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The treatment of vascular and pigmented lesions in oral and maxillofacial surgery

Joseph Niamtu III, DDS

Private Practice, Oral/Maxillofacial & Cosmetic Facial Surgery, 10230 Cherokee Road, Richmond, VA 23235, USA

If one were to list the significant contributions to medical science over the past one thousand years, 1 of the top 10 items would have to be laser technology. Prehistoric man used sharp stones to incise animal skin and muscle, and in that thought, little has changed in the scalpel blades we use today.

All laser technology does not center around incisional or resurfacing procedures. The ability to treat vascular lesions and malformations has improved the treatment for conditions that as little as 20 years ago had no real efficient treatment options. Excisional techniques with skin grafting were frequently performed to eradicate vascular lesions, with resultant scarring as bad as or worse than the original lesion.

So many laser wavelengths and treatment options now exist that it would be exhaustive to attempt to include every laser indication for every vascular or pigmented lesion. This article attempts to discuss the contemporary laser wavelengths and common lesions encountered by oral and maxillofacial surgeons. All of the lasers discussed in this article are well within the realm of an oral and maxillofacial surgical practice, especially when cosmetic surgery is part of the surgeon's practice. Like any advanced treatment, one cannot read an article or a book chapter to obtain proficiency. Continuing education and finding a colleague who has experience with a specific laser to observe is mandatory. It is easy to rent lasers in today's market, and after gaining observational experience, it is very rewarding to incorporate this technology in your practice. Tina Alster, MD, one of the true laser pioneers, stated, "in the tricks of the trade, learn the trade first, the tricks will come later." Lasers can produce very rewarding results but also devastating complications. This article is meant to provide a synopsis of some of the more common laser wavelengths and treatments of respective lesions.

Vascular lasers

Anderson and Parrish [1,2] revolutionized laser technology with their landmark article in 1981 describing selective thermolysis. This theory stated that targets in the skin (chromophores) could be selectively destroyed by specific wavelengths and pulse durations. The localized absorption of a specific wavelength by melanin or hemoglobin with the subsequent release of heat would selectively destroy the target without damage to the surrounding tissue. The pulsed dye laser (585 nm) was developed to use the concept of selective thermolysis and remains the cornerstone of vascular treatment today. Although this wavelength presents specific sequelae, all other vascular lasers are judged against its performance and results.

Another principle that has made lasers acceptable for targeting specific tissue and sparing normal tissue is pulse technology. This concept centers around the phenomenon of thermal relaxation time. The pulsed dye lasers have a pulse duration of 450 microseconds. The thermal relaxation time of small- to medium-sized blood vessels ranges from 1 to 5 milliseconds. The heat generated by each pulse of the laser is confined to the targeted blood vessels and is dissipated before it can spread to lateral normal tissue. To treat various chromophores, each tissue type has a specific

E-mail address: niamtu@niamtu.com

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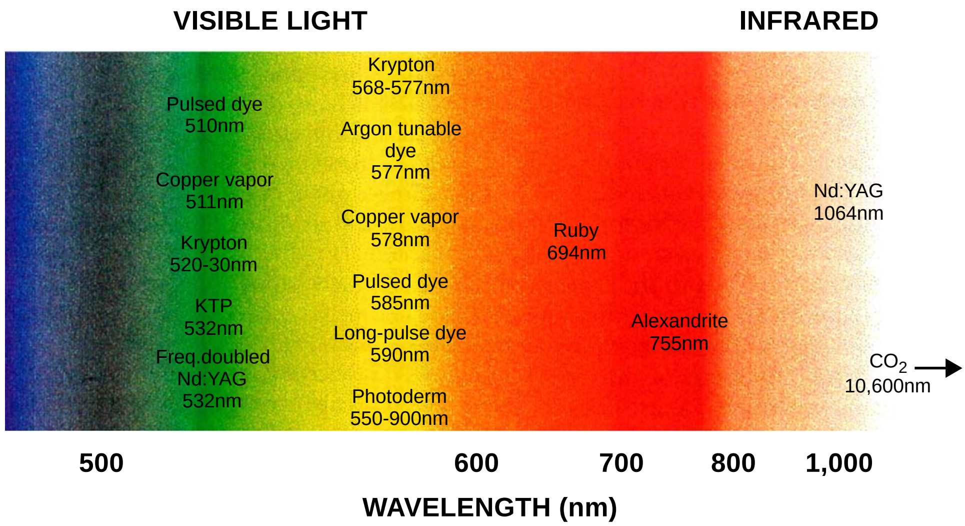

Fig. 1. Position of various vascular lesions in the light spectrum. (Courtesy of Tina Alster, MD, Washington, DC.)

thermal relaxation time that is coordinated with the duration of laser pulsing to spare normal tissue. Selective thermolysis and thermal relaxation time are paramount for the understanding of laser treatment and the development of target-selective lasers.

A caveat occurs when using vascular lasers in the 500 to 600 nm area. Melanin is a chromophore that competes with hemoglobin for yellow light. Patients with pigmented skin or even a suntan could have the laser energy absorbed by melanin instead of hemoglobin, the desired chromophore for vascular lasers. In addition, melanin may overlie the vascular lesion, making the energy that reaches the hemoglobin less effective. Pigmented skin can be treated with pulsed dye or 532-nm potassium titanyl phosphate lasers, but a more conservative approach with spot testing is recommended. The informed consent of the surgeon should also discuss hypo- and hyperpigmentation as a result of melanin disruption. Some lesions such as poikiloderma of Civatte have pigmented and vascular components and are discussed later in this article.

Historically, multiple-wavelength lasers have been developed to treat vascular lesions (Fig. 1). Box 1 lists lasers that have been used for vascular treatment [3].

Common vascular lesions

For the oral and maxillofacial surgeon performing cosmetic facial surgery, requests for the treatment of telangiectasias (spider veins) are quite common. In addition, other patients may present with various vascular lesions such as hemangiomas, port-wine stains, vascular malformations, and poilkiloderma of Civatte.

Telangiectasias are permanently dilated cutaneous blood vessels visible to the naked eye [4]. Telangiectasias occur in up to 48% of healthy children and 15% of normal adults [5,6]. Telangiectasias of the lower extremities occur in 29% to 41% of women and 6% to 15% of men [7]. Telangiectasias are also associated with various intrinsic and extrinsic factors. Intrinsic factors include genetic or congenital factors, primary cutaneous disorders (rosacea), systemic disease (collagen vascular disease, Cushing's disease, metastatic carcinoma), and pregnancy with venous incompetence. Extrinsic factors may be drug-induced (estrogen, chronic corticosteroid usage) actinic or radiation

Box 1. Lasers used for vascular treatment

- Flashlamp-pumped pulsed dye (585 nm)
- Frequency-doubled Nd:YAG (532 nm; Q-switched)
- Potassium titanyl phosphate lasers (532 nm)
- Photoderm (555 – 900 nm)
- Krypton (568 nm)
- Argon-pumped tunable dye (577 nm)
- Copper vapor (578 nm)
- Long-pulsed dye (590 nm)
- Intense-pulsed light sources (not laser technology)

dermatitis, postsurgical (rhinoplasty, wound closure under tension), or trauma.

