

# The Use of Long Pulsed Neodymium-Doped Yttrium Aluminum Garnet for the Treatment of Paediatric Venous Malformations

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**Background:** Venous malformation in the pediatric population can present with pain, bleeding, or a debilitating deformity that can be difficult to manage. Sclerotherapy, surgery, and more recently, long pulsed neodymium-doped yttrium aluminum garnet (Nd : YAG) laser have been used with variable success rates. **Objective:** Our aims and objectives, were to identify the specific group of patients that would benefit from this treatment. **Methods:** A prospective clinical trial was carried out with 59 consecutive patients. The treatment criteria included a large facial deformity and painful or bleeding lesions. One to three treatments were administered at 6~8-week intervals. **Results:** A total of 59 patients were treated. The average follow-up was 24 months. All patients achieved good to excellent results in pain and bleeding control as well as in the reduction of the size of lesions in the lip and oral mucosa. The treatment however, is not effective in reducing the size of large, relatively high-flow lesions in the limbs. Complications from treatment include skin blistering (n=4), ulceration (n=4), and subsequent hypertrophic scarring (n=3). Three patients had partial recurrence after a 3-year follow-up. **Conclusion:** Complex venous malformations cannot be cured but can be symptomatically controlled with the long-pulsed Nd : YAG laser treatment. The treatment satisfaction is high, and there is a

small but definite risk of scarring from treatment. (*Ann Dermatol* 26(4) 474~477, 2014)

## **-Keywords-**

Extremities, Long pulse Nd : YAG laser, Mucous membrane, Paediatric, Venous malformations

## **INTRODUCTION**

Venous malformations (VMs) are the most common type of congenital vascular malformations affecting 1%~4% of the population. They consist of a flattened endothelium exhibiting slow turnover due to the lack of smooth muscle. Although they are present at birth, they may not be detected until years later. These lesions may be present in the skin, mucous membrane, or in any other organ. Most VMs are asymptomatic, and as such, treatment is not necessary. However, in a small proportion of patients, VMs can present with recurrent pain due to thrombophlebitis, and swelling interfering with normal functions. Sclerotherapy, surgery, and, more recently, long pulsed neodymium-doped yttrium aluminum garnet (Nd : YAG) laser have been used for the treatment of VMs, with variable success rates.

Sclerotherapy is widely used as a treatment alone or as an adjunct to surgery. This method of treatment ultimately causes endothelial disruption and coagulation, followed by an intense initial inflammatory reaction, resulting in fibrosis of the VM and contraction of the lesion<sup>1</sup>. Success is largely dependent on the experience of the intervention radiologist, and also on the extent and flow rate of the vessels. Surgical treatment is sometimes used for smaller lesions. Complete surgical excision is often difficult because of either the extent of the lesions or the recurrence

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of adjacent abnormal vessels<sup>1</sup>.

Long-pulsed Nd : YAG laser has gained popularity for the treatment of small- to medium-sized vessels. The advantage of this laser over other shorter-wavelength lasers is that it penetrates deeper, as it has weaker melanin absorption. In addition, with its longer pulse duration, it is more likely to heat the vessels slowly and uniformly, which allows sufficient vessel damage to cause coagulation but avoids vessel rupture, subsequent purpura, and possible postlaser hyperpigmentation. It is, however, not clear from published data if such a treatment will provide long-term symptom relief and the types of VMs that will respond better.

The aim of this study was to examine the efficacy of long-pulsed Nd : YAG laser for the treatment of VMs in the mucosa and in the upper and lower limbs. We aimed to examine the effects of treatment in terms of symptom relief and improvement in cosmetic appearance as well as patient satisfaction after treatment. We also examined the long-term efficacy of treatment.

## MATERIALS AND METHODS

This was a prospective study with local ethical approval. All children with VMs who met the treatment criteria were treated with long-pulsed Nd : YAG laser. The long-pulsed Nd : YAG laser used in the study was Gentle YAG 1064 produced by Candela (spot sizes 8~12 mm, pulse width 50 ms, and power levels 80~100 J).

