A comparative study of diode laser and CO₂ laser in the treatment of gingival hyperpigmentation**Sukumar Subramanian¹, Baskaran Muthiah pillai², Sindhuja Devi Sandrasekhar^{3*}**

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Abstract

Background: Pigmented gingival tissue, many a times forces the patients to seek treatment for esthetic periodontal therapy. Gingival hyperpigmentation is caused by excessive deposition of melanin in the basal and suprabasal layers of epithelium.

Materials and Methods: This double blinded prospective study was undertaken to evaluate the effectiveness of diode laser and CO₂ laser in gingival depigmentation in ten patients using split mouth technique by evaluating the parameters like colour of the gingiva, bleeding, difficulties of the operator, pain, esthetic perception by the patient and post-operative wound healing. Out of 10 patients in the study group 6 were males and 4 were females. Gingival depigmentation was done from canine to canine in the upper anterior region. A total of 20 anterior segments were treated: 10 randomly to Carbon dioxide & Diode Laser group using Flip coin method. The data collected were tabulated and statistical analysis was performed.

Results & Conclusion: The results of this study showed that the degree of pigmentation at the end of 4th week was less in diode group with 20% of the patient showing no pigmentation compared to CO₂ group (10%). From our study, the first of its kind to compare the two lasers, we come to the conclusion that on comparing both the group, diode laser study group had appeared to be effective in the management of gingival hyperpigmentation in terms of pain, bleeding intra operatively, difficulty of the operator, wound healing and esthetics.

Keywords: Gingival hyperpigmentation, Melanin pigmentation, Laser therapy, Diode laser, CO₂ laser, Esthetic dentistry.

Introduction

Gingival hyperpigmentation occurs due to the excessive deposition of melanin pigment by active melanocytes in the basal layer of oral epithelium.^[1] They can be physiological or related to their ethnic origin. Although gingival hyperpigmentation is completely benign, it presents as esthetic concern to individuals while they smile often appearing as black. Physiologic pigmentation is genetically determined, but as Dummett suggested, the degree of pigmentation is partially related to mechanical, chemical and physical stimulation. The distribution of oral pigmentation is 60% gingiva; 61% hard palate; 22% mucous membrane and 15% tongue. The highest rate of gingival pigmentation has recorded in the region of attached gingiva underneath upper and lower anterior teeth while being less visible in the posterior region.^[2-4]

Gingival depigmentation is a surgical procedure wherein the hyperpigmented areas are removed.^[5] Various depigmentation techniques have been described in the literature, such as scalpel surgery,^[6] gingivectomy,^[7] cryosurgery, electrosurgery, chemical agents such as 90% phenol and 95% alcohol,^[8] abrasion with diamond burs, Nd:YAG laser, semiconductor diode laser and Carbon dioxide (CO₂) laser.

Laser beams have a high affinity for hemoglobin and melanin and at a specific wavelength of 800-980 nm, targets

the soft tissues. It is therefore ideal for gingival depigmentation.^[9] They are considered to be less invasive, alternative to conventional surgical technique that present with post-operative complications such as pain, edema, and infection.^[10]

The CO₂ laser has carbon dioxide gas as its medium, and emits energy at 10,600 nm. When lasers used in surgery are based on the principle of 'selective photothermolysis (SPTL)' laser destroys the substance containing chromophore, while inflicting as little damage as possible on the surrounding tissue. CO₂ laser surgery could therefore be described as tissue-selective. The advantage of this is that the CO₂ laser is not pigment-selective, and so both pigmented and non-pigmented skin lesions can be targeted with the CO₂ wavelength.^[11] The evidence comparing the clinical efficacy of diode laser and CO₂ laser are very few in literature. This double blinded prospective study was undertaken to evaluate the effectiveness of diode laser and CO₂ laser in gingival depigmentation in patients using split mouth technique.

Materials and Methods

This double-blinded study was conducted at Department of oral and maxillofacial surgery, Rajas dental college and hospital, Tirunelveli from February 2013 to November 2015. Institutional ethical approval was obtained from the same

institute. Ten patients requiring gingival depigmentation were selected from pool of a patients reporting to Rajas Dental College. A signed informed consent was obtained from all patients willing to participate in this study. All patients were evaluated by Primary investigator. A total of 20 (N=20) anterior segments were treated: among which 10 (n=10) were randomized and assigned to the CO₂ & Diode Laser group using flip-coin method by co-investigator.