A telangiectasia by definition does not exceed 1.0 mm in vessel diameter. Thin, wiry, red telangiectasias extend from arterioles or from the arterial side of a capillary loop. Cordlike blue vessels arise from venules or from the venous side of a capillary loop. Red capillary telangiectasias arising from the capillary loop may also become bluer with time as hydrostatic pressure and venous backflow increase. Spider telangiectasias consist of red radiating arms arising from a central pulsating arteriole.

Vasoactive factors cause vascular neogenesis and can be triggered by alcohol, estrogen, chronic actinic exposure, and direct trauma [8]. It should always be kept in mind that the presence of numerous telangiectasias may indicate dermatologic or systemic internal disease.

Hemangiomas

Approximately 30% of all hemangiomas are visible at birth. The remaining 70% become visible within 1 to 4 weeks after birth. Hemangiomas occur 5 times more often in females than in males and occur predominantly in Caucasians. Low birth weight infants (less than 2.2 lb) have a 26% chance of developing a hemangioma [9].

The cause of hemangiomas has not been determined, and neither parent should bear guilt over the occurrence or appearance of one of these birthmarks. The important thing to remember is that accurate diagnosis and early intervention is key. Hemangiomas present with variable morphology. Some are small and hardly noticeable, whereas others are large and disfiguring.

Approximately 83% occur in the head and neck area. The remaining 17% appear throughout the rest of the body (both externally and internally). In the early stages, some appear either as bluish or reddish spots or flat patches. Rarely is a hemangioma fully grown at birth.

Hemangiomas that are flat and appear reddish are considered superficial and those that are deep beneath the skin and appear bluish are called deep hemangiomas. When a hemangioma is both deep and superficial it is called a compound hemangioma. The correct diagnosis is critical for proper treatment.

Hemangiomas can grow for up to 18 months and then begin a long, slow regression known as involution. This involution can last from 3 to 10 years. Although all hemangiomas eventually involute, the result is not always cosmetically acceptable. Early intervention has been shown to reduce the need for corrective surgery after involution has occurred, or at least minimize extensive corrective surgeries in the future. Psychosocial scarring, which occurs when a child has been forced to live with a facial deformity until involution has been completed, can be avoided by early, aggressive intervention.

Port-wine stains

Venual malformations (port-wine stains) are always present at birth and can range from pale pink to dark purple. In the past, these lesions were erroneously called "capillary hemangiomas." Port-wine stains occur in 0.3% of births and occur equally among males and females [9].

The cause recently has been associated with a deficiency or absence in the nerve supply to the blood vessels of the affected area. These nerves control the diameter of the blood vessels. If the nerves are absent or defective, the vessels will continue to dilate and blood will pool or collect in the affected area [9]. The result is a visible birthmark. Laser therapy, which is used to remove a port-wine stain, may only be temporary. Because the deficiency is in the nervous system, in time, the blood may repool in the affected area and the birthmark will reappear. After a port-wine stain is lasered, it is important at the first sign of reoccurrence to have one or two additional treatments to keep it faded. The individual will have to have maintenance laser treatments for life. Because port-wine stains can be progressive, treatment should be done early to prevent cobbling of the skin and thickening and darkening of the stain. These lesions vary from low-grade to high-grade and from pale to dark. Low-grade lesions progress at a slower rate than high-grade lesions.

Vascular laser treatment options

Flashlamp-pumped pulsed dye laser

The Flashlamp-pumped Pulsed Dye Laser was specifically developed for the treatment of cutaneous vascular lesions (Candela Corp., Wayland, Massachusetts). This laser uses a wavelength of 585 nm (yellow light) for which the target chromophore is oxyhemoglobin. This wavelength seeks red chromophores and does not affect other tissues in the path of the beam. This selectivity for oxyhemoglobin allows the pulsed dye laser to destroy blood vessels without damaging other tissues. Also important is the pulse duration of the 585-nm laser. The pulse duration of 450 microseconds is shorter than the 1- to 5-millisecond thermal relaxation time of superficial cutaneous blood vessels [10], which means that each laser pulse ends before heat can diffuse to adjacent structures, thus confining the damage to the target vessels.

Common indications for the 585-nm pulsed dye laser are telangiectasias, port-wine stains, and poikiloderma of Civatte. It must be kept in mind that different wavelength lasers require specific eye protection. Proper goggles are paramount to prevent damage to the surgeon and patient. Approved goggles should have the correct wavelength listed on the eyewear.

The laser is fired in single pulses by depressing the switch on the handpiece. Various spot sizes are used, but 5- to 7-mm spot sizes expedite treating large areas. The laser is commonly used with a fluence of 6.0 to 7.5 J/cm^2. This firing causes a brief pain similar to being snapped with a rubber band. Generally, the spots are not overlapped. A test spot should be performed and the spot should produce immediate purpura without blistering or crusting. When treated, the lesions should no longer blanch. As with any laser treatment, conservative treatment is the safest avenue. Overlapping can damage the dermis and cause scarring. Many spider telangiectasias will clear after a single treatment. A light coat of triple-antibiotic ointment is applied if any crusting or ulceration develops; otherwise, no postoperative treatment is necessary.

A normal result of treatment (and the greatest drawback of the 585-nm pulsed dye laser) is unsightly purpura that persists for 10 days and is difficult to cover with makeup (Fig. 2). This purpura results from vessel rupture due to the rapid absorption of energy by oxyhemoglobin. It is imperative that the patient be shown pictures of the purpura in the preoperative consultation. This will allay postoperative concerns and allow the patient to prepare makeup and recuperation plans.

Fig. 2. Purpura are a normal but undesirable result of 585-nm pulsed dye laser treatment.

Because the beam is delivered in a round pattern, some areas will not touch each other and a lattice pattern may persist and require subsequent treatment. This situation is addressed at retreatment by arranging the spots to treat the latticed area.

Port-wine stains are also commonly treated with the 585-nm pulsed dye laser. These lesions require multiple treatments. A recent article [11] detailed a new means of treating port-wine stains by combining the traditional 450-microsecond short pulse with an increased long pulse of 1.500 microseconds with a wavelength of 590 to 600 nm. With this regimen, the first pass with the longer pulse damages the lesion at a deeper level while the short-pulse setting treats the more superficial portion of the lesions. This method reportedly reduces the number of laser treatment sessions.

532-nm diode laser

The 532-nm diode laser is the laser with which author has the most experience. This laser is suited for the oral and maxillofacial surgery practice for several reasons. It is smaller, more portable, and more affordable than other common vascular wavelength lasers, and it is primarily used for head and neck treatment.

