REVIEW ARTICLE

Infraorbital Dark Circles: Definition, Causes, and Treatment Options

Mi Ryung Roh, MD, and Kee Yang Chung, MD, PhD

BACKGROUND Infraorbital dark circles refer to the conditions that present with darkness of the infraorbital eyelids. Although it is not a medical concern, it can be a cosmetic concern for a large number of individuals. Moreover, clear definition and possible causes have not been elucidated.

OBJECTIVE To review the possible causes and treatment options for infraorbital dark circles.

METHODS The article is based on a review of the medical literature and the author's clinical experience in treating infraorbital dark circles.

CONCLUSION Possible causative factors of infraorbital dark circles include excessive pigmentation, thin and translucent lower eyelid skin overlying the orbicularis oculi muscle, and shadowing due to skin laxity and tear trough, but because multiple factors cause infraorbital dark circles in the majority of patients, it is essential to identify the cause and choose the appropriate treatment according to the cause.

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Infraorbital dark circle refers to conditions that present with relative darkness of the infraorbital eyelids. It can be a significant cosmetic problem, and many individuals seek treatment for this condition, but there have been few investigations regarding the cause and little research into the potential treatment of this condition. This condition affects individuals with a wide range of age, both sexes and all races. Moreover, it worsens with the aging process of skin sagging and altered subcutaneous fat distribution.[1] Cosmetic conditions that are neither health threatening nor associated with significant morbidity but that can affect the individual's emotional well-being are gaining increased attention. Infraorbital dark circles is a condition that can be a significant cosmetic concern for female patients. Although it is a condition that does not cause morbidity, it can influence the quality of life from the medical point of view.[2] Having infraorbital dark circles makes you look tired, sad, or hung over. General fatigue, especially lack of sleep, worsens dark circles under the eyes. There are many cosmetic products in the market for disguising this appearance.[3] Despite the prevalence of this condition, there are few published articles on dark circles and their pathogenesis. This article focuses on possible causes of infraorbital dark circles and treatment options.

Causes and Mechanisms

Possible causative factors of the dark circles include excessive pigmentation; thin, translucent lower eyelid skin overlying the orbicularis oculi muscle; and shadowing due to skin laxity and tear trough.[4]

Excessive pigmentation under the eyes can be a frequent cause of dark circles. Excessive pigmentation is seen in such conditions as dermal melanocytosis and postinflammatory hyperpigmentation secondary to atopic or allergic contact dermatitis (Figures 1 and 2). This condition usually appears as a slightly curved band of brownish skin approximating the shape of the underlying inferior orbital rim. The pigmentation looks darker when they are present

Both authors are affiliated with the Department of Dermatology and Cutaneous Biology Research Institute, Yonsei University College of Medicine, Seoul, Korea

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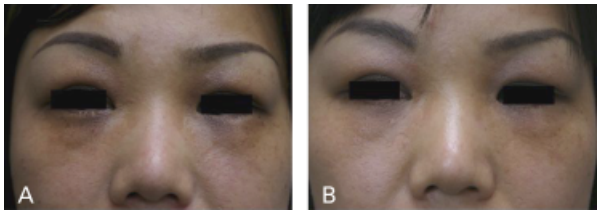

Figure 1. Infraorbital dark circles due to excessive pigmentation. (A) Due to dermal melanocytosis. (B) Improvement of dark circles after Q-switched alexandrite laser.

below bulging lower eyelids induced by pseudoherniation of orbital fat. Bulging lower eyelids add a shadow effect and worsen the appearance. When the lower eyelid skin is manually stretched, the area of pigmentation spreads out without any blanching or significant lightening of the pigmentation.[5] Dermal melanocytosis is due to congenital and environmental causes, including several benign pigmented lesions that are histologically characterized by the presence of melanocytes in the dermis.[6] Of the dermal melanocytic lesions that can appear on the face, nevus of Ota usually is present at birth.[7,8] Clinically, dermal melanocytoses are gray or blue-gray in color as a consequence of the color transmission of black pigment through the dermis. If they are located infraorbitally, they can be a cause of dark circles under the eyes (Figure 1). Watanabe and colleagues[9] studied periorbital biopsies of 12 Japanese patients with infraorbital dark circles, showing that all had dermal melanosis in the histology. According to the study, melanosis can be interpreted as dermal melanocytosis based on findings of anti-S100 protein and Masson-Fontana silver stainings. Differentiation of dermal melanocytosis relies on clinical features because the histopathologic findings are similar in most forms. Nevus of Ota is a grayish macular lesion on one side of the face following the branches of the trigeminal nerve.[10] Environmental causes that result in dermal melanocytosis include excessive sun exposure and drug ingestion.[11] Infraorbital dark circles are often seen in patients with atopic or allergic contact dermatitis. It is a form of postinflammatory hyperpigmentation due to rubbing or scratching the periorbital area (Figure 2). Other causes of periorbital hyperpigmentation include erythema dyschromicum perstans,[12] fixed drug eruption, and familial conditions.[13] Gellin and colleagues reported a familial case in which 22 members were affected in six generations that had a genetically determined form of hyperpigmentation involving the periorbital area.[13]