Patients underwent periodontal therapy consisting of oral hygiene instructions and full mouth oral prophylaxis prior to depigmentation. Pre-operative photographs & Post-operative radiographs were obtained with a digital camera with standardized settings for grey, white, black, a cm scale with standard lighting and backdrop. Macroscopic distribution and colour of the pigmentation of all surfaces were recorded in detail.

Inclusion criteria

1. Patient with healthy periodontium
2. Patients between 18-40 year of age
3. Presence of Melanin pigmentation with score of 3 (Dummett-Gupta Oral Pigmentation Index) (DOPI)

Exclusion criteria

1. Presence of systemic diseases
2. Severe Periodontal Diseases
3. Patients who have the habit of smoking.

The primary investigator was blinded about the allocation of segment evaluated the primary and secondary parameters like colour of the gingiva, bleeding, difficulties of the operator, pain perception of patient and post-operative wound healing. The parameters were evaluated intra- operatively and post-operatively till 4th week of follow-up.

Diode laser technique

Topical anesthetic was applied to the surgical field. The patient, surgeon and the assisting personnel were provided with protective eye goggles in compliance with the FDA laser safety rules. The diode laser unit tip (Picasso, AMD laser technologies, USA; wavelength 810 nm) [Fig. 1] was preset at 0.5-1.5 watts continuous wave (CW) mode and angled at 45 degrees. Small brush like strokes back and forth with gradual progression deeper along the same initial laser incision to remove the tissue. For the de-epithelialization procedure, 400 µm strippable fiber was used with a power setting of 1.5 watts initially in pulsed wave mode (PW) set at 0.20 ms of pulse duration and 0.10 ms of pulse interval.

CO₂ laser technique

The ablation using CO₂ laser was performed by a flexible fiber Luxar NovaPulse LX-20 SP [FIGURE 2] surgical laser, the predecessor of LS-1005. The repeated A5 Super Pulse mode was applied at 3 watts, 20 Hz, 10 milliseconds, with a 0.8 mm spot size.

Parameters assessed

The parameters assessed were colour of the gingiva, bleeding during the procedure, difficulties of the operator, perception of pain by the patient and post-operative wound healing

Colour of the gingiva

Pre-operative and post-operative photographs were taken at first, second, third and the fourth week after the procedure of depigmentation. The primary investigator was blinded about the allocation of segments either to CO₂ or diode laser and evaluated the pre-operative, post-operative photographs using DOPI scale [12].

Dummett-Gupta Oral Pigmentation Index (DOPI):

0 = No clinical pigmentation (Pink tissue)

1 = Mild clinical pigmentation (Light brown tissue)

2 = moderate clinical pigmentation (Brown tissue)

3 = Heavy clinical pigmentation (Deep brown or Black tissue)

Bleeding

Bleeding was assessed by the primary investigator intra-operatively and immediate post-operatively. It was evaluated as

A. None

B. Slight

C. Moderate

D. Severe

Difficulty of the operator

Difficulty of the operator was assessed by the primary investigator intra-operatively using the Visual Analogue Scale.

Pain

Pain was assessed using Visual Analogue Scale

Wound healing

Wound healing was assessed by the primary investigator clinically on the first, second, third and the fourth week post-operatively. It was evaluated by using healing index by Landry et al.^[13]

Assessment of patient opinion on esthetic change

Esthetic change was assessed by using Visual Analogue Scale

Statistics

The collected data were tabulated and statistical analysis was performed using the SPSS (SPSS Inc., Chicago IL) version 25. To compare the mean difference between the two groups for difference in the colour of the gingiva, bleeding, difficulties of the operator, pain perception of patient and post-operative wound healing, unpaired student 't' test was used. P< 0.05 was considered significant.

Results

The colour of the gingiva was assessed post-operatively for both the CO₂ and diode group at first, second, third and fourth week. Both the CO₂ and diode group had similar results at the end of 1st and 2nd week. But at the end of 3rd week and 4th week, the degree of pigmentation was less in diode group compared to the CO₂ laser group. A significant difference was observed in the colour of the gingiva between the diode and CO₂ group (p value=0.047) (Table 1, graph I and II) [Fig. 3-5]

There was no significant difference in the bleeding between both the groups intraoperatively with the data described in table 2 (p value = 1.00) however, we observed a marginally significant difference between the diode and CO₂ group during immediate post-operative period (p value=0.0632). There was no significant difference between both the groups in the difficulty of the operator (p value=1.00). On recording the pain intra-operatively, immediate post-operatively and 1st day post-operatively, there was no difference in the pain perception between the groups as given in table 3. (p value=1.00), immediate post-operatively (p value=1.00), 1st day post-operatively.