532-nm laser physics

Just as transistors made vacuum tubes obsolete, semiconductor diode-pumped lasers are replacing vacuum tube and dye lasers. The 532-nm Diolite Diode Laser (Iriderm, Mountain View, California) is a lightweight, portable unit about the size of a VCR. The laser weighs only 15 lb (6.8 kg) and uses standard wall power, consuming less than 350 W of electrical power (Fig. 3).

The 532-nm wavelength is a green light that is obtained by a process known as frequency doubling. Diodes are commonly used in many devices such as bar code readers and CD players. They are typically made of gallium arsenide and can be doped with other elements to change their characteristics. A high-powered diode laser at 808 nm is used to optically pump an Nd:YAG crystal that produces a 1064-nm light (see Fig. 2). This light is then focused onto a potassium titanyl phosphate laser crystal to double its frequency, which halves the wavelength, producing a 532-nm wavelength. A red diode aiming beam is added to

Fig. 3. The Iriderm Diolite 532-nm diode laser.

target the 532-nm beam. The diode-pumped, frequency-doubled Nd:YAG laser is referred to as the 532-nm diode laser. This laser is also called a millisecond Nd:YAG laser, to indicate its ability to vary the pulse duration according to the vessel diameter and location that determine the thermal relaxation time. The absorption of green light at 532 nm by oxyhemoglobin is very high, resulting in a high extinction coefficient. The 532-nm, green light wavelength is also highly absorbed by melanin, which is an advantage because the 532-nm diode laser may also be used to treat pigmented lesions.

The pulsed dye laser at 585 nm and the krypton laser at 568 nm also target oxyhemoglobin. All three lasers penetrate tissues to a similar depth and react with oxyhemoglobin essentially the same way; however, there are significant differences due to the pulse durations. Pulsed dye lasers produce pulse durations of 450 microseconds to 1.5 milliseconds. These pulse durations produce selective treatment of vascular lesions; however, the 585-nm flashlamp-pumped pulsed dye laser causes violent vaporization of blood within the vessel, occurring at about 140°C. The short pulses of 450 microseconds (0.45 milliseconds) heat the oxyhemoglobin so rapidly that it creates a steam bubble and bursts holes in the vessels. This destruction of the vessel, with resultant extravasation of red blood cells, gives rise to clinical purpura [8].

In contrast, the 532-nm diode laser delivers a pulse duration from 1 to 100 milliseconds, which provides selective photothermolysis without purpura. The 532-nm diode laser, using moderate pulses between 10 and 50 milliseconds, targets the abnormal vascular structures and spares the normal capillaries, hence producing no purpura. The much longer pulse duration of 1 to 100 milliseconds seems to be well matched to the thermal relaxation time of most facial vessels.

Clinicians who have experience with the 532-nm diode laser are familiar with the immediate disappearance of the ectatic vessel after laser-light exposure. Active or passive vasoconstriction cannot explain the complete gross resolution or emptying of the vessel lumen. With the longer 532-nm diode pulses, the blood is more gently heated and damages the endothelial cells, but does not burst the vessel. It is theorized that the laser energy creates a small steam bubble that expands along the axis of the vessel, clearing the lumen by pushing a column of hot blood along the vessel. As the vessel cools during its thermal relaxation time, the vapor bubble condenses, collapsing the vessel wall. Thermal coagulation of the blood, now ejected well beyond the actual exposure site, creates an intravascular "plug," leaving an empty, thermally damaged lumen at and around the site of the laser exposure. This process is significant because gentle intravascular vaporization forces extremely hot blood to travel millimeters beyond the actual site of laser impact [12].

Anesthesia

Although most surgeons use no anesthesia, this is not necessarily in the best interest of the patient. Most patients can tolerate the smaller spot sizes with no anesthetic; however, many patients jump, wince, or are otherwise uncomfortable during treatment. Single laser pulses are activated by tapping the footswitch intermittently and cause a minor, slightly delayed pain that is often described as a "rubber-band snap." Holding down the foot switch will cause a continuous but adjustable repeat rate. Using the continuous, rapid-fire repeat provides faster treatment but also is considerably more uncomfortable for the patient. The use of a refrigerated aloe gel will increase patient comfort and does not interfere with the laser light. When treating the nasal alae, upper lip, or periorbital areas, the author frequently uses local anesthetic blocks. Areas not amenable to nerve block may be treated with local infiltration. Some patients exhibit considerable lesions, and it is not uncommon to need intravenous sedation with this population. When the is patient sedated, larger areas are treated so that multiple sessions are not necessary.

Techniques and settings

Any residual makeup is removed and a spot test is performed on an inconspicuous area of the face or neck to evaluate the patient's pain response and the selected procedural parameters. Special care should be used when treating tanned or pigmented skin because a potential exists for scarring due to the affinity of the 532-nm wavelength for melanin. Due to its wavelength, the 532-nm laser penetrates less deeply than longer wavelength lasers, so is not equal to those lasers for the treatment of deeper vessels.

The laser fluence is set with the company's suggested energy levels as a guide. The handpiece size is chosen to be consistent with the diameter of the vessels being treated. Most frequently, the author uses the 700-μm handpiece with a setting of 3 W and 24 to 30 J/cm^2, with a repeat rate of 15 Hz. A rapid repeat rate is used and the handpiece is moved quickly because the induced flushing will obscure smaller telangiectasias.

The basic treatment technique is simple. The laser spot is used to trace individual vessels to an endpoint of disappearance (Fig. 4). The laser traces the individual vessels and causes them to blanch or collapse. Immediate resolution of the individual vessel is the treatment endpoint. Some vessels may require several passes; however, a gray blanching of the skin should be used as an absolute endpoint. Excessive thermal energy can cause linear hypopigmentation, hyperpigmentation, and atrophic scarring.

Arborized telangiectasias are treated by starting at the center of the branching and working distally. Cherry angiomas or round punctate lesions are treated with multiple pulses at the center of the lesion. Matted ectatic vessels or small port-wine stains are better treated with a larger spot size and lower fluence. This treatment usually requires some form of anesthesia.

The 532-nm laser will cause immediate erythema and edema. Prolonged treatments become difficult because the erythema obstructs smaller vessels. Therefore, multiple short sessions are often used. Although most vessels can be adequately treated with a single session, some vessels can be recalcitrant or recurrent and may require additional sessions or maintenance several times per year. For those patients with severe ectatic vessels or self-consciousness, this is usually a minor trade off.

Fig. 4. The individual ectatic vessels are traced with the 700-nm handpiece.

Because the epidermal integrity is not violated, no specific postoperative treatment is necessary and makeup may be worn immediately. For crusting or ulceration, a triple-antibiotic ointment is applied for several days. Cool compresses are used for edema and discomfort, and analgesics have not been necessary in the author experience. Treatment sessions are spaced at least 2 weeks apart when aggressive treatment is used or when sensitive skin response is seen. The credo for treating facial telangiectasias is that if a vessel is large enough to be injected, then it is too big for this laser. Figs. 5 and 6 show successful before and after pictures of 532-nm diode laser treatment of facial telangiectasias. Fig. 7 shows immediate, successful 532-nm diode laser treatment of a spider angioma, and Fig. 8 shows the results of multiple treatment sessions for a small port-wine stain with the 532-nm diode laser.

