Various gingival depigmentation techniques have been introduced to realize esthetic gingival color enhancement. Unfortunately, many of these procedures have nonesthetic outcomes, have the potential to damage the gingiva and connective tissues, subject the patient to postoperative pain, and do not offer long-term efficacy. The proper combined application of a 4.0-MHz radiofrequency and specialized electrode brush may result in the selective and complete removal of melanocytes from the gingival epithelium down to and including the basal layer, with minimal to no effect on the connective tissue. This article presents a case report and histopathologic examination to demonstrate the effectiveness and safety of this technique for achieving uniform pink gingival appearance. Int J Periodontics Restorative Dent 2023;43:13–20. doi: 10.11607/prd.6027

Gingival hyperpigmentation, melanin-induced gingival discoloration, and physiologic oral melanin pigmentation are among the terms used to label the nonesthetic but often benign condition associated with an excessive deposition of multifocal or diffuse melanin pigments in the gingival epithelium. Although gingival color is influenced by several factors (including tissue keratinization, epithelial thickness, and the number and size of blood vessels), the presence of melanin pigments in the layers of the gingival epithelium is largely responsible for gingival pigmentation.1

Melanocytes are located in the basal epithelial layer of the gingiva. Melanocytic cells (which develop from melanoblasts) and their activity produce the melanin granules and pigments that determine gingival color.1–3 The greater the melanocyte activity (and therefore the production of melanin granules and pigments), the greater the likelihood of physiologic gingival pigmentation and its distinctive multifocal, blotchy, and diffuse melanin pigmentation.3

To actualize esthetic gingival color enhancements, a variety of gingival depigmentation techniques have been introduced and attempted by clinicians. These treatments have included, but are not limited to, the use of soft tissue lasers.4,5
partial-thickness flaps, partial-thickness flaps, and scalpel, among others. Determining which technique is most appropriate for a given case is dependent upon several considerations, including the clinical experience of the dentist, patient preference and expectations, extent of gingival pigmentation, and characteristics and placement of other components of the smile architecture. Additional criteria for depigmentation procedures have also previously included preservation and/or minimal damage to the attached gingiva and connective tissue (preventing gingival recession and/or injury to the soft tissues), simplicity and cost-effectiveness, and patient comfort.

Soft tissue depigmentation laser treatments have been reported in the literature as efficacious and advantageous in terms of the esthetic results achieved, reduced postoperative pain and bleeding, and low incidence of repigmentation. However, successful treatments are predicated on the use of costly and complicated equipment, and the potential exists to damage the gingiva and underlying hard and soft tissues.

Surgical techniques, whether incorporating a partial-thickness flap, gingival grafting, or scalpel, have been associated with bleeding, periodontal dressings, postoperative pain, and at least one surgical site. Although surgical scalpel techniques have been cited for their cost-effectiveness, simplicity, and low rate of repigmentation, these techniques are contraindicated in patients presenting with thinner gingival biotypes and narrow papillary areas.

Abrasions depigmentation treatments utilizing a bur to superficially remove pigmented gingival epithelium are inherently technique-sensitive in terms of handpiece speed and pressure to prevent injury to underlying bone, require postoperative periodontal dressings, and are associated with postoperative pain. Despite the benefit of non-invasiveness, abrasion depigmentation has been associated with a high incidence of repigmentation.

The literature is also replete with articles about other depigmentation techniques—including electrosurgery—that have demonstrated varying success rates, clinical implications, contraindications, costs, and patient comfort. Traditional electrosurgery is associated with postoperative pain during the healing period. Like other techniques, damage to adjacent teeth and underlying bone can occur, as well as unintended soft tissue destruction, particularly if the electrosurgical tip contacts unintended structures, or if prolonged exposure accumulates heat.

Radiofrequency Electrosurgery

Radiofrequency electrosurgical units inherently produce alternating currents of a specific waveform, number of wave units, and frequency (Hertz). Historically, electrosurgical devices in dentistry have been beneficial for their cutting, slicing, and coagulation abilities. The interaction between the heat and high-frequency energy current produced by these devices and the soft tissue at which they are directed produces the coagulation effect. It is hypothesized that this type of interaction may also form the basis for the use of these devices with different techniques for gingival depigmentation. In particular, it is hypothesized that selective ablative deep epithelization can be accomplished using a monopolar radiofrequency electrosurgery device based on its mechanism of action and the composition of pigmented gingival epithelial layers.

Monopolar electrosurgical units generate a current (usually a fixed frequency) that passes along a wire to the surgical site and ultimately to a dispersive electrode plate that is placed behind the patient’s back. With monopolar mode devices, a variety of active surgical electrodes (cutting, scraping) can be used; as these electrodes contact gingival tissues, heat is generated in a controlled and precise manner.