Statistically, there was marginally significant between the CO₂ and diode group in the 1st (p value=0.0632) (Graph III) and 2nd week (p value=0.037). At the end of 3rd (p value=1.0) and 4th week (p value=1.0), there was no significant difference between the two groups.

The esthetic perception was assessed at the end of 4th week. Regarding the aesthetic consideration diode laser group scored more satisfaction than CO₂ laser study group.

Fig. 1 AMD Diode Laser Picasso, Usa

Fig. 2: Novapulse Lx-20 Sp Surgical Laser

Fig. 3: (a): Pre-Operative Photograph; (b): Immediate Post – Operative Photograph using Diode laser;

Fig. 4: (a): Post Operative Photograph 1st Week using Diode laser; (b): Post Operative Photograph 2nd Week using CO₂ laser

Fig. 5: Post Operative Photograph 4th Week using Diode laser

Graph I: Colour of gingiva – end of 3rd week

Table 1: Colour of gingiva – comparison between 3rd and 4th week

	Colour of the gingiva					
	3 rd week			4 th week		
	No Pigmentation	Mild	Moderate	No Pigmentation	Mild	Moderate
Diode laser	2(20.0%)	7(70.0%)	1(10.0%)	2(20.0%)	7(70%)	1(10.0%)
CO ₂ laser	1(10.0%)	8 (80%)	1(10.0%)	1(10.0%)	8(80%)	1(10.0%)
pValue	0.047*			0.047*		

Table 2: Assessment of bleeding

	Intraoperative Bleeding			Immediate postop Bleeding		
	No Bleeding	Mild	Moderate	No Bleeding	Mild	Moderate
Diode laser	10 (100%)	0(0%)	0(0%)	0(0%)	2(20.0%)	8(80.0%)
CO ₂ laser	10 (100%)	0(0%)	0(0%)	0(0%)	0(0%)	10(100%)
pValue	1.00			0.0632*		

Table 3: Assessment of pain between during operative and one day post operative period

Parameter		Pain Immediate Post-op		Pain Immediate 1st day Post-op		P Value
		Mild Pain	Moderate Pain	Mild Pain	Moderate Pain	
Group	Diode	10 (100.0%)	0(0%)	10 (100.0%)	0(0%)	1.00
	CO ₂	10(100.0%)	0(0%)	10 (100.0%)	0(0%)	

Graph II: Colour of gingiva – end of 4th week **Graph III:** Wound healing – end of 4th week

Discussion

Since the procedure with lasers is relatively painless, zero downtime, post-surgical dressings or sutures, minimal recurrence of pigmentations, patient compliance is much

better compared to the conventional techniques used for depigmentation.^[14-16] CO₂ laser introduced in 1965 by

Polanyi & associates, CO₂ laser wavelength is absorbed by water based tissues resulting in vaporization of intra and extra cellular fluid & disintegration of cells. Collateral thermal damage is less. Diode laser was introduced in 1995. The diode laser is a solid-state semiconductor laser that typically uses a combination of Gallium (Ga), Arsenide (Ar), and other elements, such as Aluminum (Al) and Indium (In), to change electrical energy into light energy. The semiconductor diode laser is emitted in continuous-wave or gated-pulsed modes, and is usually operated in a contact method using a flexible fibre optic delivery system.^[17]

In this study, A total of 10 patients clinically diagnosed grade 3 (heavy clinic melanin pigmentation) with gingival hyperpigmentation were enrolled for this study. They were aged between 18-23 years. Mean age of male and female patients were 19.2 years and 20.5 years respectively. In a study by Simsek Kaya et al,^[18] the patients with untreated bilateral melanin pigmentation in the anterior portion of the upper and lower gingiva were evaluated as severe according to modified Dummett et al criteria.

