



Treatment of Skin Hyperpigmentation using Q-Switched (1064nm and 532nm) Nd:YAG Laser

Ali F. AL-Saadi and Ali S. Mahmood

Institute of Laser for Postgraduate Studies, University of Baghdad, Baghdad, Iraq.

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Abstract: Hyperpigmentation is the increase in the natural color of the skin. The purpose of this study is to evaluate the efficacy and safety of Q-Switched Nd:YAG (1064 & 532 nm) Laser in treatment of skin hyper pigmentation. This study was done in the research clinic of Institute of laser for postgraduate Studies/University of Baghdad from October 2008 to the end of January 2009. After clinical assessment of skin hyperpigmentation color, twenty six patients were divided according to their lesions. Eight Patients with freckles, seven patients with melasma, four patients with tattoo. Cases with tattoo, were subdivided into amateur tattoos two, professional tattoos one, and one traumatic tattoo. Four Patients with post inflammatory hyperpigmentation, one patient with gazzal eye, one patient with spilus nevus, one patient with becker's nevus. The time of treatment session was from 5-20 minutes according to the size of lesion at 3-4 week interval. The distributions of lesions were on different part of body, face, hand, forearm, and back. Twenty two patients completed the study; four patients defaulted from the study for unknown reasons. Conclusion: The use of Q-Switched lasers offers a low risk, effective therapy with minimal side effects because they offer bloodless, low risk, effective treatment, Q-Switched Nd:YAG lasers have replaced other methods and are now considered standard treatment. The Q-Switched Nd:YAG laser have great advantages in removing hyperpigmentation, its longer wavelength (1064nm) would increase dermal penetration and decrease melanin absorption so that it's used in skin type (III,IV,V,VI) without the risk of depigmentation or hypopigmentation.

Introduction

Hyperpigmentation is the increase in the natural color of the skin. Melanin, a brown pigment manufactured by certain cells in the skin called melanocytes, is responsible for skin color. Melanin production is stimulated by a pituitary hormone called melanocyte stimulating hormone (MSH). Other pigments appear in the skin much less often. Pigmentation changes may also be caused by medication, and the drug responsible for the reaction must be identified and removed (Bernstein L. J., et al. 1997).

Skin sensitive to sunlight must be protected by shade or sunscreens with an SPF of 15 or greater, unsightly benign lesions may be, surgically removed. Laser surgery is an effective removal technique for many localized lesions.

Sunlight is the leading cause of dark spots on the skin, so shade and sunscreens are necessary

preventive strategies, especially in people who burn easily. There are a lot of causes of skin hyper pigmentation the following are some of them:

Freckles: Freckles are clusters of concentrated melanin which are most often visible on people with a fair complexion (Hanson Kerry M.; 2006). A freckle is also called an "ephelis."

Predisposition to freckles is genetic and is related to the presence of the MC1R gene variant. Freckles can be found on anyone no matter the background, however, having freckles are genetic and is related to the presence of the dominant melanocortin-1 receptor MC1R gene variant. The formation of freckles is triggered by exposure to sunlight. The exposure to UV-B radiation activates melanocytes to increase the melanin production, which causes freckles to become darker.

- **Nevus Spilus:** Speckled lentiginous nevus is a patch of hyperpigmentation that can be seen on any area of the body. This patch contains a variable number of darkly pigmented macules and papules. Some authorities believe that speckled lentiginous nevus is a subtype of congenital melanocytic nevus (Mosher DB, et al., 1999). Speckled lentiginous nevus may represent a localized defect in neural crest melanoblasts that populate a particular area of the skin. Environmental and genetic factors may also play a role.

Becker's Nevi : Becker's Nevi is usually a sporadic condition that manifests in the peripubertal period, both congenital and familial cases have been described. The earliest finding of Becker nevus is an asymptomatic irregular tan-to-brown patch, most commonly located over the shoulder, upper chest, or back (Mosher DB, et al., 1999)

Pigmentation may be subtle, The patch expands during the first several years as new irregular pigmented macules and patches develop at the periphery and coalesce with the larger patch. This expansion results in a geographic configuration that may cover a large area.