The treatment criteria included any of the following: functional impairment, large facial deformities, and painful or bleeding lesions. Either magnetic resonance imaging or ultrasonography was used to determine the extent of the VM in all cases. Demographic details were collected before the commencement of treatment. Additional treatments before long-pulsed Nd : YAG treatment, which had not been successful, were also recorded.

All patients received 1~3 treatments that were delivered in 6~8-week intervals, under general anesthesia as day-case procedures.

Clinical efficacy was evaluated subjectively (degree of pain, functional improvement, and cosmetic improvement) and objectively (size and discoloration of the malformation). The results were graded as excellent when there was 75%~100% improvement and good if there was 50%~75% improvement. The efficacy was evaluated for different patient groups, i.e. those with mucosal lesions and those with limb lesions. Any adverse effects from treatment were also recorded.

## RESULTS

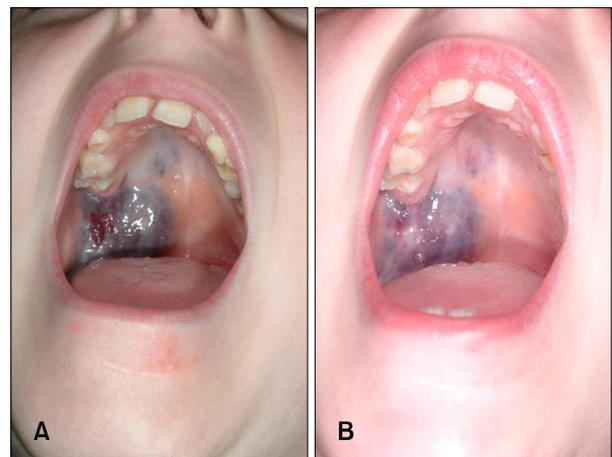
A total of 59 patients with VMs were treated in this study. The mean age of patients was 12.3 years (range, 2~18 years). The patients were predominantly girls (81.3%, 48 of 59). The average follow-up period for these patients was 24 months (range, 6 months to 9 years). The distribution of the VM was as follows: head and neck (23 of 59), 17 of which were on the mucosa; upper limb (15 of 59); lower limb (18 of 59); chest wall (3 of 59).

Before long-pulsed Nd : YAG laser treatment, 32 patients had received multiple other treatments with the candela 595 nm pulsed dye laser (PDL) and/or sclerotherapy. These treatments had not been successful.

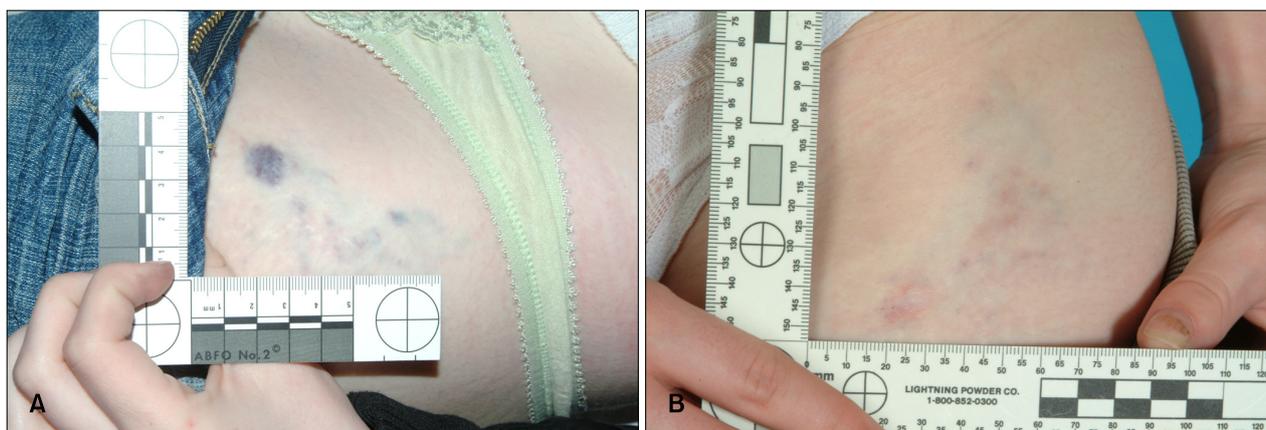
The mean fluence used for upper-limb VMs was 87.5 J/cm<sup>2</sup>; for the lower limbs, 85.7 J/cm<sup>2</sup>; and for mucosal lesions, 86.9 J/cm<sup>2</sup>. The pulse width used was 50 ms for all lesions. The average number of treatments in the upper and lower limbs was 3.4 compared with 3.1 for mucosal lesions.