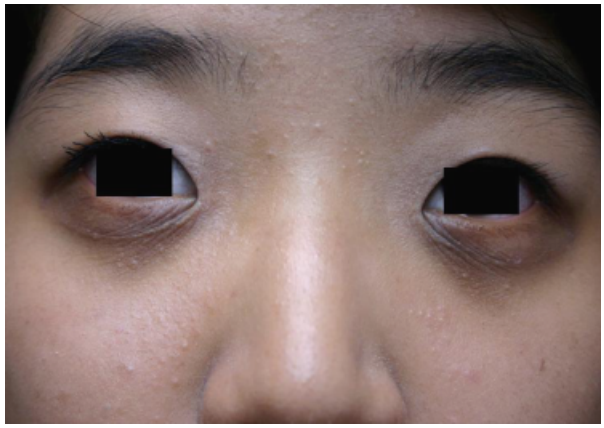

Figure 2. Infraorbital dark circle due to postinflammatory hyperpigmentation secondary to atopic dermatitis.

Another common cause of infraorbital dark circles can be thin, translucent lower eyelid skin overlying the orbicularis oculi muscle (Figure 3). The orbicularis oculi muscle lies right beneath the skin, with little or no subcutaneous fat, and the darkness may be due to the visible prominence of the subcutaneous vascular plexus or vasculature contained within the muscle. This condition usually involves the entire lower eyelids, with a violaceous appearance consistent with prominent blood vessels covered by a thin layer of skin. The violaceous appearance is more prominent in the inner aspect of the lower eyelids

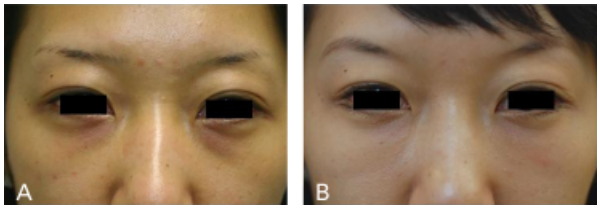

Figure 3. Infraorbital dark circles due to thin, translucent lower eyelid skin overlying the orbicularis oculi muscle. (A) Before treatment. (B) Improvement after autologous fat transplantation.

and is usually accentuated during menstruation. When the lower eyelid skin is manually stretched, the area of relative darkness spreads out without blanching but results in deepening of the violaceous color, which could be used as a useful diagnostic test to confirm the vascularity. This phenomenon seems to result from the underlying vascularity becoming more visible through the skin that has been pulled thin.

It has been suggested that the combination of exceptional transparency of the overlying skin and excessive subcutaneous vascularity causes this hypervascular appearance,[5] but our experience with successfully treating this condition with autologous fat transplantation implies that the causative vasculature may be present within the muscle. This part of the skin is extremely thin, with barely any subcutaneous fat, and it would be impossible to separate the skin and subcutaneous vascularity with an injection cannula. Excellent long-term correction achieved by injecting a thin layer of autologous fat between the skin and muscle with a blunt cannula is evidence of our assumption that the cause of the hypervascular appearance could also lie in the muscle and not only in the subcutaneous fat. The thin layer of injected fat between the skin and muscle could act as a barrier, shielding the hypervascularity in the muscle.

Another cause of infraorbital dark circles is shadowing due to skin laxity and tear trough associated with aging (Figures 4 and 5). Dermatochalasia and periocular rhytides are a common manifestation of aging. Over time, collagen and elastin in the thin

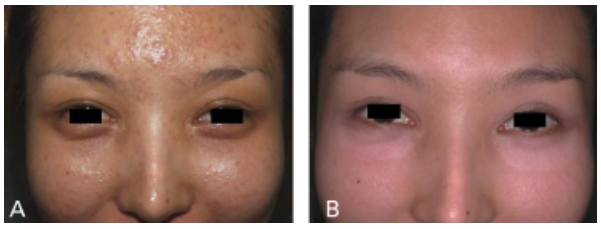

Figure 4. Infraorbital dark circles caused by shadowing due to skin laxity. (A) Before treatment. (B) Improvement of dark circles after ablative laser treatment.

