GINGIVAL DEPIGMENTATION WITH Er:YAG LASER: WHAT IS NEW?

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ABSTRACT

Gingival melanin or metal tattoo pigmentation is occasionally observed and produces aesthetic problems to the patients while smiling. Among dental lasers, the Er:YAG laser used water spray minimizes the thermal changes of the irradiated soft tissue and safe and effective tool for depigmentation procedure. Microscope-assisted Er:YAG laser surgery can precisely detect and remove melanin pigmentation and metal debris embedded in the connective tissue. When using a laser device in a microsurgery, it is necessary to pay attention to safety. It is essential to wear protective goggles to protect from reflections and scattered light during treatment.

Key words: Laser depigmentation; Er:YAG laser; Melanin hyperpigmentation; Metal tattoo

Introduction

The healthy color of the gingiva plays a vital role in the attractiveness of a smile, particularly in individuals with a high smile line [1]. Under normal physiological conditions, the gingiva appears coral or salmon pink, though this shade may vary depending on several factors, including the degree of vascularization, epithelial thickness, gingival biotype, and the concentration of melanin pigment [1, 2].

Gingival hyperpigmentation may be either physiological or pathological in origin (Figure 1). Physiological pigmentation most commonly appears as visible oral melanin pigmentation, which is most frequently observed on the gingiva among all intraoral tissues. Melanin, the pigment responsible for this coloration, is synthesized and stored within melanosomes produced by melanocytes [1]. These melanocytes are located in the basal cell layer of the epithelium and contribute to the darkened appearance of the gingiva, referred to as melanin hyperpigmentation/MH [1, 2].

To the contrary, iatrogenic pigmentation, such as metal or amalgam tattoos, can occur unintentionally during dental procedures. This type of pigmentation presents as blue-grey discoloration of the gingiva, resulting from the accidental deposition of metallic particles or micro fragments from dental prosthetic materials into the gingival tissue adjacent to treated teeth [1, 2].

Although melanin hyperpigmentation and amalgam tattoos are not associated with medical complications, patient demand for their removal, particularly in cases involving pigmentation of the anterior labial gingiva, continues to rise due to aesthetic concerns. A wide range of treatment modalities have been introduced for MH removal, including bur abrasion, electrosurgery, chemical and cryosurgery, laser therapy, gingivectomy, flap surgery, gingival grafting, and various combinations of these methods [1-4]. Among these, laser surgery has proven to be an effective, safe, comfortable, and reliable technique for gingival depigmentation [5-7].

In recent years, the Er:YAG laser, among other laser types, has gained significant attention for its exceptional efficiency in soft tissue ablation while minimizing thermal damage to surrounding and underlying tissues [5-7]. In vivo studies have shown that the thermally affected layer in gingival connective tissue following Er:YAG laser incision is limited to only 5-20 μm [7, 8]. As a result, Er:YAG laser treatment is widely recognized as a minimally invasive and highly precise approach to gingival depigmentation. Moreover, combining the Er:YAG laser with a surgical microscope enhances the precision, safety, and completeness of the procedure [2, 9]. These technical advantages of Er:YAG laser microsurgery contribute to improved wound healing, reduced postoperative discomfort, and enable delicate or complex interventions that are difficult to perform using conventional methods [2].