Treatment of deep cutaneous vascular lesions

This section is dedicated to the treatment of deeper and larger vessels that would likely be out of the realm of the 532-nm diode laser. Although these stronger lasers will also treat minor teleangectasias, they are more often employed for their power

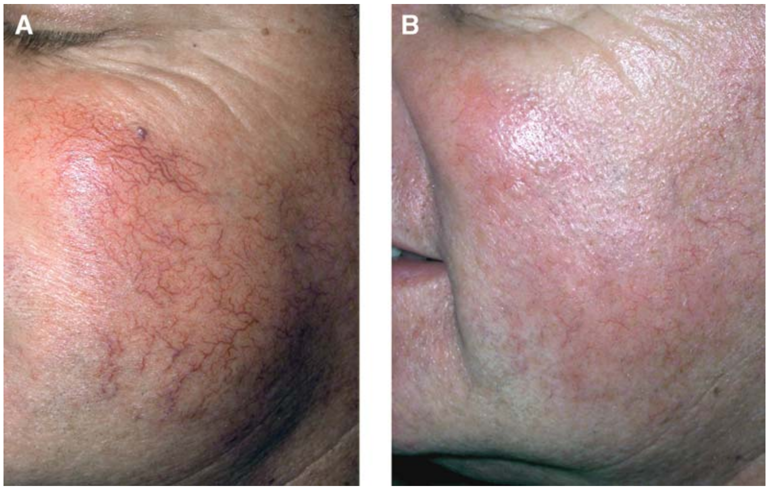

Fig. 5. (*A*) Before and (*B*) after two treatment sessions for facial telangiectasias with the 532-nm diode laser.

and depth capability to treat larger and deeper vessels, especially leg veins.

Although the 585-nm pulsed dye laser has proved to be effective in superficial lesions and some deeper lesions, it is less than ideal in deeper lesions. For instance, port-wine stains rarely clear completely, and hypertrophic port-wine stains and hemangiomas do not respond consistently [13]. In addition, multiple treatment sessions are required, and each session can leave unsightly purpura that last up to 10 days, although the newer systems shorten this period.

Other modalities that have been used for deeper vascular lesions of the face and extremities include electrocautery, cryotherapy, sclerotherapy, radiation, corticosteroids, intralesional interferon, and cytotoxic agents [14]. These techniques have not been effective and can cause significant side effects.

Newer lasers with longer wavelengths and pulse durations have enabled the treatment of deeper and larger caliber vessels. The 1064-nm Nd:YAG laser can create a coagulation effect at a depth of 5 to 6 mm. New systems feature high peak power, long-pulse Nd:YAG lasers. These systems have wavelengths of 1064 nm, a maximum peak power of 14,000 W, and a pulse duration that ranges from 0.1 to 300 milliseconds. Maximum fluence that can be delivered is 300 J/cm^2. The spot size is adjustable from 3 to 10 mm at the level of the handpiece. A self-contained, internal cooling system is administered to tissue by the handpiece. Oxyhemoglobin contained in

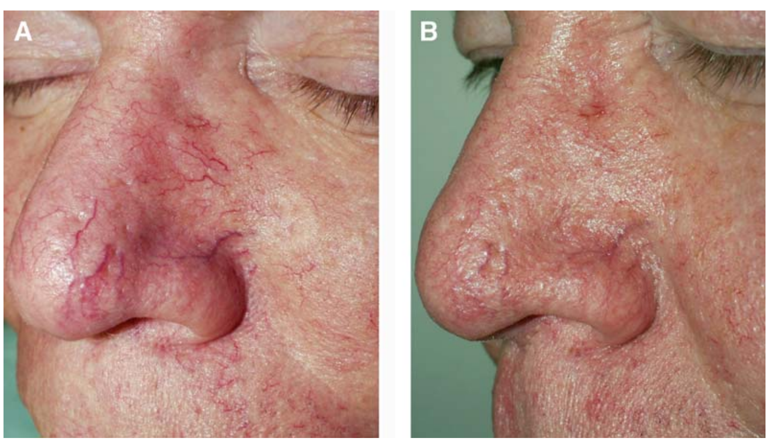

Fig. 6. (*A*) Before and (*B*) after a single session for the treatment of facial telangiectasias with the 532-nm diode laser.

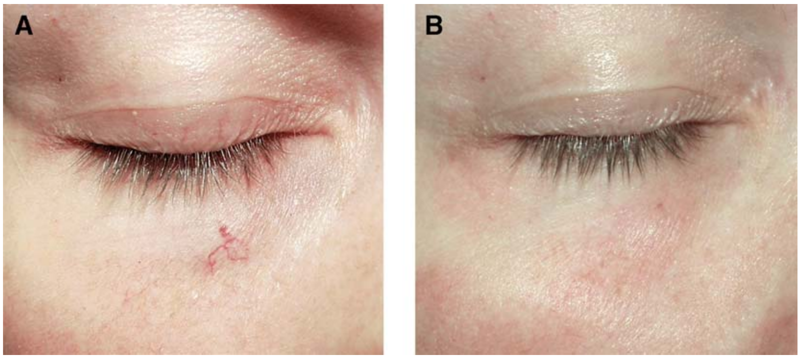

Fig. 7. This photograph shows (*A*) before and (*B*) immediately after 532-nm diode laser treatment of a spider angioma.

blood vessels has initial peaks of absorption below 600 nm and a broad band of absorption from 800 to 1200 nm (Fig. 9). The high peak power, long-pulse 1064-nm Nd:YAG lasers approximate this later, broad peak in oxyhemoglobin absorption. Groot et al [14] put forth an algorithm for treating facial vascular lesions such as hemangiomas, port-wine stains, small-caliber ectasias, and large-caliber ectasias (vessel over 2 mm).

Fig. 8. (*A*, *B*) This small port-wine stain was successfully treated with four treatment sessions using the 532-nm diode laser.