In both the study group, at the end of 1st week the colour of the gingiva revealed no pigmentation in 2(20%) of the patients, while in 8(80%) of the patients there was a mild pigmentation. Similar findings have been reported by Murthy MB et al^[19] who observed that in 1st week, the colour of the gingiva was pink with an uneventful healing. Diode lasers are concentrated at 800 to 980 nm has high affinity for substances with chromophores such as hemoglobin and melanin. They are ideal for treating soft tissues especially for gingival procedures such as gingivoplasty, gingivectomy and curettage.^[19]

Patients treated with diode laser at the end of 3rd week, the gingiva in 2(20%) of the patients had no visible pigmentation. 7(70%) of the patients had mild pigmentation and 1(10%) had moderate pigmentation. In CO₂ laser study group 1(10%) of the patients showed no pigmentation while,

8(80%) of the patients presented with mild pigmentation and 1(10%) with moderate pigmentation. Phimon Atsawasuwan et al^[20] clinical reports says that after ablating the epithelium with the Nd:YAG laser, the wound was covered with some dried and charred epidermis. The wound was almost healed completely within 3 weeks. The colour of ablated gingiva was dark pink in some areas.^[5]

In diode laser study group at the end of 4th week the colour of the gingiva in 2(20%) of the patients had no pigmentation. 7(70%) of the patients had mild pigmentation and 1(10%) had moderate pigmentation. In CO₂ laser study group 1(10%) of the patients had no pigmentation. 8(80%) of the patients had mild pigmentation and 1(10%) had moderate pigmentation. These results were in accordance with the results observed by Sushma Lagdive et al^[21] who studied and compared the effectiveness of diode laser and scalpel technique, they concluded that there was significant improvement in colour of the gingiva at the end of 4th week.

The diode laser causes minimal damage to the periosteum and removes a thin layer of epithelium cleanly. Healing takes a longer duration with procedures performed with lasers, a sterile inflammatory reaction occurs after laser use ensuring a uneventful healing^[22,23] Bhanu noted that one of the advantages of diode laser is sealing of blood vessels up to 0.5 diameter in surrounding tissue, one advantage of it, is homeostasis and consequently dry treatment sites.^[24] In both the study group all the patients 10(100%) had moderate bleeding during the time of procedure. M Bhanu Murthy et al stated that gingival depigmentations with diode laser had less intra operative bleeding compared to scalpel technique. Carlo Mairana et al employed a superpulsed diode laser in oral surgery and observed instant coagulation of the surgical site intraoperatively.^[25] Bleeding seen during lasers is due to vasodilation of blood vessels. Measurable changes in small vessel components of lamina propria were not seen, in diode laser treated sites.^[26]

In diode laser study group, 20% of the patients had slight bleeding and 8(80%) had moderate bleeding in the immediate post-operative period compared to CO₂ laser study group, where all the patients 10(100%) experienced moderate bleeding. The bleeding could also be explained on the depth of ablation where the CO₂ laser penetrates deeper than depth required to remove the pigmentation.^[27] The operators found no difficulty while treating the patients and was easy in all the patients 10(100%) in both the study groups. This finding was in line with Simşek Kaya et al and Amit Bhardwaj et al observed that from the operator's point of view, the laser technique was easier and faster to perform than the epithelial excision technique.^[17,28]

There was no pain perceived by the patients during intra operative period in both the study group 10(100%). These findings was in resonance with the study of Azzeh MM et al^[29] who observed that all patients in his study reported absence of pain intra operatively, immediately postoperatively, and 4 days after the procedure. The absence of pain during lasers is due to the ability of the laser beam to seal nerve endings^[30] Pain reduction after using lasers is due to the protein coagulum formed on the wound surface that

seals off sensory nerve endings and it also acts as a biologic dressing. The rapid wound healing after using lasers may be related to the photobiomodulation (PBM). PBM accelerates lymphatic and blood flow resulting in reduction in toxins and contributes to a larger expression of collagen and elastic fibers during the early phases of the wound-healing process. This helps to reduce pain, enhance repair, and induce regeneration thus promoting faster healing and return to normal.^[31]

At the end of 1st week the wound healing scored grade B. In our study, All the patients in both the study group had excellent wound healing at the end of 4th week. This was in agreement with Geethi Gupta and MB Moorthy et al observed that healing of laser wounds was slower than healing of scalpel wounds, and a sterile inflammatory reaction occurred after the procedure.^[10,18]

Amit Bhardwaj et al observed that both scalpel technique and diode laser, on 30 days revealed restoration of normal features of the gingiva without any scar formation. Thus, the healing of the depigmented gingiva was uneventful irrespective of the techniques used.^[25] Geethi Gupta et al^[33] stated that compared to scalpel surgery, diode laser showed delayed healing. No adverse events were noted at 1 week and 1 month post operatively with either of the techniques. Bassar Ali Abdullah et al^[34] observed that the use of diode laser is associated with delayed healing compared with Er Cr YSGG.

