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Perspectives on Innovations in Pulsed Dye Laser Development

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Introduction

In the late 1970's, argon lasers were the first lasers used to treat cutaneous vascular lesions. Because of the argon's non-selective injury to blood vessels and surrounding tissue, proper treatment technique was truly an art form. Physicians who used argon lasers successfully were highly skilled with an expansive understanding of laser tissue interaction. Today's lasers are used by a much larger audience with varying degrees of experience over a much wider range of clinical applications. This growth in the use of lasers is in large part due to leaps in technology, as well as, increased clinical understanding of laser tissue interaction. In this article we will review some of the major innovations in technology that have enabled growth in clinical applications of one of the most widely used lasers—the pulsed dye laser.

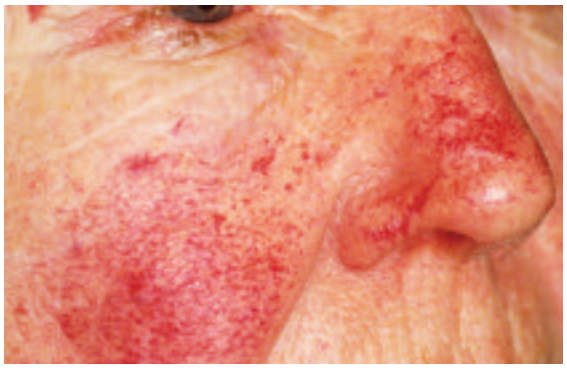
The pulsed dye laser is, and has always been, the gold standard for the treatment of vascular lesions, especially port wine stains and hemangiomas. Over the past 20 years, it remains the safest and most effective treatment for the widest range of vascular lesions that present for treatment.

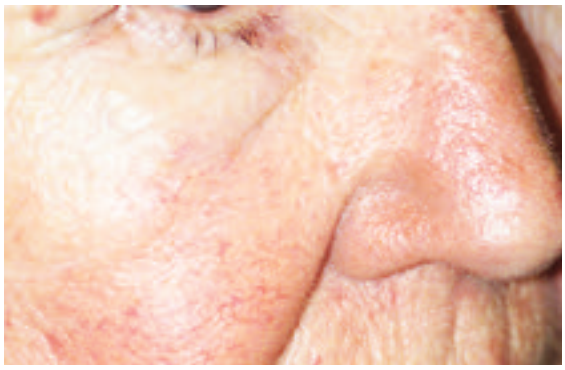
Background

During the mid 1980's, the introduction of the theory of Selective Photothermolysis by Anderson and Parrish, led to the birth of the pulsed dye laser. Pulsed dye lasers are unique in that they can deliver very high peak powers of energy over short periods of time. These high peak power pulses cause a selective thermal injury to targeted structures in the skin with minimal collateral injury to surrounding tissue. The first commercialized pulsed dye laser was designed to deliver 450 microsecond pulses at a wavelength of 585 nm. This parameter set was the closest technical specification to the ideal parameters per Anderson and Parrish's description of Selective Photothermolysis. These specifications enabled users to treat pediatric port wine stains, hemangiomas, facial telangiectasia, rosacea as well as warts, striae and scars. Port wine stains and hemangiomas could be dramatically improved and facial veins could be eliminated in just a few treatments. While extremely effective and safe when compared to existing laser therapies, these early pulsed dye lasers caused intense purpura or bruising in the skin. While purpura was acceptable to many port wine stain patients, most cosmetic patients with facial telangiectasia were not willing to accept purpura as a side-effect.

The first pulsed dye laser commercialized was approximately the size of a washing machine, requiring water cooling and weighing approximately 1,000 pounds. This laser operated at a maximum repetition rate of 1 pulse every three seconds using a 5 mm spot. It could take several hours to treat a

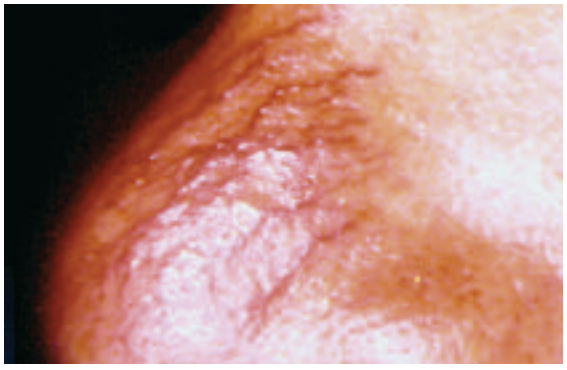
Rosacea

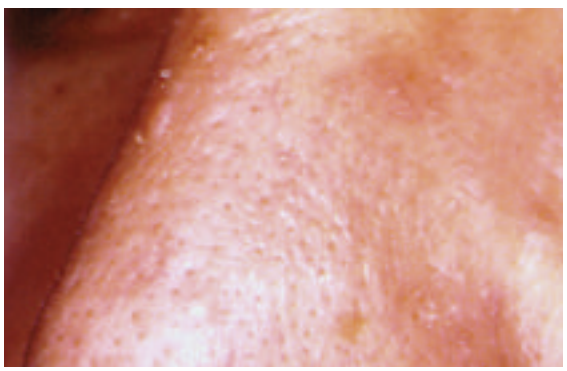




10-20 ms, 10 mm, 7.5 J/cm^2, DCD: 30-10, 3 tx

Facial Telangiectasia





6-20 ms, 7 mm, 11-12 J/cm^2, DCD: 40-20, 2 tx

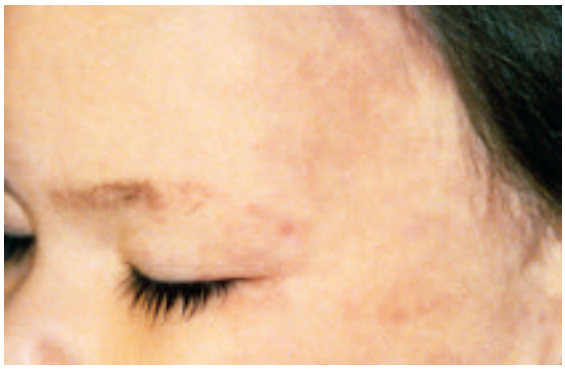
large port wine stain on a patient often requiring general anesthesia for many pediatric patients. Nevertheless, the original pulsed dye laser was extremely safe and very effective making it the gold standard for vascular lesion treatment.