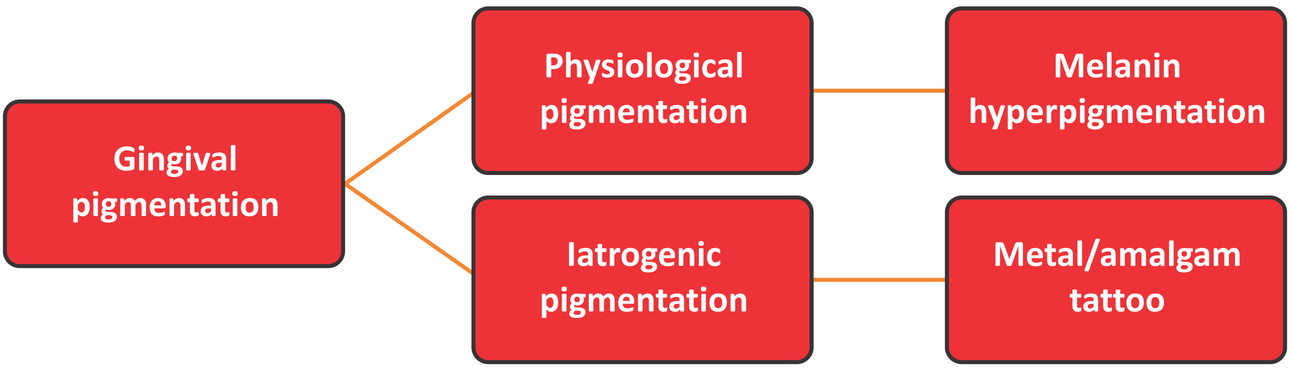

Figure 1. Gingival pigmentation

A critical consideration in ensuring the safety of clinical laser applications is the prevention of accidental eye exposure. The eye possesses the lowest maximum permissible exposure threshold of all body tissues [10]. Because the Er:YAG laser wavelength is absorbed by the surface layers of the eyeball, accidental irradiation can result in thermal injury to the cornea [10]. Therefore, before beginning treatment, it is essential that the patient, operator, and assistant wear protective eyewear (goggles) specifically designed for the laser's wavelength to safeguard against reflected or scattered laser light [10].

Removal of melanin pigmentation

Melanin depigmentation using the Er:YAG laser can be performed under local, topical, or no anesthesia, depending on the severity and extent of pigmentation as well as the patient's comfort and preference [1, 2]. The laser irradiation is typically set at an energy level of 50-80 mJ per pulse on the control panel (corresponding to an actual energy output of 25-40 mJ per pulse), with an energy density of 8.8-14.2 J/cm^2 per pulse when using a 600 μm diameter contact tip. The procedure is carried out at a repetition rate of 10-30 Hz under continuous water spray, with the laser applied in an oblique contact mode at an angle of approximately 20-30 degrees to the gingival surface [1, 2].

The laser beam is moved using the “brush” or “sweeping motion” technique-entailing slow, continuous movements with overlapping laser spots to ensure uniform ablation. After the initial complete ablation of the pigmented area, any residual pigmentation is meticulously removed under 20–30× magnification by fine-tuning the laser focus, targeting small dotted or occasionally linear pigment deposits, particularly those located at the base of epithelial rete pegs. Immediately after the procedure, spontaneous hemostasis is achieved in a few minutes and no suture is required [2-4].

Figure 2. Case presentation of Er:YAG laser melanin depigmentation. a) Female, 19 years old. Generalized severe melanin hyperpigmentation in the upper arch, on the first visit, b) During irradiation with local anesthesia, 40-47 mJ/pulse at tip end (62-72 mJ/pulse on the control panel) and 30 Hz under water spray in oblique contact mode using an 80 degree curved contact tip, c) immediately after Er:YAG laser melanin depigmentation, no severe thermal injuries such as carbonization and severe coagulation of the gingival tissue, d) 9 days postoperatively, ablated gingiva showed fast epithelialization with a healthy appearance, e) 42 days postoperatively, f) 6 months following irradiation complete healing was observed without recurrences or gingival recessions or deformities. [Picture from Ishii S, Aoki A, Kawashima Y, Watanabe H, Ishikawa I. Application of an Er:YAG laser to remove gingival melanin hyperpigmentation-Treatment procedure and clinical evaluation. J Jpn Soc Laser Dent. 2002;13:89-96. © copyright (2002) J Jpn Soc Laser Dent] [9]

Removal of metal tattoo pigmentation

Most treatment sites are located in the maxillary anterior region, followed by the mandibular anterior and premolar areas. Typically, a small amount of local anesthesia (0.2-0.45 ml) is sufficient for this procedure. In cases of mild pigmentation, treatment can sometimes be performed under topical anesthesia or even without anesthesia, depending on the extent and severity of pigmentation [1-4].