Melasma: Melasma is a common acquired, localized, usually symmetrical hyperpigmentation characterized by irregular, light to dark-brown macules that occur almost exclusively in the sun exposed areas, and it usually exacerbated by sun exposure, pregnancy, oral contraceptives and certain drugs (Dhahir SA. 1999). Clinical features: Melasma presents in three symmetrical facial patterns:

The centrofacial pattern: is the most common pattern and it involve the cheek, forehead , upper lip, nose and chin. The malar pattern: is less commonly encountered, and it involves the cheeks and nose. The mandibular pattern: involving the ramus of the mandible (Dhahir SA. 1999)

Periorbital hypermelanosis with cheek (Gazzal eye):

This disease is seen mainly in young females, characterized by periorbital hyperpigmentation with cheek extension in a symmetrical fashion ended with pointed end like a tail & a white band apparently normal skin across. It divides the pigmentation into two parts. many provoking factors such as fatigue, sunlight, premenstrual exacerbation, cosmetics, pregnancy and emotional upset were observed.

Family history was seen in 36 % of N cases. (AI-Baghdadi HA , 1997)

Postinflammatory Hyperpigmentation:

Postinflammatory hyperpigmentation (PIH) is a frequently encountered problem and represents the sequelae of various cutaneous disorders as well as therapeutic interventions. This acquired excess of pigment can be attributed to various preceding disease processes that affect the skin; these processes include infections, allergic reactions, mechanical injuries, reactions to medications, phototoxic eruptions, trauma (burns), and inflammatory diseases (lichen planus, lupus erythematosus, atopic dermatitis). Typically, PIH is most severe in patients with lichenoid dermatoses in which the basal cell layer of the epidermis is disrupted, (Goldstein N, 1979 N)

Tattoo : A tattoo is a permanent mark or design made on the body when pigment is inserted into the dermal layer of the skin through ruptures in the skin's top layer. The word tattoo is derived from the Tahitian word "tattau" and the Polynesian (Marquesan) word "tatu", which mean, "to mark," and was first mentioned in 1769 by explorer James Cook's after his expedition to the South Pacific. The practice of permanently decorating the human body however has been in existence for thousands of years with origins tracing back to the Stone Age (12,000BC). (Goldstein N, 1979 N)

Absorption Spectrum : Each type of tissue has its specific absorption characteristics depending on its specific components (i.e., skin is composed of cells, hair follicles, pigment, blood vessels, sweat glands, etc.) The main absorbing components, or chromophores, of tissue are: Hemoglobin in blood, Melanin in skin, hair, moles, etc. Water present in all biologic tissue, (H. Niemz. 1996).

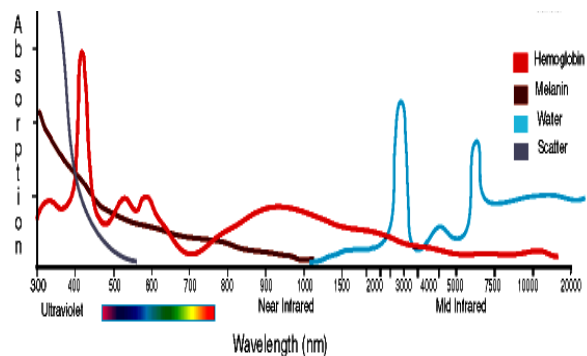


Fig. (1): Absorption spectra of melanin, hemoglobulin and water.

Infrared light is absorbed primarily by water, while visible and ultraviolet light are absorbed mainly by hemoglobin and melanin, respectively. As the wavelength decreases toward the blue-violet, and ultraviolet, scatter, which limits the depth that light may penetrate into tissue, becomes more significant.

Patients and Methods: After clinical assessment of skin hyperpigmentation color, (26) patients were divided according to their lesions.

Eight patients with freckles, Seven patients with melisma, Four patients with tattoo.

Cases with tattoo were subdivided them to amateur tattoos (2) (which is done with commonly available inks or pigments introduced into the skin manually), and professional tattoos (1) (those where inks are injected deep into the lower layer of the skin done by professional person). (1) Traumatic tattoo.

Four Patients with post inflammatory hyperpigmentation. One Patient with gazzal eye, One Patient with spilus nevus, One Patient with becker's nevus

The time of treatment session was from 5-20 minutes according to the size of lesion, the distribution of lesions on different part of body face, hand, forearm, and back.

