidermis and thus permitting patients to handle pain better.

**Summary and conclusion:**

The long-pulse 1064 nm Nd:YAG laser as applied in the presented cases offered an excellent solution in the treatment of leg veins up to 4mm in diameter. These results were equal to that of sclerotherapy in leg veins up to 4mm recorded in some refrences without the drawbacks of sclerotherapy. The fear of sclerotherapy of most of the patients has tremendously increased the demand for this type of laser specifically with these results and low side effects. The long pulse Nd:YAG produced high clearance percent in facial and leg veins up to 4mm without complications, most of the side effects recorded in this study were reversible . The shadow that occurred in 60% and 75% of cases of facial and leg telangectasia dissapeard in a period of 2 -3 weeks, as it gave some patients wrong impression that the veins are not completely cleared. Hyperpigmentation ratio was very low in this study due to the parameters used and also the air cooling that was used through out treatment, as cooling decrease the incidence of unrequired thermal damage. Cooling also succeded in controlling pain so that all patients were comfortable through the session and after it. The convertion of hemoglobin into methemoglobin after the first laser pulse used in some cases with increased the efficacy of the used parametes and decreased the demands of further sessions. The high fluence long pulse duration used was very successful in this study. Follow up of cases up to 6 months showed excellent improvement and the high patient satisfaction.

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