Laser irradiation is generally applied at an energy setting of 50-80 mJ per pulse on the panel (corresponding to an actual energy output of 25-40 mJ per pulse and an energy density of 8.8-14.2 J/cm^2 per pulse when using a 600 µm contact tip). The procedure is performed at a repetition rate of 10-30 Hz under continuous water spray, with the laser applied in a vertical or oblique contact mode at an angle between 30° and 90° to the tissue surface. Curved, round-ended contact tips (400 or 600 µm in diameter) are recommended. Each treatment session typically lasts about 20-40 minutes [1-4].

Minimal gingival ablation is performed in the darkly pigmented (black or gray) areas to expose the underlying metal debris deposited within the connective tissue. A magnified visual field (approximately 10–30×) enables precise and safe tissue ablation while minimizing injury to surrounding areas. The metal fragments and adjacent discolored connective tissue are carefully removed, while the papillary edges, free gingival margins, and periodontal tissue attachment to the root surface are preserved to prevent tissue detachment and potential gingival recession caused by excessive or inadvertent irradiation [2-4].

The limited hemostatic effect of the Er:YAG laser is advantageous for wound healing, as postoperative bleeding promotes blood clot formation and subsequent granulation within the ablation site. This process supports favorable healing and helps prevent gingival defects. Care must be taken to minimize tissue injury in order to maintain the integrity of the blood clot and avoid postoperative complications [2, 3].

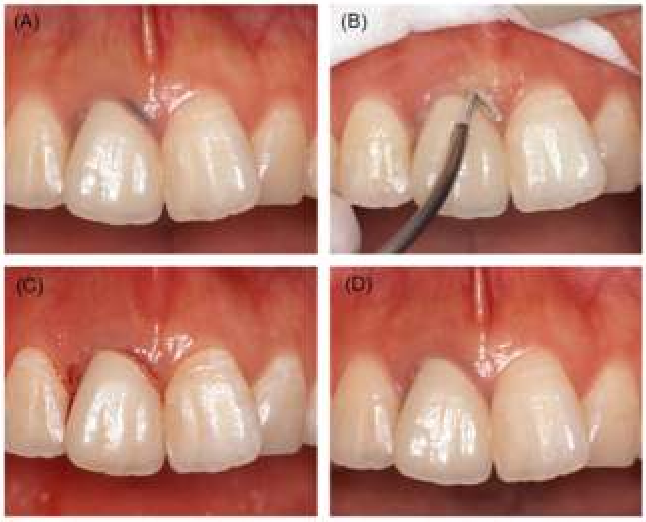

Figure 3. Patient was a 27-years old female who had (A) linear moderate metal tattoo pigmentation in the mesial and distal marginal gingiva of the maxillary right central incisor. (B) The metal tattoo area was vaporized using an Er:YAG laser and topical anesthesia only. (C) The postoperative view immediately after minimally-invasive metal tattoo removal. Slight bleeding followed by spontaneous hemostasis was observed. (D) One week after treatment, epithelialization was complete and the gingival discoloration had disappeared. No gingival recession was observed. [Picture from Mikami R, Mizutani K, Nagai S, Pavlic V, Iwata T, Aoki A. A novel minimally-invasive approach for metal tattoo removal with Er:YAG laser. J Esthet Restor Dent. 2021;33(4):550-559, with permission] [3]

Recently, a minimally invasive approach known as Er:YAG Laser Micro-Keyhole Surgery (EL-MIKS) has been introduced [2, 4]. In this microsurgical technique, small “keyholes” are created to enable targeted removal of pigmentation. Initially, a keyhole with a diameter of 1-2 mm is prepared using the Er:YAG laser with a 400 or 600 µm contact tip. The laser is applied vertically at 60-80 mJ per pulse on the panel (actual energy output approximately 30-40 mJ per pulse; energy density 23.9-31.2 J/cm^2 per pulse for a 400 µm tip) and a frequency of 20-30 Hz. Deposited metal fragments and surrounding discolored connective tissue are eliminated [4].