Pulse duration is the length of time that a pulse of laser light is emitted. The main determinant of appropriate pulse duration is the diameter of the vessel being treated. Shorter pulse durations are best for small-diameter vessels, and longer pulse durations are best for larger diameter vessels. The small-diameter vessels treated in Fig. 10 were treated with pulse durations of 20 milliseconds, whereas larger dilated leg veins are treated with a pulse duration of 45 milliseconds. Laser pulses that are too short can cause purpura from poor coagulation and vessel lysis, whereas using pulse durations that are too long can cause excessive coagulation, resulting in accumulation of interstitial fluid. Of course, stacking of pulses, too-rapid application of adjacent pulses, or high light

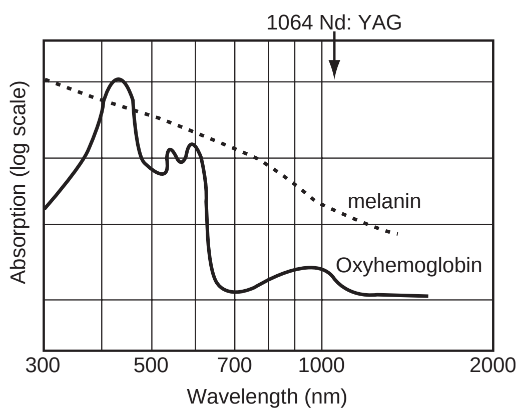

Fig. 9. The absorption of melanin ad oxyhemoglobin as a function of wavelength. Note the third broad peak at which the 1064 wavelength operates. (Courtesy of Don Groot, MD.)

intensity can always produce unwanted lateral tissue damage. For homogenous lesions, pulse duration should remain constant throughout the treatment.

Spot size is a very important variable. Spot size selection is primarily related to the depth of the vessel to be treated. Smaller spot sizes are better for superficial and smaller diameter vessels. Larger spot sizes, on the order of 7 to 10 mm, result in greater light penetration and are best for treating deep vessels and those of larger diameter. Larger spot sizes deliver significantly more energy, and when in doubt, it is best to begin with a smaller spot size and perform test areas.

Fluence is the final variable when choosing laser treatment parameters and is defined as the laser light delivered per unit area. Selection of laser fluence with the Nd:YAG is primarily based on vessel color. Purple and blue vessels tend to absorb more light energy than pink or red vessels and, therefore, require less fluence [14]. The light-blue dilated vein shown in Fig. 11 was treated with 130J/cm^2, whereas the dark-purple cavernous hemangioma shown in Fig. 12 was treated with a fluence of only 60 J/cm^2. The large, deep cavernous ascular malformation shown

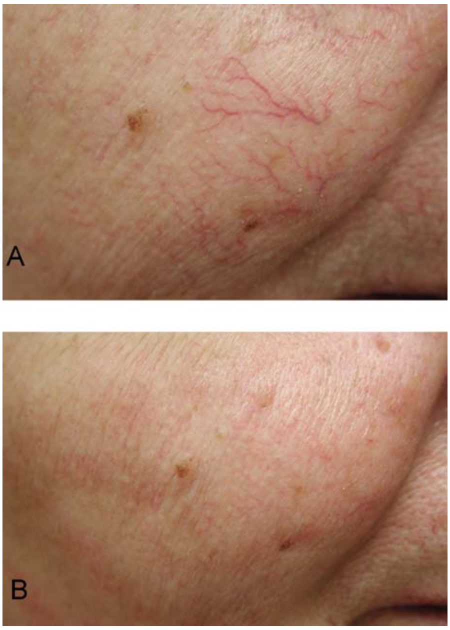

Fig. 10. (*A*, *B*) Small-diameter vessels treated with the Nd:YAG laser using a pulse duration of 20 milliseconds. (Courtesy of Don Groot, MD.)

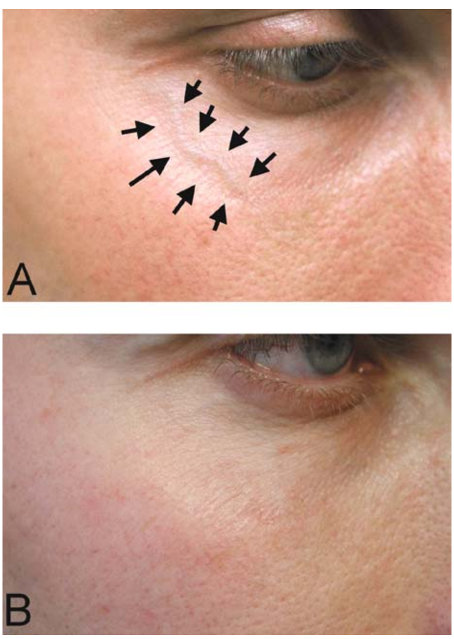

Fig. 11. (*A*, *B*) A large-caliber, dilated facial vein treated with the Nd:YAG laser with settings of 35 milliseconds, 7-mm spot size, and 130 J/cm^2. (Courtesy of Don Groot, MD.)

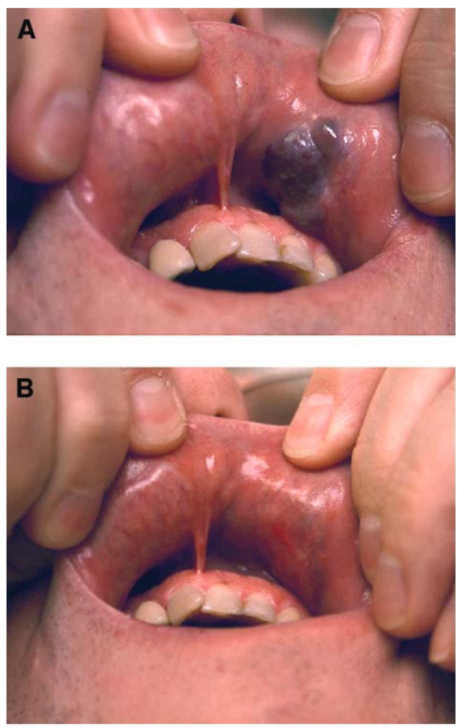

Fig. 12. A vascular malformation of the mandibular vestibule (*A*) before and (*B*) 6 weeks after a single treatment session. The laser parameters were 35 milliseconds, 7-mm spot size, and 60 J/cm^2. (Courtesy of Don Groot, MD.)

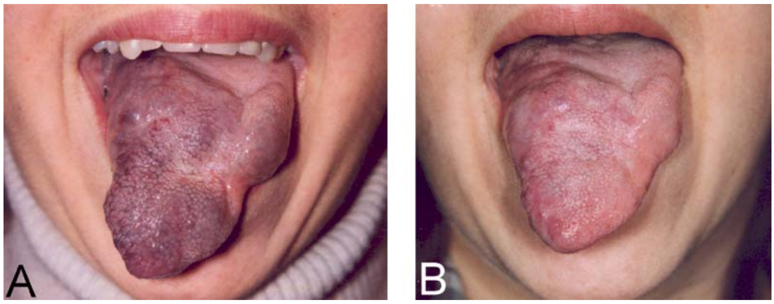

Fig. 13. (*A*) Before and (*B*) 3 months after four fractionated treatment sessions with the Nd:YAG laser with settings of 35 milliseconds, 7-mm spot size, and 130 J/cm^2. (Courtesy of Don Groot, MD.)

in Fig. 13 was treated with twice the fluence as the lesion shown in Fig. 12. A larger spot size was also used in this large, deep lesion compared with the more superficial mucosal lesion.

Treatment of small vessels consists of precooling the area for 1 second, followed by a single pulse of laser energy. Postcooling is accomplished by using the handpiece to freeze the lesion for 1 second after treatment. Two to three nonoverlapping passes are performed.

