Clinical applications of Q-switched NdYAG laser

Apratim Goel
Medical Director, CUTISKLINIC, Mumbai, India

Address for correspondence: Apratim Goel, Medical Director, CUTISKLINIC, Skin, Laser and Cosmetic Clinic, Sadguru Sadan, Opp. Babulnath Temple, Girgaum Chowpatty, Mumbai - 400 007, India. E-mail: mycutis@hotmail.com

INTRODUCTION

Skin hyperpigmentation is usually caused by excess production and/or clumping of the skin pigment 'melanin' with the appearance of darker brown or even black spots on skin. Pigmented lesions can be classified either based on location of pigment as epidermal and dermal, or based on causation as nevoid, hereditary, or acquired – drug induced, postinflammatory, hormonal, etc. – and the treatment depends on the underlying cause. Various topical applications, chemical peels, microdermabrasion, etc. have been used with variable benefits. However, lesions like nevus, tattoos, freckles, etc. are not amenable to the above line of treatment.

This resulted in a search for an ideal laser/light system to effectively target the skin melanin without damaging the surrounding skin. Twenty years of improvements in laser dermatology has resulted in current technology which allows selective targeting of melanin, variable spot sizes, different wavelengths, and a variety of effective cooling devices. These developments have made the treatment of cutaneous pigmented lesions safe and efficacious by targeting selected chromophores while minimizing damage to the surrounding tissue. The absorption spectrum of melanin is extremely broad – a property that allows pigmented lesions to be treated with a wide variety of lasers.

If we closely observe the absorption curve of melanin [Figure 1] (which is the target chromophore in all pigmented lesions), the graph clearly shows that any laser right from 400–1100 nm plus can hit the melanin. We are also aware that many laser systems function in this visible and the infrared range of the electromagnetic spectrum. Though all these lasers would have some effect on melanin, three wavelength bands are most useful for treating pigmented lesions – green, red, and infrared.[1] Its not only about the wavelength, it is more about the right pulse duration and at sufficient fluence. Since green and blue light lasers are long pulsed continuous waves, they cause a lot of damage to surrounding skin. However, in the last decade, the Q-switching technique has given birth to Q-switched ruby, Q-switched alexandrite, and in the infrared category, Q-switched NdYAG laser.

WHAT IS Q SWITCHING?

In addition to their categorization by wavelength, lasers can be divided into continuous wave (CW) or pulsed. A CW laser delivers a steady stream of light that is measured as average

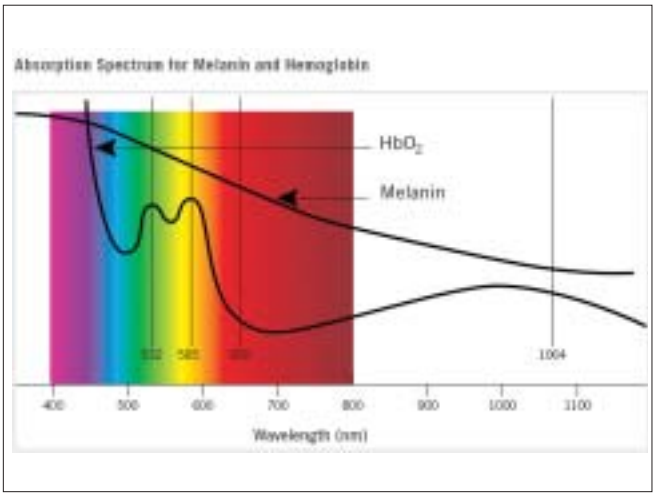

Figure 1: Absorption spectrum of melanin and hemoglobin

How to cite this article: Goel A. Clinical applications of Q-switched NdYAG 1064 nm Laser. Indian J Dermatol Venereol Leprol 2008;74:682-6.

Received: June, 2008. **Accepted:** October, 2008. **Source of Support:** Nil. **Conflict of Interest:** None Declared.

Figure 2a: Nevus of Ota before treatment

Figure 2b: Nevus of Ota treated with NdYAG laser

Figure 3a: Postinflammatory hyperpigmentation with hypertrichosis before treatment

Figure 3b: After treatment with Q-switched NdYAG laser

Figure 4a: Melasma before treatment

Figure 4b: Melasma treated with Q-switched NdYAG laser

Figure 5: Ghost image of a tattoo after treatment with Q-switched NdYAG laser

Figure 6: Hypertrophic scar after treatment with Q-switched NdYAG laser

power in watts or kilowatts. A pulsed laser delivers a very short but intense light emission followed by a period of no light. If the laser is repetitively pulsed, the pulse repeats itself on a regular basis. The time between the pulses is referred to as the interpulse period and the length of each pulse is called the pulse duration. The number of hertz (Hz) represents the number of pulses emitted per second. The length of the pulse duration is an important characteristic of any pulsed laser/light device. Pulses lasting a few milliseconds (10^{-3}) are generally characterized as long pulses. Nanosecond (10^{-9}) pulses are considered short. Q-switched NdYAG laser pulses are typically 3–7 nanoseconds in length.[2]

What is the advantage of Q switching?