Developments

Presumably the single most important technical advance in pulsed dye lasers since then was the advent of dynamic cooling. Developed by Stuart Nelson of the Beckman Institute, the concept of dynamic cooling is to deliver a short spurt of cryogen to the skin prior to the laser pulse to cool and protect the epidermis. The evaporative cooling of the cryogen reduces the temperature of the epidermis creating an anesthetic effect. Dynamic cooling is particularly helpful in decreasing the level of discomfort during treatment. Dynamic cooling allows for large port wine stains to be treated more quickly, and less painfully in adults and in children under the age of one year, even on the face. An additional benefit of dynamic cooling is the ability to utilize higher laser fluences. Physicians can employ higher fluences, causing greater thermal injury to the targeted vessels without causing increased trauma to the epidermis. This enables physicians to reach a clinical endpoint in fewer treatments. In many cases the use of higher fluences can achieve additional clearing in port wine stains and hemangiomas that had reached a clinical plateau with lower fluences.

As technology has matured, so has the pulsed dye laser. More recent clinical research has demonstrated that the use of a longer wavelength (595 nm) and larger spot sizes would allow for deeper penetration into skin and vessels, enabling improved clinical responses for many applications. Along with this clinical development, technical advances in pulsed dye laser design enabled the commercialization of longer, more suitable pulse durations. The pulse duration of the pulsed dye laser could now be extended from 450 microseconds to 1500 microseconds (1.5 msec). This longer pulse duration more closely matched the original desired parameters described by Anderson and Parrish. The combination of the use of longer wavelengths and extended pulse durations improved clinical responses in many applications. Deeper lesions could now be targeted along with larger diameter vessels. The duration and intensity of purpura was also noted to be reduced with the longer pulse durations.

Port Wine Stain

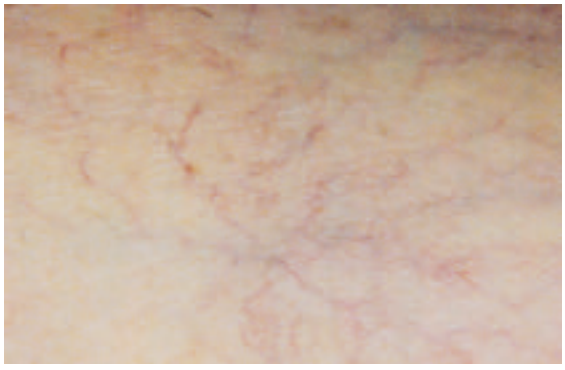


6 ms, 7 mm, 12 J/cm², DCD: 30-30, 1 tx

Angioma

6 ms, 7 mm, 12 J/cm², DCD: 30-30, 1 tx

Leg Telangiectasia



20 ms, 7 mm, 12.5 J/cm², DCD: 30-10, 1 tx

The longer wavelength made it possible to target deeper port wine stains and larger diameter vessels such as telangiectasia on the nasal ala. For many applications the use of 595 nm is accepted as the desirable wavelength due to its deeper penetration.

Further developments in power supply design enabled the pulsed dye laser to overcome the 1.5 millisecond barrier. The innovative design of the Vbeam utilizes Micro-pulses that can be strung together to reach 10 milliseconds and beyond. Even greater energies could be applied to the skin over longer periods of time. The effective peak power delivered to the skin could be dramatically reduced. From a clinical perspective, this led to the development of purpura-free procedures for facial telangiectasia and rosacea. Cosmetic patients who were previously opposed to the use of the pulsed dye laser and the associated purpura were now candidates for treatment. This opened up a new chapter for the pulsed dye laser. In most cases, facial spider vein patients and rosacea patients can safely be treated with little or no purpura.

Rosacea

20 ms, 3x10 mm, 11.5 J/cm^2, DCD: 20-30, 1 tx

Scar

6-20 ms, 7 mm, 8 J/cm^2, DCD: 30-20, 4 tx

Facial rejuvenation has become one of the most popular procedures for the pulse dye laser. Patients can have blood vessels and diffuse facial redness removed from their skin and at the same time stimulate the production of new collagen in the dermis. New collagen deposition has been shown to smooth the surface of the skin filling imperfections and soften wrinkles over a series of treatments. Patients are able to return to normal activities within an hour of the procedure.

The Vbeam represents the latest version of the pulsed dye laser. It is almost 20 times more powerful and 18 times faster that the original pulsed dye laser. It is a fraction of the size of the original and weighs in around 400 pounds. These leaps in technology and clinical innovation have enabled us to routinely perform what was once thought to be impossible. I look forward with earnest to the next 15 years of innovation and wonder how far it will take us.

Conclusion

The Vbeam is the most used laser in our practice. We use it to treat all types of vascular lesions: from port wine stains, and hemangiomas to facial redness, spider veins, scars, striae, leg veins and for facial rejuvenation . . . with great success. Included here are a series of most impressive clinical examples.

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