On evaluating the esthetic outcome of the procedure, all the patients 10(100%) had a significant improvement in their aesthetics in diode laser. In CO₂ laser study group 2(20%) had better aesthetics and 8(80%) had beautiful aesthetic appearances. These results were in accordance with Esen et al. observed similar results.^[35] Regarding the aesthetic consideration diode laser group scored more satisfaction than CO₂ laser study group. The depigmentation using lasers was more compatible to the patient as the procedure takes less time and was more comfortable as the area did not require injecting local anesthesia and absence of post-operative pain and hemorrhage.

Conclusion

Growing esthetic concern among individuals requires the removal of hyperpigmented areas to create pleasant and confident smile which altogether alters the personality of an individual. Diode lasers are effective in the management of gingival hyperpigmentation in terms of appearance of gingiva, perception of pain, bleeding intra operatively, difficulty of the operator, wound healing and esthetics.

Abbreviations

CO₂ - Carbon dioxide
 Nd:YAG - Neodymium-Doped Yttrium Aluminum Garnet
 DOPI - Dummett-Gupta Oral Pigmentation Index
 SPTL - Selective Photothermolysis
 CW - Continuous Wave
 PW - Pulsed Wave
 Ga - Gallium
 Ar - Arsenide

Al - Aluminum

Ind - Indium

PBM - Photobiomodulation

Er Cr YSGG - Erbium, Chromium-Doped Yttrium, Scandium, Gallium and Garnet

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Conflict of Interest

None.