In the present case report, a selective radiofrequency ablative deep epithelialization technique is performed using a 4.0-MHz radiofrequency electrosurgery unit and specialized electrode brush to vaporize basal cells, which are richly engorged with cytoplasts (cytoplasmic fluid) at the interface; beneath these engorged basal cells is dense collagen protein with little moisture. The difference in impedance between the dense collagen and the water-filled basal cells (cytoplasts) may facilitate depigmentation through epithelial stripping.
radiofrequency energy likely follows the path of least resistance, which is directly through the undulating basal layer. This effectively vaporizes the pigmented basal cells, leaving the connective tissue perfectly undamaged. This result is likely achieved because, when tuned properly, the radiofrequency energy remains in the moisture-rich epithelium, rather than reaching the connective tissue. It is believed that the precision provided by the device combined with the current used to ablate (vaporize) pigmented cells may make it possible to perform selective radiofrequency ablative deep epithelization and achieve a uniform pink gingival appearance.

The following case report and histopathologic examination demonstrate the effectiveness of the selective radiofrequency ablative deep epithelization technique for achieving a uniform pink gingival appearance. It also confirms the safety of this technique for underlying connective tissue.

Materials and Methods

Case Description

A 40-year-old Black man presented with the chief complaint of non-uniform maxillary gingival color. Clinical examination revealed the presence of multifocal (ie, blotchy/spotted) oral mucosa physiologic pigmentation (Fig 1).\textsuperscript{17-19} The examination also revealed a thick biotype,\textsuperscript{12} a wide band of keratinized attached gingiva, no systemic or localized illnesses, no contraindications for periodontal treatment, and no medications known to interfere with periodontal surgery.

The patient agreed to treatment consisting of a radiofrequency ablative deep epithelization process concomitant with three tissue biopsies: just prior to the depigmentation process; immediately postoperatively; and 4 months after the depigmentation treatment. Prior to initiating any treatment procedure, the patient agreed to participate in the study and signed written informed consent, in full accordance with the ethical principles of the 1975 Declaration of Helsinki as revisited in 2000.

Local anesthetic (septocaine 4% plus epinephrine with 1:100,000) was administered via buccal infiltrations around the entire maxilla. Prior to initiating the depigmentation procedure, the first biopsy specimen was removed from a site apical to the papilla, between the maxillary right first and second premolars. This site presented with focal pigmentation, thick biotype, and a tissue width sufficient for removing a 1.5-mm cylindrical diameter biopsy sample, leaving 3 mm of attached tissue coronal to the biopsy site and 1 mm of attached tissue apical to the biopsy site.\textsuperscript{20}

Tissue Biopsies

The harvesting of all three biopsy samples was performed using a standard manual tissue punch (1.5-mm diameter), which was rotated in a twisting motion with concomitant deliberate axial force until hard tissue was encountered. The tissue plug was carefully excised using hemostats and a curette.\textsuperscript{21} The tissue samples were placed into standard 10% formalin for fixation, labeled, and prepared for standard light microscopy.\textsuperscript{22} All three samples were sent to a pathology laboratory for hematoxylin eosin (h&E) and periodic acid–Schiff (PAS) tissue staining techniques. Histologic light microscopy analysis and comparison were conducted on all three samples.

Selective Radiofrequency Ablative Deep Epithelization

The gingival pinkening procedure was performed using a commercially...
available 4.0-MHz radiofrequency surgical unit (Radiosurge 3, Ellman International). The unit was set to monopolar cut mode with a power setting of 40%, and a grounding plate was placed under the patient’s right shoulder, separated from the skin by the thickness of the patient’s shirt.

Additional equipment included a newly fabricated active electrode designed to remove tissue through an ablative process. The electrode was placed in contact with the attached tissue using a constant brushing motion to prevent excessive thermal damage beyond the desired ablation of the epithelium down to and including the basal layer.

During the ablative procedure, white coagulum formed and was subsequently removed using a dry surgical sponge throughout the treatment. No hemostatic agent was necessary, as the surgical field was devoid of bleeding.

When the gingival depigmentation procedure ended, a biopsy of a second site apical to the papilla (between the maxillary left first and second premolars) was performed according to the previously described protocol.21 Surgical dressing was omitted, and the maxilla was allowed to heal by secondary intent (Fig 2).

After 17 weeks of healing, the patient returned for the third biopsy. This tissue sample was taken from the same general location as the preoperative biopsy according to the same protocol previously described.21

**Results**

At 2 weeks postoperative, the patient presented with pink, immature, reepithelialized attached gingiva devoid of stippling, slightly edematous in nature, and ranging in color from dark pink to light pink (Fig 3).

At 4.8 years postoperative, stippled, thick attached keratinized gingiva could be seen, pink in color and with pyramidal, knife-edged papillary regions. Additionally, the gingiva was devoid of any regions with multifocal pigmentation (Fig 4).

Histopathologic analysis of the preoperative gingival sample revealed an acanthotic stratified squamous epithelium with a regular maturation pattern (Fig 5a). A linear pattern of melanin deposition was observed in the basal layer, and a substantial dendritic transfer of the melanin into the epithelium’s spinous layer was evident (Fig 5b). Underlying connective tissues showed evidence of melanin incontinence in the form of melanophages and free melanin proximal to the epithelium.