It is due to this technique of Q switching that the principle of selective photothermolysis can be applied to the pigmented lesions to achieve the desired clinical results without much damage to the surrounding area.

CLINICAL APPLICATIONS

Most pigmentary skin lesions, whether epidermal or dermal, acquired or congenital, can be treated with Q-switched lasers of blue, green, and infrared light. Though the clinical indications of a Q-switched NdYAG laser are numerous, a few are listed below:

Pigmented lesions

While the epidermal lesions respond best to 532 nm (frequency doubled NdYAG) the dermal lesions are better treated with 1064 nm. Q-switched lasers are the gold standard for treatment of tattoos [Figures 2-4].[3]

1. Lentigines: usually 1–2 sessions are enough to clear lentigines at 532 nm. However there is a risk of hypo/hyperpigmentation, so avoidance of sun exposure for 4–6 weeks post laser is very important.
2. Café-au lait macules: these again can be treated effectively in 1–2 sessions, but recurrence is common which requires multiple treatments.
3. Freckles: Response is same as for lentigines. Although very effective, risk of dyspigmentation exists.
4. Dermal pigmented lesions: Nevus of Ota, Nevus of Ito, mongolian spots, Hori's nevus,[4] ABNOMs[5] (acquired bilateral nevus of Ota like macules), and other flat pigmented birthmarks respond well at 1064 nm. Multiple sessions are usually required with near-total clearing of the lesion in most cases.

Medium depth nonablative skin resurfacing[6]

Frequency doubled 532 nm Q switched is a well-established technology for treating photoaging. When used at lower fluences with a larger spot size, it is a medium depth laser peel, with less downtime and high patient satisfaction. However, due to the risk of postinflammatory pigmentary changes in Indian skins, it should be used only after a test patch and adequate sun protection advised to the patient.

Melasma[7]

High-energy pigmented selective laser, for example, 694 nm, Q-switched ruby laser, 755 nm Q-switched alexandrite laser, 532 nm frequency doubled Q-switched NdYAG laser, and 1064 nm Q-switched NdYAG laser had been studied for treatment of melasma with poor results. Normal skin color was rarely achieved. Epidermal melasma responds better and faster than dermal/mixed melasma. Complete clearing of lesions may be expected in more than 50% of

cases of epidermal melasma. Complete clearing of dermal/mixed melasma may be seen in about 30–50% cases, while the remaining cases will show moderate improvement. Postinflammatory hyperpigmentation and rebound melasma are dreaded complications that may occur in the individual with sensitive skin. Lower energy and fewer repetitions are adequate to produce marked improvement. Improvement will need to be maintained by repeated treatments. However, recurrence is common in melasma.

Tattoos

Though Q-switched ruby and Q-switched alexandrite lasers have been earliest lasers for tattoos, Q-switched NdYAG 1064 nm, due to its longer wavelength, higher fluence, and shorter pulse, has emerged as a better laser for the black and dark blue/ black tattoo pigment. The textural changes, scarring, and hypopigmentation of earlier lasers are remarkably low. However for colored pigments, use of multiple wavelengths is mandatory. Response to Q-switched 1064 nm depends on the type of tattoo:[2]

1. Professional tattoos: Most of such tattoos have even distribution of ink, mainly in subcutaneous tissue. Ink quality is good; hence, 4–6 treatments are usually required.
2. Amateur tattoos: Usually these are easy to remove, but in some cases, if the ink is at deeper level, a few extra sessions could be required.
3. Cosmetic tattoos: Cosmetic tattoos like eyebrows, and eye and lip line are mostly made of iron-based inks. This can sometimes oxidize and turn black, so a test patch must be given.

Nonablative skin resurfacing for wrinkles and acne scars[8]

Q-switched NdYAG laser 1064 nm offers a new technology that helps treat scars and wrinkles at their root, deep in the skin. Using laser energy that penetrates deeply without injuring the top layer of skin, the deep dermis is stimulated to produce natural collagen and other vital proteins that make up healthy, youthful skin. Painlessly done in less than 20 minutes, you'll leave the office with only mild redness that will fade within a few hours. After 3–6 treatments, done at monthly intervals, wrinkles soften and skin gets toned. Hence it is also referred to as laser skin toning. This is a good option for improving acne scars, wrinkles, and stretch marks without complicated procedures and long recovery times.

Laser-assisted hair reduction[9]

Though the long-pulsed lasers are gold standards for the removal of terminal hair, Q-switched laser has been tried with and without topical carbon suspension. Q-switched pulses produce a photomechanical impact on the tissue and also on hair shaft and hair follicle, causing reduction as well as delay in hair growth cycle. Since it is not color dependent, it can be suited for all skin types, even on tanned skins without fear of pigmentary changes.