In the objective assessment for the upper and lower limb groups, 18% (6 of 33) of patients had excellent results, 27% (9 of 33) had good results, and 55% (18 of 33) had no change in their VMs. For the mucosa group, 28% (5 of 18) had excellent results, 56% (10 of 18) had good results, and 17% (3 of 18) had no improvement.

In the subjective assessment of treatment efficacy, 72% of patients responded positively and thought their treatment was worthwhile; they said that they would undergo the laser treatment again. Sixty-seven percent of these patients underwent treatment for VMs on their mucosa. All patients who said they would not undergo treatment again



**Fig. 1.** (A) Mucosal lesion (palate): pretreatment with long-pulsed neodymium-doped yttrium aluminum garnet (Nd : YAG) laser. (B) The same lesion after treatment with long-pulsed Nd : YAG laser.



**Fig. 2.** (A) Lesion in the right thigh: pretreatment with long-pulsed neodymium-doped yttrium aluminum garnet laser. (B) The same lesion in the right thigh: posttreatment.



**Fig. 3.** Ulceration to the medial malleolus after the neodymium-doped yttrium aluminum garnet laser treatment.

(28%) had received treatment for VMs on their upper or lower limbs (Fig. 1).

Thirty-one of 33 patients with upper- and lower-limb lesions had a previous unsuccessful treatment before long-pulsed Nd : YAG laser treatment, i.e. sclerotherapy or PDL. After the long-pulsed laser treatment, 55% (17 of 31) of those patients with previous treatment experienced no change. Twenty-six percent (8 of 31) of patients with previous treatment had good results, and 19% (6 of 31) had excellent results. Half of the patients with mucosal lesions (9 of 18) did not undergo prior treatment; however, from those who did (9 of 18), 11% (1 of 9) had no change, 78% (7 of 9) had good results, and 11% (1 of 9) had excellent results (Fig. 2).

The overall complication rate of the long-pulsed Nd : YAG laser treatment was 20% (12 of 59). Skin blistering accounted for 10% (6 of 59) of the patients treated; 3 patients

showed blisters on the lower limb, 2 patients showed blisters on the upper limb, and 1 patient showed blisters on the mucosa. Ulceration (Fig. 3) occurred in 13.4% (4 of 59) of the patients treated; 2 experienced ulceration on the upper limb, 1 experienced ulceration on the lower limb, and 1 experienced ulceration on the mucosa. Two of 59 patients (3.4%) developed hypertrophic scarring after the ulceration; 1 patient developed scarring in the upper limb and 1 developed scarring in the lower limb.

Overall, 83% (10 of 12) of the complications occurred in either the upper or the lower limb. Mucosal lesion complications accounted for 17% of the total number.

The overall recurrence was defined on the basis of patients whose symptoms had improved (good or excellent results) but subsequently recurred. Fifteen patients had good or excellent results in the limbs, and 4 had a recurrence (26%). In the mucosa group, 1 patient out of 15 who were treated successfully experienced a recurrence (7%).

## DISCUSSION

Treatment of VMs is largely symptomatic in most patients. It is important that the treatments administered are effective in improving the symptoms of the malformation in the medium or long term, with little adverse effects. It is also important to know which subtypes of patients respond best to treatment.

We assessed the efficacy of the treatment of VMs with long-pulsed Nd : YAG laser in terms of symptom relief, i.e. pain, and also the cosmetic appearance of the lesions. We found that almost all lesions in the lip and oral mucosa were treated successfully. The treatment was, however, proven less effective in reducing the size of large,

relatively high-flow lesions in the limbs. Our results are comparable to most of the published results, for example, those of Rebeiz et al.<sup>2</sup> who reported successful treatment in most of their patients with head and neck VMs, with minimal morbidity. In addition, Scherer and Waner<sup>1</sup> recommend the Nd : YAG laser treatment as a first measure for VMs in the face and neck. Patients in both the limb and mucosa groups who complained of pain as their main symptom all showed good improvement.