PAS staining analysis of the preoperative sample accentuated several attributes of the patient’s gingival tissue pigmentation. In particular, the staining revealed delineation of the basement membrane (sharply highlighted by the prominent magenta linear staining below the epithelium); melanin in the basal layer and slender dendritic transfer of pigment into the upper portions of the epithelium; and central pigment incontinence in multiple connective tissue papillae (Fig 6a). However, the granules...
of melanin pigment in the basal layer (and the basal cells richly filled with cytoplasmic fluid) were evident under high-powered magnification (Figs 6b and 6c).

The histopathologic sample obtained immediately after deepithelization displayed complete ablation of the epithelium, with no evidence of pigment in the upper connective tissue (Fig 7a). The low-power h&e stain confirmed that the papillae were preserved, with only a small amount of coagulation necrosis focused at the tips (Fig 7b).
The connective tissue was devoid of inflammation and demonstrated total loss of all melanin pigment (Fig 7c). When observed under a higher magnification, the health and stability of the connective tissue was further confirmed, as well as the complete loss of pigment. An island of detached epithelium (E) that exfoliates during the procedure can also be seen.

Histopathology of the sample taken at 17 weeks postoperatively revealed a section of treated stratified squamous epithelium with no evidence of melanin pigmentation (Fig 10).

**Discussion**

In the present case, as with all depigmentation procedures, the objective was the safe, effective, and permanent removal of melanocytes to achieve a uniform, long-term pink gingival appearance. Although the literature indicates that depigmentation procedures often demonstrate a high recurrence rate, very little histologic evidence has been provided for depigmentation procedures to explain this phenomenon. A possible explanation for the high reoccurrence rate might be the ineffective removal of melanocytes from the basal layer of the epithelium.23-24

The benefits of selective radiofrequency ablative deepithelization

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**Fig 7** Histologic views of the immediately postoperative gingival specimen (h&E stain). (a) At ×10 magnification, the sample confirms complete ablation of the epithelium, with no evidence of pigment in the upper connective tissue (CT). Papillae (P) are intact, with a small amount of focal thermal necrosis (TN) at the tips. (b) At ×20 magnification, the sample confirms preservation of connective tissue papillae (CTP), with only mild focal thermal necrosis at the papillae tips. (c) At ×40 magnification, the sample shows epithelial ablation, intact focal connective tissue papilla, thermal necrosis, and total loss of all melanin pigment.

**Fig 8** Histologic view of the immediately postoperative gingival specimen (PAS stain). At ×40 magnification, the intact nature of the connective tissue papilla (CTP) architecture was revealed, with only slight focal thermal necrosis (TN) but complete loss of pigment. An island of detached epithelium (E) that exfoliates during the procedure can also be seen.

**Fig 9** Clinical view of a different patient who received the same gingival treatment. The close view illustrates the typical presentation of deepithelialized (DE) attached gingiva immediately after treatment, with intact connective tissue papilla.

**Fig 10** Histologic view of the 4-month postoperative gingival specimen (h&E stain). At ×20 magnification, no evidence of melanin pigmentation is seen in the treated stratified squamous epithelium (E). CT = connective tissue.
to achieve a uniform pink gingival appearance are numerous, not the least of which is successful gingival depigmentation. Additional benefits of the procedure include little to no connective tissue damage, little to no postoperative pain, a reduced likelihood of melanin recurrence, and intact connective tissue papillae, among others. A significant aspect to realizing these benefits is the proper combined application of a 4.0-MHz radiofrequency and specialized electrode brush, which results in the selective and complete removal of melanocytes from the gingival epithelium down to and including the basal layer, with minimal to no effect on the connective tissue. The cascading effect may have a higher efficacy in permanently removing melanocytes for long-term, uniform gingival pinkening. To the present authors’ knowledge, no other treatment modality can accomplish these unique objectives (Fig 11). Of course, the need
for randomized controlled clinical trials comparing the radiofrequency technique vs other techniques would help confirm the safety and efficacy of the present technique.

Interestingly, upon examination of the preoperative gingival sample (Fig 5a) and identification of melanin in the connective tissue, the patient was asked further questions, at which time the patient admitted to attempting to remove the pigmentation using an at-home remedy (vigorously scrubbing baking soda and lemon juice onto the gingiva). It is hypothesized that this action caused further visible pigmentation to occur by forcing melanin into the connective tissue, resulting in significant melanin incontinence, effectively making the presentation of multifocal pigmented lesions more prominent. This clinical finding may inform clinician and patient discussions regarding abrasive home remedies.

Conclusions

The selective ablative deepithelialization technique described herein was successful at removing the pigmented gingival epithelium down to and including the basal layer while leaving the connective tissue layer intact. In the present procedure, no collateral damage was caused to the connective tissue; only minor focal thermal necrosis was noted on isolated connective tissue papillae, and most of the connective tissue was unaffected. At 4.8 years after the deepithelialization procedure, the initial goal of a unified gingival presentation was accomplished.

Acknowledgments

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References