Q-switched Neodymium: Yttrium-Aluminum-Garnet (QsNd:YAG):

The laser employed in the present work is a Q-switched Nd: YAG laser, it is a solid-state laser containing a crystal of yttrium-aluminum-garnet (YAG) doped with neodymium (Nd) ions. An Nd:YAG rod is placed within the laser cavity where xenon lamps excite the neodymium ions to provide an emission of 1064nm with 6-10 ns pulse durations. The longer wavelength of the Q-switched Nd:YAG laser allows deeper penetration. In addition, the 1064 nm light interacts less with absorption spectra of melanin thus decreasing the incidence of hypo pigmentation. In our case the YAG laser is modified with "Frequency doubling" or "harmonic generation". The light is passed through a KTP crystal producing green light at a wavelength of 532nm that achieves good results in the removal of freckles and epidermal melasma.

The treatment parameters : The parameters Include pulse duration, wavelength, fluence, and

spot size. As in all of the Q-switched lasers, the laser is in the nanosecond range, and the pulse width is predetermined by the laser. The wavelength is chosen based on the best available wavelength for the tattoo ink color. For example, red ink is best treated by a green wavelength (510 or 532 nm). When melanin is present, the 1064 nm wavelength is the best choice to avoid disruption of the epidermis, (Jones A, 1996).

Parameter used

- Max out put 1J (Energy)
- Peak power [1J/10 nsec]
- Plus duration 6-10 nsec
- Wavelength, 1064, 532nm.
- Repetition frequency (1- 5 Hz)
- Dia. of light spot 2-8mm (for 1064nm)
- Dia. of light spot 2-6mm (for 532nm)
- Fluence:- different fluencies were used according to treatment

Evaluation

Clinical assessment (patients with Fitzpatrick skin phototypes I-III table one have a better response than those with the skin phototypes IV-VI, photographs of the lesions should be taken prior to each treatment session.)

Table (1): Fitzpatrick skin types.

Skin type	Skin color	Sunburn & tanning history
I	White	Always burn , never tans
II	White	Always burn , tans minimally Burns
III	White	moderately, tans gradually
IV	Olive	Minimal burning, tans well
V	Brown	Some time burns and tans darkly
VI	Dark brown	Never burns and tans darkly - black

Subjective method

Depending on recording improvement in patients satisfaction measures during the time course of intervention and graded as follows:

Grade 0= not satisfied , Grade1= moderately or partially satisfied, Grade 2=greatly but not fully satisfied, Grade3=fully or completely satisfied (Rashid SA. 2004).

Safety measures (Class 3B):

In the present work, the laser employed was Class 3B laser which include any continuous-wave device with energy outputs above 5.0 *mW* and less than or equal to 500mw. These lasers can cause damage with direct intra-beam exposure and from specular or diffuse reflections. Additional performance requirements and safety measures must be taken to provide protection form the energy emissions of these lasers. Some of these precautions include.

- a. All personnel were asked to wear protective glasses appropriate to the procedure to eliminate the risk of eye damage. This glasses designed with special wavelength and optical density for the Q-switched Nd:YAG laser (1064nm,532nm).
- b. In addition to protective glasses, the eyes of the patient was covered with mops of wet cotton, when the procedure is done in the face.
- c. To avoid the reflection hazard avoid placing reflection materials such as glass, metals and polished plastic in the laser room.
Explosion hazard, avoid using flammable or fume emitting substances e.g. (ether, iodine solution, collodion and alcohol in operative field).

Procedure: The procedure Includes preparation of patient before laser, and after laser treatment and the relative and absolute contraindication to laser treatment.

Before treatment by laser

Complete history from patient taken for blood disease, viral hepatitis.

- a. The site of lesion in body.
- b. Age of patient.
- c. Color of lesion.
- d. Type of ink, Instrument used to make tattoo whether Amateur or professional.
- e. The age of lesion.
- f. History of any treatment taken.
- g. Complete history of drug (steroid, Isotretinoin, anticoagulant).
- h. Then clean the area.

i. Shaving the hair.

Take photograph by digital camera to each patients before any session and after completed the study for comparing. Apply a topical anesthetic (EMLA cream) to skin and covered with an occlusive dressing and left for 30 minutes.

The treatment session taken from five minutes to twenty minutes according to the size of lesions and 3-4 weeks interval between sessions. Small test done to small area.

After treatment by laser, The laser arm putted in perpendicular manner to the lesion and move slowly till all the lesional area hit by laser beam. The laser causes instant whitish “popcorn” frosting over the lesion that last for 10 or 15 minutes. Then the lesion gradually returns to how it looked before the treatment. The difference is that the lesion area is slightly raised and the area around them become a little reddish and warm, much like sunburn. With higher energies you can expect some local swelling and small amounts of bleeding are possible.