Large vessels absorb laser energy to the extent that auxiliary frozen gel packs are required with each pulse. The desired clinical endpoint is constriction, darkening, or lightening of vessels. If this is not observed, then fluence is gradually increased by 5 to 10 J/cm^2 or the spot size is increased for increased penetration. In some cases, an increase in spot size is followed by a decrease in fluence to prevent overheating of tissue. It is extremely important to not overlap pulses at these higher fluences. Overlapping (overtreatment) can cause immediate blistering or gray discoloration of the surrounding epidermis. If blistering or discoloration is seen, spot size and/or fluence is decreased.

Laser treatment of pigmented lesions

In the author's experience, it is unfortunate that that so many patients present with depressed, hypopigmented facial scars from previous cryotherapy treatment for pigmented lesions. This common and proven modality is a mainstay of dermatology but, nonetheless, leaves unsightly scars due to the relative lack of control of cryodamage.

In searching for a more cosmetic option, other modalities are available, including ablative lasers and melanin chromophore–specific wavelength lasers.

Ablative lasers include the carbon-dioxide (CO_2) laser (10,600 nm) and the erbium:YAG laser (2940 nm). These lasers have affinity for water and do not target any specific chromophore, thus destroying any tissue in their path. Due to this characteristic, operator proficiency is especially important. The primary consideration in any lesion, especially pigmented varieties, is the potential pathology. A biopsy of any suspicious lesion should be performed (eg, with a simple scalpel-shave biopsy) at a representative area of the lesion before ablation.

The patient is counseled on the potential for retreatment. All patients are informed that the surgeon will remove as much of the lesion at the initial treatment as possible without leaving an obvious scar. It is further explained that the surgeon can always take more off but cannot replace tissue after it is gone. Touch-up treatments may be required in 2% to 3% of the lesions. By taking this conservative approach, the surgeon can more accurately judge the tissue ablation depth and, therefore, better predict the lateral tissue

Fig. 14. All lesions are marked with a fine-tip surgical marker before local anesthetic infiltration. The 3-mm straight handpiece is shown in the picture.

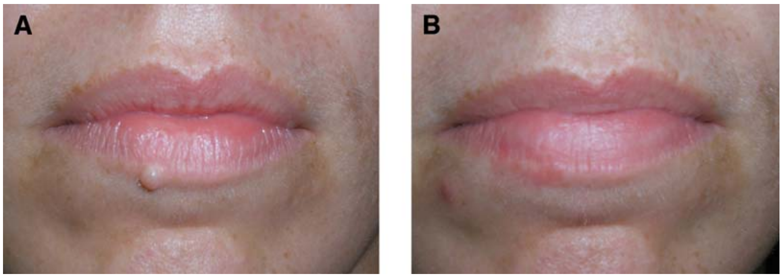

Fig. 15. (*A*) Before and (*B*) after pictures of a nevus treated with CO_2 laser ablation.

destruction. This strategy has proved to be effective for aesthetic scars after lesion removal. It is also important to explain to the patient that scars on the neck will not heal as well as those on the face due to the disparity of pilosebaceous units. Preoperative photographs are obtained for most lesions for documentation and marketing use.

The next step is to mark clearly the lesion boundaries with an extra–fine-tipped surgical marking pen. It is imperative to do this before local anesthetic injection because the local will distort the lesion margins. After marking the lesion, enough 2% lidocaine, 1:100,000 epinephrine is infiltrated subcutaneously to blanch the lesion and a suitable perimeter for pain control. The author uses the Lumenis (formerly Coherent) Encore ultrapulsed CO_2 laser (Lumenis, Santa Clara, California) with a 3-mm straight handpiece with a setting of 200 MJ and 15 Hz. The marked lesion is ablated by making successive wiping motions with the laser handpiece, followed by wiping the charred tissue with moist gauze. This procedure is repeated until the base of the lesion is visualized. The surgeon should wear surgical loupes and a headlight for this simple procedure because it allows differentiation of the abnormal tissue of the lesion from the normal surrounding skin. The base of the lesion is frequently chamois-leather colored compared with the surrounding skin. The ablation is continued until a slight concavity is achieved at the skin surface. The surgeon must keep in mind that even though some of the lesion is still visible, the lateral thermal damage from the laser may have devitalized this tissue and no further treatment is necessary. If the surgeon is unsure about total ablation, the patient returns in several weeks to touch up the remnant tissue. In the case in which there is obvious deep remnant tissue from pigmented lesions, the patient must be alerted to the possibility of scarring or the need for an excisional biopsy technique. Fig. 14 shows the marking of the lesion and the CO_2 laser straight 3-mm handpiece.

The patient is instructed to keep the lesion covered with a triple-antibiotic ointment for several days and to avoid direct sunlight. A mild erythema persists for several weeks, and at 1 month, most lesions are imperceptible. Figs. 15–17 show a typical pre-and postlaser treatment for a benign nevus.

Flatter pigmented lesions such solar lentigines and actinic or seborrheic keratoses can be treated with the CO_2 laser, but with a different technique. These

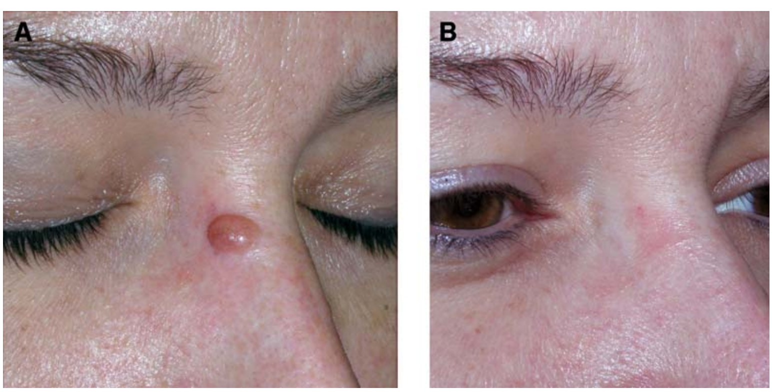

Fig. 16. (*A*) Before and (*B*) after pictures of a nevus treated with CO_2 laser ablation.

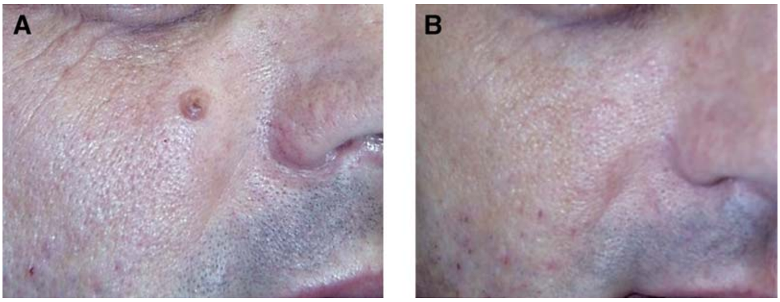

Fig. 17. (*A*) Before and (*B*) after pictures of a nevus treated with CO_2 laser ablation.

lesions are usually flat and more extensive, sometimes covering large areas of the face or neck. It is imperative to differentiate between epidermal and dermal pigmentation because the latter may not be amenable to superficial ablation. When viewing these lesions under a Wood's light, the epidermal melanin will stand out, indicating a superficial lesion, whereas the dermal melanin will not be as visible [15]. Fig. 18A shows a picture taken under conventional flash and Fig. 18B shows the enhancement of epidermal melanin by ultraviolet light.