When comparing the treatment efficacy of the different groups of patients, we observed a clear difference between the treatment of mucosal lesions and limb lesions. Patients with mucosal lesions generally responded very well to treatment, whereas patients with relatively high-flow malformations on the limbs rarely did so.

The difficulty in treating VM in the limbs is evident from other studies that used different modalities such as sclerotherapy. Rautio et al.<sup>3</sup>, Mendonca et al.<sup>4</sup>, and Tan et al.<sup>5</sup> all reported that when sclerotherapy was used to treat lower-limb VMs, the success rates were lower, and the symptoms were likely to remain unchanged after treatment, or they were likely to recur after a temporary treatment. Their hypothesis that the effectiveness of treatment is diminished because blood pooling occurs constantly in dependent areas, causing engorgement, and dilatation of the malformations may be among the reasons why long pulsed Nd : YAG laser is less successful compared to the treatment of mucosa lesions.

All of our patients received simultaneous cooling during treatment to reduce cutaneous complications. Despite this effort, our overall complication rate was 20% (12 of 59), comprising blistering, hypertrophic scarring, and ulceration. Most of these complications followed the treatment of the lower or upper limb. The head and neck lesions in our patients accounted for 3.4% of the complications in the total number of patients. Similarly, Scherer and Waner<sup>1</sup> reported a <5% complication rate in patients with head and neck lesions.

Our high recurrence rate of 26% on the limbs as well as the overall complication rate of 20% emphasize the necessity for treatment to provide long-term benefits, especially in treating asymptomatic cases in the hope of gaining

cosmetic improvement. From the current literature, Groot et al.<sup>6</sup> report short follow-up periods of 6 months, and Ulrich et al.<sup>7</sup> report a limited number of cases (n=5). Both parameters must be substantially increased to draw definitive conclusions for the long-term efficacy of long-pulsed Nd : YAG laser for treating VMs, especially in the limbs. In conclusion, long-pulsed Nd : YAG laser is an effective treatment of mucosal VMs. Most of the patients in our study found the treatment to be successful and would opt for it again if need be. Owing to the high risk of complications of the treatment, we feel that this treatment should be offered to a selective group of patients and should be carried out with caution. Further study will help in establishing the best parameters to achieve better results, with minimal complications.

## REFERENCES

1. Scherer K, Waner M. Nd:YAG lasers (1,064 nm) in the treatment of venous malformations of the face and neck: challenges and benefits. *Lasers Med Sci* 2007;22:119-126.
2. Rebeiz E, April MM, Bohigian RK, Shapshay SM. Nd-YAG laser treatment of venous malformations of the head and neck: an update. *Otolaryngol Head Neck Surg* 1991;105:655-661.
3. Rautio R, Saarinen J, Laranne J, Salenius JP, Keski-Nisula L. Endovascular treatment of venous malformations in extremities: results of sclerotherapy and the quality of life after treatment. *Acta Radiol* 2004;45:397-403.
4. Mendonca DA, McCafferty I, Nishikawa H, Lester R. Venous malformations of the limbs: the Birmingham experience, comparisons and classification in children. *J Plast Reconstr Aesthet Surg* 2010;63:383-389.
5. Tan KT, Kirby J, Rajan DK, Hayeems E, Beecroft JR, Simons ME. Percutaneous sodium tetradecyl sulfate sclerotherapy for peripheral venous vascular malformations: a single-center experience. *J Vasc Interv Radiol* 2007;18:343-351.
6. Groot D, Rao J, Johnston P, Nakatsui T. Algorithm for using a long-pulsed Nd:YAG laser in the treatment of deep cutaneous vascular lesions. *Dermatol Surg* 2003;29:35-42.
7. Ulrich H, Bäumlner W, Hohenleutner U, Landthaler M. Neodymium-YAG Laser for hemangiomas and vascular malformations – long term results. *J Dtsch Dermatol Ges* 2005;3:436-440.