Healing cream (antibiotic + steroid) is applied locally. Lesion is covered with a protective dressing; mostly after five day healing occurs. Then, during 21 days, the skin cells and other immune cells will slowly remove the tiny pigmented particles, which have been “broken up” by laser treatment and the lesion will look lighter.

The patients were asked to avoid sun exposure every day by using wide spectrum sun-blocking cream.

Results

Twenty two patients completed the study, four patients defaulted from the study for unknown reasons.

Freckles : Seven patients completed the study their ages from 19-48 years all female with variable number of lesions range from 5-100 lesions.

Number of session from 2-4 sessions according to the number of lesions. According to Fitzpatrick classification 4 patients skin type (II) and 3 patients skin type (III).

Laser parameter used

Q-switch KTP laser wavelength 532 nm, spot size 2 mm , R.R 2-4 Hz, fluence from 100-220 mJ/cm².

Clinically good improvement, patients self-assessment grade 3.

Melasma : Six patients completed the study their ages from 25-42 years , 5 patients female and 1 male, type of melasma:- 3 patients dermal type, 3 patients mixed type (epidermal and dermal type). According to Fitzpatrick classification 3 patients skin type (III)and 2 patients skin type (IV)and only one patient skin type (V) .

number of session rang from 4-6 session. Laser parameter used Q-switch Nd:YAG laser wavelength 1064 nm, spot size 3 mm , R.R 5 Hz, fluence from 600 – 900 mJ/cm² indermal type of melasma.

While in mixed type of melasma beside the above parameter use Q-switch KTP laser wavelength 532 nm, spot size 2 mm , R.R 2-4 Hz, fluence from 100-220 mJ/cm².

Clinically moderate improvement in mixed type and mild response in dermal type, patients self-assessment grade 2 in mixed type and grade 1 in dermal type.

Tattoo : Three patients completed the study their ages from 28-38 years , 2 patients male and 1 female.

Male patient with Traumatic green tattoo after 5 sessions completely recovery and patient self-assessment grade 3.

Laser parameter used

Q-switched Nd:YAG laser wavelength 1064 nm, spot size 3 mm , R.R 3-5 Hz, fluence from 600 – 900 mJ/cm²

Male patient with amateur blue to black tattoo after 4 sessions good improvement with shadow, patient self-assessment grade 2.

Laser parameter used

Q-switched Nd:YAG laser wavelength 1064 nm, spot size 3 mm , R.R 3-5 Hz, fluence from 600 – 900 mJ/cm²

Female patient with professional eyebrow green tattoo after 4 sessions mild improvement with patient self-assessment grade 1.

Laser parameter used

Q-switched Nd:YAG laser wavelength 1064 nm, spot size 3 mm , R.R 3 Hz, fluence from 600 – 900 mJ/cm²

Post inflammatory hyper pigmentation: Three patients completed the study their ages from 25-28 years, 2 patients male and 1 female.

female patient with wide area in her Back for many years durations 4 sessions with moderate improvement, patient self-assessment grade 2.

Two male patients with patches of hyper pigmentation in the face after 4 session's

moderate improvement, patient self-assessment grade 2.

Laser parameter used

Q-switched Nd:YAG laser wavelength 1064 nm, spot size 3 mm , R.R 3-5 Hz, fluence from 600 – 900 mJ/cm²

Periorbital hypermelanosis with cheek (Gazzal eye):

Female patient age 42 years, after 4 sessions mild improvement with patient self-assessment grade 1.

Laser parameter used

Q-switched Nd:YAG laser wavelength 1064 nm, spot size 3 mm , R.R 3-5 Hz, fluence from 600 – 900 mJ/cm²

Nevus Spilus:

Female child patient age 10 years, her nevus in forehead after 6 sessions moderate improvement with patient self-assessment grade 2.

Laser parameter used

Q-switched Nd:YAG laser wavelength 1064 nm, spot size 3 mm , R.R 3-5 Hz, fluence from 600 – 900 mJ/cm² with Q-switch KTP laser wavelength 532 nm, spot size 2 mm , R.R 2-4 Hz, fluence from 100-220 mJ/cm².