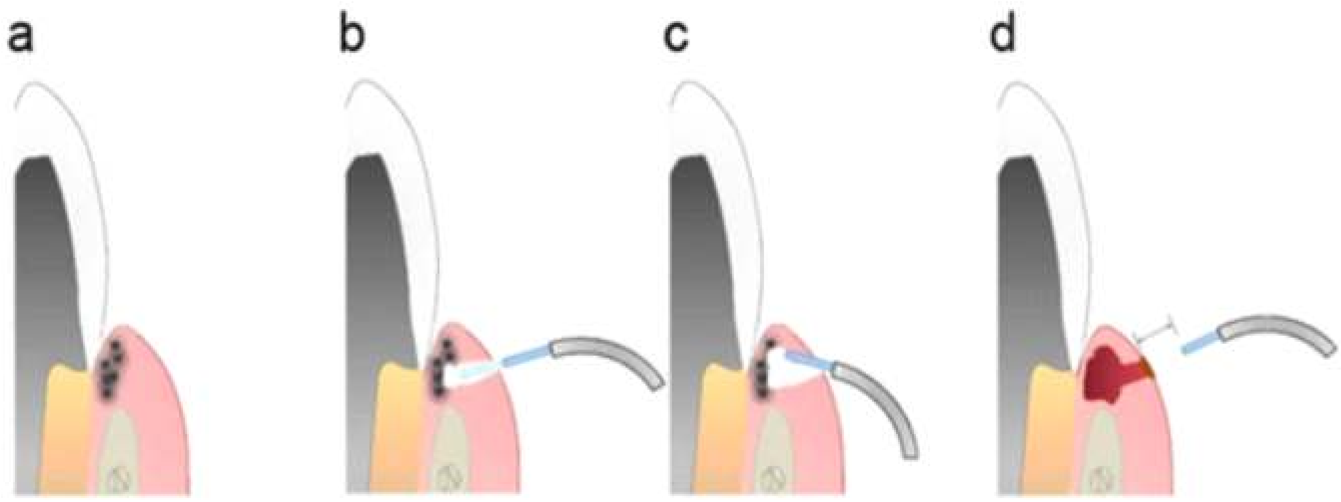

Figure 4. Step-by-step procedure of Er:YAG laser micro-keyhole laser surgery (EL-MIKS) for removing metal tattoos in the gingiva adjacent to prosthetic teeth (a). Making a small keyhole with a diameter of 1-2 mm to access the pigmented gingiva to ablate metal fragments and the surrounding discolored connective tissue using an Er:YAG laser (b). Shifting the laser direction to ablate the metal and surrounding tissue. Eliminate micro-metal fragments as much as possible through the keyhole so as not to expand the size of the keyhole. Carefully preserve the overlaying gingiva of the discolored tissue intact (c). After the tissue evaporation, the ablated space fills with blood. Defocus irradiation (10 Hz, 60 mJ) without a water spray to the micro-keyhole entrance with more than 5 mm distance between the laser tip and gingiva (double-headed arrow) was performed. The coagulation of the blood surface is encouraged by a laser-derived heat reaction. The blood clot is stabilized within the evaporated space (d). If the pigmentation is widespread, the area to be treated must be divided into several parts that are treated one by one. Micro keyholes are prepared to access the center of each part. [Picture from Mizutani K, Mikami R, Tsukui A, Nagai S, Pavlic V, Komada W, Iwata T, Aoki A. Novel flapless esthetic procedure for the elimination of extended gingival metal tattoos adjacent to prosthetic teeth: Er:YAG laser micro-keyhole surgery. J Prosthodont Res. 2022;66(2):346-352, licensed under CC BY-NC 4.0, Japan Prosthodotic Society]. [4]