Vascular lesions[2]

Medlite™ laser from Hoya ConBio has been shown to be effective in treating vascular lesions like telangiectasia, cherry angiomas, and small spider nevi. More than one treatment could be required. However, it can cause purpura which could take up to a week to clear.

Dark lips[10]

Dark lips are a common cosmetic concern in India. Two to four sessions of Q-switched 532 nm is an effective treatment for lip lightening.

COMPLICATIONS

The following complications are transient reactions and do not require termination of treatment.

- Immediate erythema
- Physical urticaria
- Acneiform eruption
- Minute petechiae
- Whitening of fine hair
- Rebound hyperpigmentation

The following complications need either stopping the laser therapy or modification of laser parameters:

- Mottled hypo and hyperpigmentation
- Leukoderma
- Severe urticaria
- Severe acneiform eruption
- Herpes simplex activation

Ghost shadows and scarring can occur with tattoo treatment at higher fluences [Figures 5-6].

Management of complications

Prognosis is excellent once the right treatment parameters are chosen. However in case of freckles and melasma, recurrence is a possibility. The most common complications observed with treatment of pigmented lesions are hypo and hyperpigmentation. If hypo pigmentation occurs, the fluence should be reduced and also treatment interval doubled. If hypopigmentation is speckled, this required cessation of treatment and adopting the medical line of

treatment like azelaic acid, kojic acid, etc. Hydroquinone-containing preparations must be avoided. After a period of 2–3 months, once the hypopigmentation resolves, laser can be restarted at a lower fluence (less than 2.5 J/cm^2). Temporary erythema, edema, and urticaria are transient and settle in a few hours.

COMBINATION TREATMENTS

For faster resolution of lesions as well as to increase the efficacy, laser treatment in some conditions can be combined with following procedures:

- Topical bleaching agents, for example, 7% arbutin, Kligman's formula
- Intralesional tranexamic acid (5 mg/ml)
- Topical sunscreen
- Chemical peels (Glycolic acid, Jessner's peels)
- Microdermabrasion
- Long pulsed lasers/Intense pulsed light
- Microneedling/Dermaroller

CONCLUSION

The search for an ideal laser for pigmented lesions has been long and continuing. We started with the ruby and carbon dioxide in continuous mode with heavy and bulky lasers systems which were not practical to use. Moreover, the complications/side effects far outweighed the benefits. Today, we stand tall with new Q-switched technology which delivers a flat top beam to utmost perfection and at the same time sparing the surrounding skin. But does that end our quest for ideal laser for pigmented lesions? We still can't treat melasma effectively. We still have problems like scarring, ghost shadows, etc. with tattoos. We are still apprehensive of using frequency doubled Q-switched laser 532 nm in Indian skins due to fear of hyperpigmentation. Hence, there is definitely still a long learning curve ahead of us to overcome these lacunae in the application of the existing technology to common skin problems. However, in Q-switched technology we certainly have found answers to some of the previously untreatable conditions. Nevertheless, newer future developments overcoming the shortcomings of the existing ones would certainly be welcome.

REFERENCES

1. Goldberg D. Laser treatment aimed at benign pigmented lesions: Dermatology Times. Vol.15, USA: Advanstar Publication; July 1994. Number 7.
2. Physician Guideline for Medlite C6. Hoya –ConBio, USA 2006
3. Grevelink JM, Duke D, van Leeuwen RL, Gonzalez E, DeCoste SD, Anderson RR. Laser treatment of tattoos in darkly pigmented patients: Efficacy and side effects. J Am Acad Dermatol 1996;34:653-6.
4. Niwat P, Somsak T, David JG. Treatment of Hori's nevus with Q switched NdYAG laser. Dermatol Surg 2000;26:477-80.
5. Suh DH, Han KH, Chung JH. Clinical use of Q switched NdYAG laser for the treatment of ABNOMs (Acquired Bilateral Nevus of Ota like macules) in Koreans. J Dermatol Treat 2001;12:163-6.
6. Anderson RR, Margolis RJ, Watenabe S, Flotte T, Hruza GJ, Dover JS. Selective photothermolysis of cutaneous pigmentation by Q switched NdYAG laser: Pulses at 1064, 532 and 355 nm. J Invest Dermatol 1989;93:28-32.
7. Niwat P. Treatment of refractory dermal melasma with Medlite C6 Q switched NdYAG Laser. J Cosmet Laser Ther 2008;10:167-73.
8. Friedman PM Jih MH, Skover GR, Payonk GS, Kimyai-Asadi A, Geronemus RG. Treatment of atrophic facial acne scars with the 1064nm Q switched NdYAG laser. Arch Dermatol 2004;140:1337-41.
9. Nanni CA, Alster TS. Optimizing treatment parameters for hair removal using a topical carbon based solution and 1064nm Q switched NdYAG laser energy. Arch Dermatol 1997;133:1546-9.
10. Somyas K, Somsak K, Suntharee K, Pannadda L, Sansanee W. An effective treatment of dark lip by Frequency doubled Q switched NdYAG laser. Dermatol Surg 2001;27:37-40.