Becker's Nevus: Female patient age 13 years, her nevus in left shoulder and upper forearm after 6 sessions moderate improvement with patient self-assessment grade 2.

Laser parameter used

Q-switched Nd:YAG laser wavelength 1064 nm, spot size 3 mm , R.R 3-5 Hz, fluence from 600 – 900 mJ/cm² with Q-switch KTP laser wavelength 532 nm, spot size 2 mm , R.R 2-4 Hz, fluence from 100-220 mJ/cm².

Discussion:

The Nd:YAG Q-switched laser used in this study offers a great advantage for treating skin hyperpigmented patients. The 1064nm wavelength effectively treats dermal pigment and the 532nm setting treats superficial epidermal lesion. The primary disadvantage of this laser is the high cost.

The laser treatment of pigmented lesions is based on the concept of selective photothermolysis; in essence the chosen laser must emit a wavelength that is specific and well absorbed by the intended target. In the case of tattoos, the chromophore is exogenously placed ink found either within macrophages or extracellularly throughout the dermis. In the case of benign pigmented lesions, the intended

chromophore is melanin found within melanocytes, keratinocytes of dermal macrophages. Destruction of this pigment is thought to occur mainly through photoacoustic injury. Because the target particles are small, it is important to use pulses of energy that are extremely short to minimize collateral thermal injury to the normal surrounding tissue. For this reason, QS lasers, with energy pulses in the nanosecond range, enable energy to be deposited very quickly. The intense heat transients cause some particles to shatter and kill the cells in which the pigment resides. The rupture of pigment-containing cell eventually triggers phagocytosis and the packaging of pigment fragments for lymphatic drainage and scavenging by dermal macrophages. For epidermal pigment, the pigment-containing cells are killed with the laser pulses resulting in epidermal necrosis and subsequent sloughing and replacement with normal epidermal. (Kilmer SL., 2002, Folder KD, et al., 2011)

Conclusion

The use of Q-switched lasers has been able to help the vast majority of patients seeking hyperpigmentation removal by offering a low risk, highly effective therapy with minimal side effects because they offer bloodless, low risk, effective treatment, Q-switched Nd:YAG lasers have replaced other methods and are now considered standard treatment. The Q-switched Nd:YAG laser have great advantage in removing hyperpigmentation, its longer wavelength (1064nm) would increase dermal penetration and decrease melanin absorption so that it's used in skin type (III,IV,V,VI) without risk of depigmentation or hypopigmentation . The short pulse duration which is in nanosecond (6-10 ns) shorter than the chromophore's thermal relaxation time, this lead to maximal target destruction with minimal collateral thermal damage.

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علاج فرط التصبغ الجلدي باستخدام ليزر النيديميوم-ياك (1064نانو متر، 532 نانومتر)