The ablative technique uses a computer pattern generator with a superficial fluence of 3 to 3.5 J/cm^2 at 600 Hz. This setting is very superficial, and a single pass will barely penetrate the epidermis. After local anesthetic infiltration, the lesion is "painted" with a single pass at the aforementioned setting. The area is then debrided with moist gauze and inspected. Frequently, a single pass of the laser at this setting will ablate the lesion. If the residual lesion is significant, then a second pass is used, but it is explained to the patient that postlaser erythema will be more persistent with successive passes. If extremely large or multiple lesions are present, then spot resurfacing is not a good idea due to the relative color difference in the untreated skin. In this case, it is optimal to perform a full-face superficial resurfacing. After lasering these macular-type lesions, they are coated with triple-antibiotic ointment or petrolatum until re-epithelialized. Cosmetically, superficial pigmented macular lesions respond well to superficial resurfacing. Fig. 19 shows a small macular pigmented lesion before and after treatment with the Lumenis Encore laser using the "CO_2 light" setting.

532-nm diode laser for the treatment of pigmented lesions

Because the absorption spectrum of melanin includes the ultraviolet, visible, and near-infrared portions of the electromagnetic spectrum, virtually every wavelength along the spectrum can theoretically be used to target melanin [16]. Melanosomes are much smaller than blood vessels (10 versus 100 μm) and require a shorter pulse duration for treatment compared with telangiectasias [16].

Pigmented lesions such as lentigines, keratoses, ephledes (freckles), dermatosis, and papulosis nigra have been successfully treated with the 532-nm wavelength [17]. Early hypertrophic scarring and keloids that possess significant vascularity have also been successfully treated [17]. For most macular lesions such as lentigines, the endpoint is a uniform gray color and a popping sound that occurs when tissue becomes plasmoid [17]. Fig. 20 shows before and after pictures of 532-nm diode laser treatment of a benign nevus.

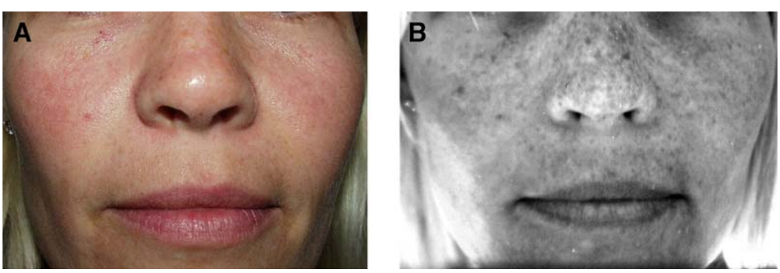

Fig. 18. (*A*) A photograph showing what the patient sees in the mirror everyday. (*B*) Photograph taken with an ultraviolet light source to enhance the epidermal melanin that is usually related to actinic damage.

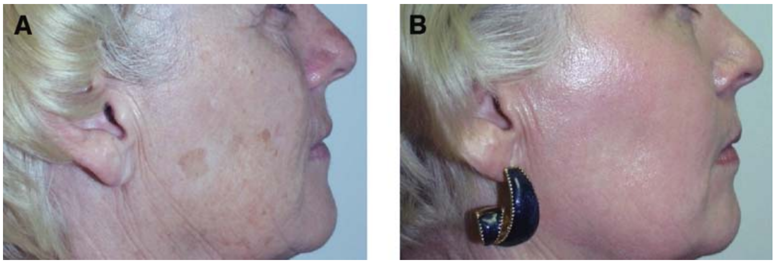

Fig. 19. Macular lentigines (*A*) before and (*B*) after treatment with the "CO_2 light" setting, 3.5 J/cm^2, 600 Hz, and the computer pattern generator.

The pigmented lesions exfoliate over 1 to 2 weeks. Larger or thicker lesions may need re-treatment until clinical clearing is achieved. Lesions with varied areas of pigmentation will respond differently to treatment, with darker areas absorbing more laser energy.

Nonpigmented lesions have been treated with an artificial chromophore such as ink [17]. Dermatosis papulosa nigra (DPN) is a benign cutaneous condition that is common among African Americans. It usually is characterized by multiple small, hyperpigmented, asymptomatic papules on the face. Histologically, DPN resembles seborrheic keratoses. The condition may be cosmetically undesirable to some patients. The incidence of DPN and the number and size of individual lesions increases with age, with maximum incidence in the sixth to seventh decade [18].

No treatment generally is indicated for DPN unless lesions are cosmetically undesirable. The prognosis for patients with DPN is excellent because it is not a premalignant condition or associated with any underlying systemic disease. Lesions of DPN, however, show no tendency to regress spontaneously, and they gradually may increase in number and size with age.

Aggressive therapeutic modalities have been complicated by postoperative hyperpigmentation or hypopigmentation or scarring. Keloid formation is a potential complication. Therefore, conservative treatment is advisable. Abrasive curettage with or without anesthesia, superficial liquid nitrogen cryotherapy, and electrodessication followed by curettage have been used in the past and been shown to be effective. The 532-nm diode laser has been shown to be a very useful adjunct for this condition and a welcome relief for those patients who have been treated with the other, previously mentioned modalities.

Like other lesions amenable to laser treatment, DPN treatment with the 532-nm diode should include a spot test to determine the patient's response to treatment. The author warns the patient that initially, there will most likely be a hyperpigmentation of the treated area that is much less noticeable than the original raised lesion. These hyperpigmented areas usually fade in time and because this condition is a

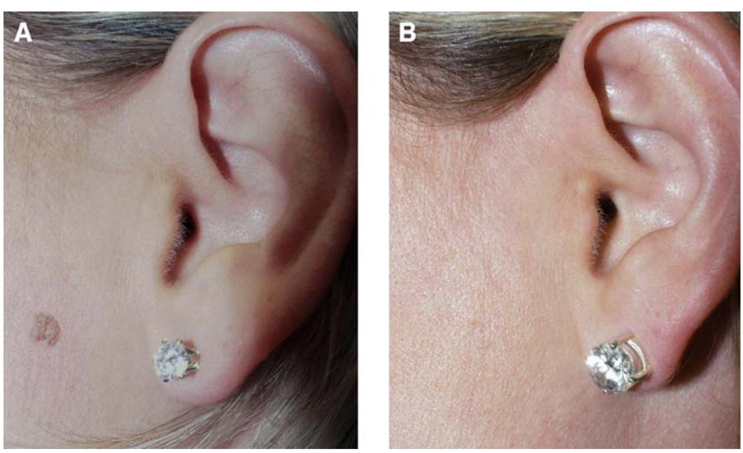

Fig. 20. A benign facial nevus (*A*) before and (*B*) after treatment with a 532-nm diode laser.