Next, the lateral wall of the pigmented area is treated at an inclined angle to evaporate the pigmented tissue while preserving the overlying epithelium and preventing enlargement of the keyhole entrance. Accessible metal particles and pigmented tissue within the undercut area are carefully ablated [2-4]. For better visualization, a laser tip or periodontal probe may be used to gently retract the marginal gingiva. The coaxial water spray accompanying the Er:YAG laser helps flush out residual metal fragments and tissue debris from the keyhole. The irradiation angle is repeatedly adjusted in multiple directions within each micro-keyhole to remove as much pigmented tissue as possible within the accessible range. After blood fills the tissue defect, the surface at the keyhole entrance is coagulated using defocused laser irradiation (60-80 mJ per pulse; 400 or 600 µm contact tip; 10-20 Hz) without water spray [4].

Figure 5. A representative case of Er:YAG laser micro-keyhole laser surgery (EL-MIKS) on a widespread metal tattoo (a). The patient was a 61-year-old female with a prominent metal tattoo in the gingiva of #12 (b). Because the pigmentation was widespread, the area to be treated was divided into several parts (dotted line). Micro-keyholes were prepared to access the center of each part. In this case, the distal part with the most severe discoloration was treated first (c). All procedures were performed with a microscope and Er:YAG

laser under local anesthesia. Immediately after the first session, only the apical part of the distal pigmentation was treated through one micro-keyhole (arrowhead) (d). One month after the first surgery, the area treated in the first session was completely epithelized (e), and treatment of the distal pigmentation of the coronal part and mesial, buccal middle areas were partly performed through five microkeyholes (arrowheads) in the second session (f). One month after the second session (g), the deposited pigments in the deep mesial region were removed through four micro-keyholes (arrowheads) in the second session (h). At one month after the third session, the pigmentation slightly remained (i). Three months after the third session, the gingival pigmentation had completely disappeared. Since the metal fragments causing the pigmentation had been removed, the slightly remained discoloration spontaneously disappeared with the gingival turnover. The recession of the marginal gingiva was generally prevented. Note the crown was replaced (j). Two years after the procedures, the improved gingival color has been maintained, and the patient was esthetically satisfied with the treatment (k). Figure reproduced from Mizutani K, Mikami R, Tsukui A, Nagai S, Pavlic V, Komada W, Iwata T, Aoki A. Novel flapless esthetic procedure for the elimination of extended gingival metal tattoos adjacent to prosthetic teeth: Er:YAG laser micro-keyhole surgery. J Prosthodont Res. 2022;66(2):346-352, licensed under CC BY-NC 4.0, Japan Prosthodotic Society. [4]

Because of the minimally invasive nature of the procedure, postoperative medication is usually unnecessary for small treatment areas [2, 4]. However, analgesics or antibiotics may be prescribed depending on the treatment extent and patient preference. Patients are advised to avoid tooth brushing in the treated area and to use antiseptic mouth rinses for one week following the procedure. Re-epithelialization typically occurs within 4-7 days, depending on the size of the treated region, while complete tissue maturation is generally achieved within approximately two weeks [1-4].

Conclusion

The Er:YAG laser allows for precise and efficient treatment of gingival tissue, enabling controlled ablation through the use of fine contact tips. Its minimal thermal effect offers significant advantages, including improved visibility of the treated surface, enhanced wound healing, and effective pain management during soft tissue procedures. Moreover, when combined with microscopic assistance, Er:YAG laser irradiation permits careful and accurate removal of gingival pigmentation with minimal tissue trauma. This approach simplifies the procedure, reduces postoperative discomfort, and promotes smooth and rapid healing. Notably, the novel minimally invasive technique for metal tattoo removal utilizing the Er:YAG laser under microscopic monitoring has proven to be simpler, more efficient, and far less invasive than conventional periodontal surgical methods.

Literature

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