علي فاضل الساعدي علي شكر محمود

معهد الليزر للدراسات العليا ، جامعة بغداد ، بغداد، العراق

الخلاصة : فرط التصبغ هو الزيادة الطبيعية في لون الجلد. وكان الهدف من الدراسة لتقييم فعالية وسلامة كيوسوج اندي ياك ليزر (1064 ، 532 نانومتر) لعلاج فرط تصبغ الجلد. تمت هذه الدراسة في العيادة الخارجية لمعهد الليزر اعتباراً من مطلع تشرين الاول / اكتوبر 2008 الى نهاية كانون الثاني/ 2009 . بعد التقييم السريري الـ 26 مريضاً بفرط التصبغ الجلدي / قسموا على الشكل التالي (8) مرضى مصابين بنمش، (7) مرضى مصابين بكلف، (4) مرضى وشم (اثان منهم وشم غير حرفي ، 1 وشم حرفي ، صدمات الوشم، مرضى ذكور واثان مع متغير العمر 20-45 عاماً (4) مرضى فرط التصبغ ما بعد الالتهابات ، مريضة واحدة عين الغزال ، مريضة الشامة المنقطة، مريضة وحمه بيكر. مدة العلاج 5-20 دقيقة وفقاً لحجم البقعة مع وجود فترة زمنية بين جلسة و اخرى من (3-4) اسابيع. والنتائج اثان وعشرون مريضاً اكملوا الدراسة ، اربعة مرضى تخلفوا عن الدراسة لاسباب غير معروفة. النمش: سبعة من المرضى الذين اتموا الدراسة اعمارهم 19-48 سنة كلهم اناث مع عدد الآفات 5-100 آفة. عدد الجلسات بين 2-4 جلسة وفقاً لعدد الآفات، وفقاً لتصنيف فينيز باتريك 4 مرضى من النوع الثاني، وجلد 3 مرضى من النوع الثالث. الليزر المستخدم ذات طول موجي 532 نانومتر/ حجم البقعة 2 ملم ، تردد 2-4 هرتز ، شدة الاشعاع 100-220 ملي جول/سم². يوجد تحسن سريري ملحوظ والتقييم الذاتي للمرضى من الصنف الثالث. الكلف: ستة مرضى اكملوا الدراسة اعمارهم بين 25-42 سنة ، 5 اناث + ذكر ، نوع الجلد وفقاً لتصنيف فينيز باتريك 3 من النوع الثالث، 2 من النوع الرابع 1 من النوع الخامس ، عدد الجلسات 4-6 جلسة . الليزر المستخدم اندي ياك مع حجم البقعة 3 ملم تردد 5 هرتز ، شدة الاشعاع 600-900 ملي جول /سم² بالنسبة الى النوع العميق من الكلف ، اما الكلف المختلط تم استخدام بالاضافة الى اندي ياك 1064 ليزر ذات طول موجي 532 نانومتر مع حجم البقعة 2ملم تردد 2-4 هرتز ، شدة الاشعاع 100-220 ملي جول / سم²، تحسن متوسط في الكلف المختلط، استجابة ضعيفة بالنسبة الى الكلف العميق. الوشم: 3 مرضى اكملوا الدراسة اعمارهم 28-38 سنة ، اثان ذكور + انثى، احدهم مع الصدمات الخضراء تحسن بدرجة كبيرة بعد الجلسة الخامسة مع التقييم الذاتي للمريض من الصنف الثالث، الليزر المستخدم 1064 نانومتر، حجم البقعة 3 ملي متر تردد 3-5 هرتز شدة الاشعاع 600-900 ملي جول /سم²، آخر وشم ازرق تحسن بعد الجلسة الرابعة مع وجود ظل، التقييم الذاتي للمريض من الصنف الثاني الليزر المستخدم نفس السابق. مريضة واحدة مع وشم حرفي في منطقة الحاجب تحسن بسيط بعد الجلسة الرابعة ، التقييم الذاتي للمريضة من الصنف الاول، الليزر المستخدم نفس المستخدم في الوشم الاول. فرط التصبغ ما بعد الالتهاب: ثلاثة مرضى اتموا الدراسة اعمارهم من 25-28 عاماً، 2 ذكور + انثى. جميع المرضى تحسنا بعد الجلسة الرابعة مع التقييم الذاتي من النوع الثاني، الليزر المستخدم 1064 نانومتر حجم البقعة 3 ملم تردد 3-5 هرتز ، شدة الاشعاع 600-900 ملي جول/سم². عين الغزال: انثى 42 عاماً بعد 4 جلسات تحسن طفيف تقييم ذاتي صنف الاول الليزر المستخدم نفس الليزر في فرط التصبغ. الشامة المنقطة: طفلة في سن 10 سنوات، الشامة في جبهتها ، تحسن بعد 6 جلسات تقييم ذاتي من الصنف الثاني الليزر المستخدم طول موجي 1064 نانومتر/حجم البقعة 3 ملم، تردد 3-5 هرتز شدة الاشعاع 600-900 ملي جول /سم² مع ليزر طول موجي 532 نانومتر حجم البقعة 2 ملم ، تردد 2-4 هرتز ، شدة الاشعاع 100-220 ملي جول /سم². وحمه بيكر: انثى عمرها 13 سنة الشامة في كتفها الايسر العلوي مع الساعد وبعد 6 جلسات تحسن بدرجة متوسطة مع تقييمها الذاتي من الصنف الثاني ، الليزر المستخدم نفس الشامة المنقطة. **الاستنتاج :** استخدام الليزر كيوسوج فعال للغاية مع الحد الادنى من الآثار الجانبية لانه غير دموي واقل مخاطر من العلاجات الاخرى، الليزر ذات الطول الموجي 1064 نانومتر يخترق الجلد مع انخفاض امتصاص الميلانين بحيث يستخدم بامان مع الجلد من النوع الثالث والرابع والخامس والسادس من دون مخاطر التصبغ او نقص التصبغ.