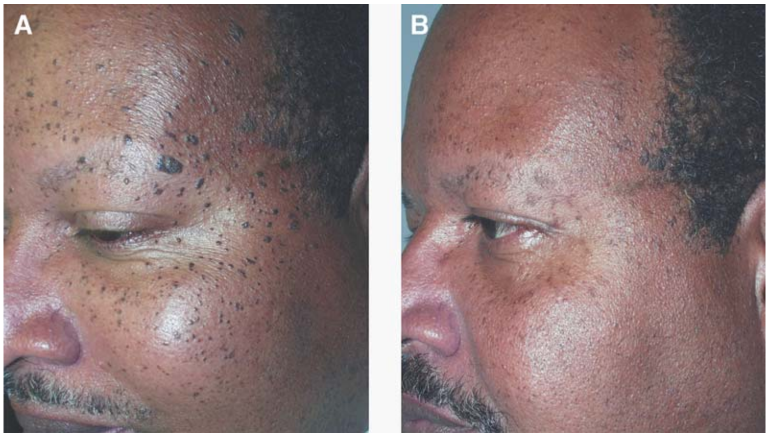

Fig. 21. (*A*, *B*) Successful treatment of multiple dermatosis papulosa nigra lesions. This patient was treated with local anesthesia for two sessions and sedated for third, larger session.

vast improvement over the original lesions, its presence has not seemed to bother patients.

Several lesions in a cluster are photographed and treated as a test spot. The technique uses the 700-nm handpiece with a setting of 30 J/cm^2, a repetition rate of 8 to 10 Hz, and a power setting of 3 W. The lesion is treated with a rapid succession of pulses until an audible pop is heard. This noise indicates the treatment endpoint, and the lesion immediately will appear gray. The patient is instructed to keep the treated area coated with triple-antibiotic ointment and return to the office in 2 weeks. The gray areas will slough off over the next week, leaving a smooth, frequently hyperpigmented base. Large or undertreated lesions will need re-treatment, which is usually performed at monthly intervals. Fig. 21 shows a before and after photograph of a patient with DPN who was treated with the 532-nm diode laser 3 months earlier.

Pigmented lesion removal with the Q-switched ruby laser

Because melanin characteristically absorbs red light at all skin depths, the Q-switched ruby laser provides effective treatment for the removal of benign pigmented lesions of the epidermis and dermis. Com-

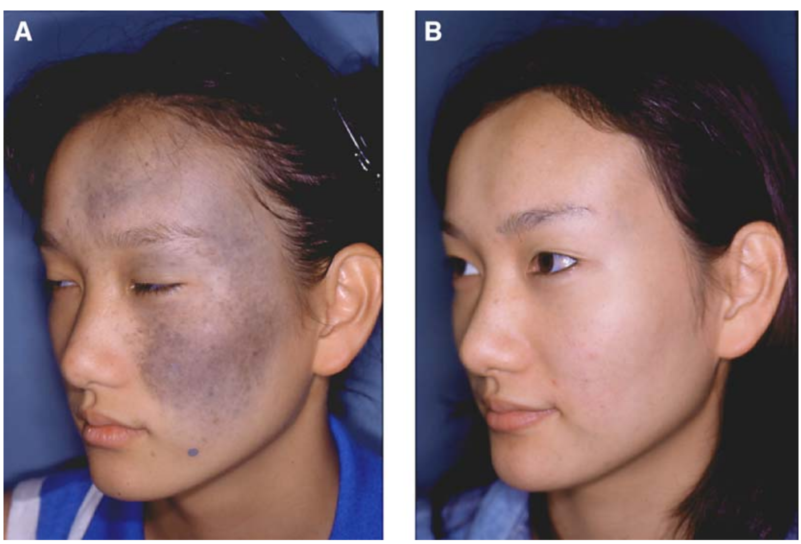

Fig. 22. (*A*) Before and (*B*) after picture of a patient with nevus of Ota treated with the Q-switched ruby laser. (Courtesy of Taro Kono, MD.)

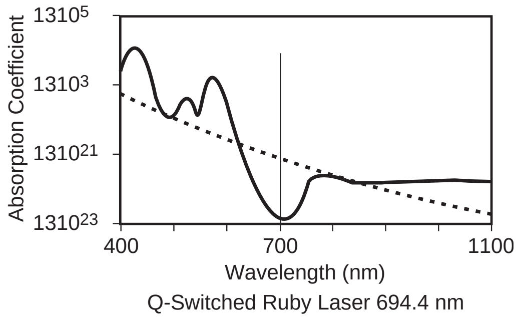

Fig. 23. Melanin but not oxyhemoglobin absorbs the Q-switched ruby laser wavelength; therefore, blood vessels are not damaged and there is no pupura.

mon indications include solar lentigines and other benign pigmented lesions. This technology is also used for treatment of postinflammatory hyperpigmentation and infraorbital dark circles. The Q-switched ruby laser also represents the treatment of choice for many deeper lesions such as nevus of Ota [19–23]. Q switching is a method to generate a short pulse duration yet deliver high peak powers with sufficient laser energy per pulse for efficient implementation. Nevus of Ota is a dermal melanocytic hamarotoma that commonly affects Asians (Fig. 22). Clinically, it presents as bluish hyperpigmentation along the distribution of the trigeminal nerve. Chan et al [20] recently showed excellent clearing of lesions with early treatment.

Tattoo removal

Technically, tattoo ink could be construed as an "intentional pigmented lesion." Multicolored, professional, amateur, and traumatic tattoos may be removed using the Q-switched ruby laser. Ink trapped within the dermis is selectively targeted by the laser and broken into minute particles that are then eliminated through phagocytosis. The result is a gradual fading of the tattoo image, with a decreased risk of scarring. Only melanin absorbs ruby laser energy (Fig. 23). Because there is no absorption by oxyhemoglobin, there is no damage to blood vessels; hence, no purpura are formed with this technology, unlike the pulsed dye lasers.

Summary

It is unusual to write an article on a topic that basically did not exist 2 decades ago. Pigmented and vascular lesions on the head and neck may have significant psychologic impact on individuals and, to a lesser extent, pose cosmetic problems. The exponential progress in laser technology has enabled oral and maxillofacial surgeons to treat lesions that previously required disfiguring surgeries and produced poor results. Thousands of patients including many children have been helped with laser technology. Laser technology and therapy are simple after gaining an understanding of selective photothermolysis, wavelength specificity, and target chromophores.

There are many uses for lasers in an oral and maxillofacial surgery practice. CO_2 and 532-nm diode lasers are a good start because they are affordable, have a minor learning curve, and treat many facial lesions and conditions commonly presenting to oral and maxillofacial surgery offices.

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