References

1. Cicek Y, Ertas U. The normal and pathological pigmentation of oral mucous membrane: A review. *J Contemp Dent Pract.* 2003;4:76–86.
2. Bhardwaj A, Dadlani H, Grover HS, Lal S, Yadav A. Evaluation of patient response and recurrence of pigmentation following gingival depigmentation using laser and scalpel technique: A clinical study. *J Indian Soc Periodontol.* 2014;18(5): 586-592
3. Dummett CO. Clinical observation on pigment variations in healthy oral tissues in the Negro. *J Dent Res.* 1945;24:7–13.
4. Kauzman A, Pavone M, Blanas N, Bradley G. Pigmented lesions of the oral cavity: Review, differential diagnosis of case presentation. *J Can Dent Assoc.* 2004;70:682-3.
5. Almas K, Sadiq W. Surgical Treatment of Melanin-Pigmented Gingiva: An Esthetic Approach. *Indian J Dent Res.* 2002;13:70–3.
6. Ginwalla TM, Gomes BC, Varma BR. Surgical removal of gingival pigmentation. (A preliminary study) *J Indian Dent Assoc.* 1966;38:147–50.
7. Dummett CO, Bolden TE. Post-surgical clinical repigmentation of the gingiva. *Oral Surg Oral Med Oral Pathol.* 1963;16:353–65.
8. Hirschfeld I, Hirschfeld L. Oral pigmentation and a method of removing it. *Oral Surg Oral Med Oral Pathol.* 1951;4(8):1012-6.
9. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in non-surgical periodontal therapy. *Periodontology.* 2000;36(1):59–97.
10. Gupta G, Management of gingival hyperpigmentation by semiconductor diode laser. *J Cutan Aesth Surg.* 2011;4(3):208-10.
11. Anderson RR, Parrish JA: Selective photothermolysis, precise microsurgery by selective absorption of pulsed radiation. *Science.* 1983;220:524-7.
12. Dummett CO, Gupta OP. Estimating the epidemiology of gingival pigmentation. *J Natl Med Assoc.* 1964;56:419–20.
13. Landry RG, Turnbull RS, Howley T. Effectiveness of benzydame HCl in the treatment of periodontal post-surgical patients. *Res Clin Forums.* 1988;10:105-18.
14. Atsawasuwan P, Greethong K, Nimmanon V. Treatment of gingival hyperpigmentation for esthetic purposes by Nd: YAG laser: Report of 4 cases. *J Periodontol.* 2000;71:315–21.
15. Tal H, Oegieser D, Tal M. Gingival depigmentation by erbium: YAG laser: Clinical observations and patient responses. *J Periodontol.* 2003;74:1660–7.
16. Arthiie Thangavelu, Sugumari Elavarasu, and Piranitha Jayapalan, Pink esthetics in periodontics – Gingival depigmentation: A case series. *J Pharm Bioallied Sci.* 2012;4(2):S186–90.
17. Simşek Kaya G, Yapici Yavuz G, Sümbüllü MA, Dayi E. A comparison of diode laser and Er:YAG lasers in the treatment of gingival melanin pigmentation. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2012;113(3):293-9.
18. Murthy BM, Ka-ur J, Das R. Treatment of gingival hyperpigmentation with rotary abrasive, scalpel, and laser techniques: A case series *J Indian Soc Periodontol.* 2012;16(4):614–619.
19. Featured wavelength: Diode - the diode laser in dentistry (Academy report) Wavelengths. *Acad Laser Dent.* 2000;8:13
20. Atsawasuwan P, Greethong K, Nimmanon V. Treatment of gingival hyperpigmentation for esthetic purpose by Nd:YAG :Report of 4 cases. *J Periodontol,* 2000;71:315-21.
21. Lagdive S, Yogesh D, Marawar PP, Management of Gingival Hyperpigmentation Using Surgical Blade and Diode Laser Therapy: A Comparative Study. *JOLA.* 2009;9(1):
22. Kanakamedala AK, Geetha A, Ramakrishnan T, Emadi P. Management of gingival hyperpigmentation by the surgical scalpel technique-report of three cases. *J Clin Diagn Res.* 2010;14:2341–6.
23. Ozbayrak S, Dumlu A, Ercalik-Yalcinkaya S. Treatment of melanin pigmented gingiva and oral mucosa CO2 laser. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2000;90:14–5.
24. Bhanu M, Kaur J, Das R. Treatment of gingival hyperpigmentation with rotary abrasive, scalpel, and laser techniques: a case series. *J Indian Soc Periodontol,* 2012;16:614-9
25. Carlo Maiorana, Sergio Salina Versatility of a super pulsed diode laser in oral surgery- a clinical report. *J Oral Laser Applications.* 2006;6:193-99.
26. Giannelli M, Formigli L, Bani D, Comparative evaluation of photoablative efficacy of erbium: yttrium-aluminium- garnet and diode laser for the treatment of gingival hyperpigmentation. A randomized split-mouth clinical trial. *J Periodontol.* 2013;85:554-61.
27. Kishore A, Kathariya R, Deshmukh V, Vaze S, Khalia N, Dandgaval R et al. Effectiveness of Er: YAG and CO2 lasers in the management of gingival melanin hyperpigmentation. *Oral Health Dent Manag.* 2014;13(2):486–91.
28. Bhardwaj A, Grover H, Lal S, Gingival Depigmentation with Scalpel and Diode Laser, 2012. *World J Dent.* 3(4):359-62.
29. Azzeh MM. Treatment of Gingival Hyperpigmentation by Erbium-Doped:Yttrium, Aluminum, and Garnet Laser for Esthetic Purposes. *J Periodontol.* 2007;78(1):177-83.

30. Khakar M, Kapoor R, Jayakumar O, Padmalatha SS, Varghese MS, Advantages of 980 nm diode laser treatment in the management of gingival pigmentation. *J Laser Dent.* 2011;19(3):283-5.
31. Carlo Maiorana, Sergio Salina Versatility of a super pulsed diode laser in oral surgery- a clinical report. *J Oral Laser Applications* 2006;6:193-199.
32. Mani A, Mani S, Shah S, Thorat V. Management of gingival hyperpigmentation using surgical blade, diamond bur and diode laser therapy: a case report. *J Oral Application* 2009;9 227-32.
33. Gupta G. Management of gingival hyperpigmentation by semiconductor diode laser. *J Cutaneous Aesth Surg.* 2011;3(4):208-10.
34. Abdullah BA, Al-shmaah ZA. The Use of ErCrYSGG Versus Diode Laser in Gingival Melanin Depigmentation. *Int J Enhanced Res Sci Technol Eng.* 2014;3(5):12-21.
35. Esen E, Haytac MC, Oz IA, Erdoğan O, Karsli ED Gingival melanin pigmentation and its treatment with the CO2 laser. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2004;98(5):522-7.