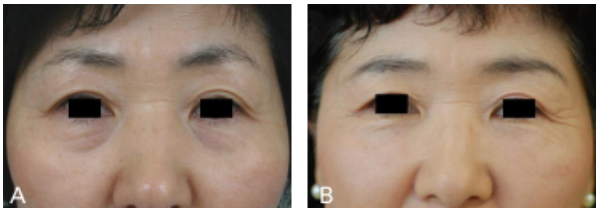

Figure 5. Infraorbital dark circles caused by shadowing due to skin laxity and tear trough. (A) Before treatment. (B) Improvement of dark circles after autologous fat transplantation.

tissue of the eyelids and periorbital skin undergo ultraviolet-induced and age-related degeneration.[14] In addition, the damaged epidermis releases collagenases, which further contributes to collagen degeneration. Skin laxity due to photoaging imparts a shadowing appearance on the lower eyelids that results in infraorbital dark circles. The tear trough is a depression centered over the medial side of the inferior orbital rim. It is also an age-related change due to the loss of subcutaneous fat with thinning of the skin over the orbital rim ligament that confers hollowness to the orbital rim area.[15] Combination of the hollowness and the overlying pseudoherniation of the infraorbital fat accentuate the shadow in the tear trough depending on the lighting conditions.[16] Wood light and polarized diagnostic light imaging may be useful tools in the evaluation and differentiation of the pigmentary and vascular causes of infraorbital dark circles.[17,18]

Treatment Options

A number of therapies are available for treating infraorbital dark circles. Despite the great number of available medications and therapies to attenuate dark circles, there are no evidence-based studies to support their use. The therapeutic modalities must differ depending on the cause because infraorbital dark circles are due to multiple factors.

Topical Agents

In general, treatment with depigmenting agents must be continued for several months before cosmetic

benefits are obtained. The action mechanisms of depigmenting agents are inhibition of tyrosinase activity, inhibition of DNA synthesis in hyperactive melanocytes, reduction of epidermal content of melanin, and thickening of the epidermis (granular layer).[19]

Hydroquinone is the most prescribed bleaching agent world-wide and is still the criterion standard for the treatment of hyperpigmentation. It inhibits DNA and RNA synthesis and induces degradation of melanosomes and destruction of melanocytes.[20,21] In 1975, Kligman and Willis performed an early study assessing the clinical efficacy of hydroquinone.[22] The depigmenting effects of hydroquinone treatment become evident after 5 to 7 weeks, usually preceded by erythema and scaling. Treatment should be continued for at least 3 months and up to 1 year. Hydroquinone can be used in combination with other agents. The Kligman formulation (5% hydroquinone, 0.1% tretinoin, and 0.1% dexamethasone) represents the best known combination, but adverse reactions such as erythema, scaling, colloid milium, irritant and allergic contact dermatitis, nail discoloration, and paradoxical postinflammatory hypermelanosis have been reported.[23]

Topical retinoic acid (RA), 0.01% to 1%, reduces pigmentation by inhibition of tyrosinase transcription and significant thickening of the granular layer and epidermis. The number of melanocytes is apparently unaffected, but melanocyte damage is evident.[24] RA must be applied for a longer time than hydroquinone, and significant lightening becomes evident after 24 weeks. Clinical data show good effects in patients with melasma, but superior effects are shown in combination with other compounds.[25,26] Commonly found side effects include erythema, peeling, burning, and stinging. Other compounds used as depigmenting agents include azelaic acid, steroids, kojic acid, and pidobezone, but different combined preparations have been used with the goal of increasing the efficacy and reducing the side effects in the treatment of various hyperpigmentation disorders.

Chemical Peeling

Chemical peeling is defined as the application of one or more chemical agents that lead to controlled destruction of the skin, resulting in the removal of lesions localized in the epidermis or in the upper dermis. This treatment can be less or more intense according to the therapeutic intent and the kind of peeling used. Peels can be superficial, medium, or deep. Superficial peeling with trichloroacetic acid is still widely used in concentrations of 15%, 25%, 50%, and even 75%. At the highest concentration, destruction of epidermis and superficial dermis occurs, and re-epithelialization takes place from the epidermal adnexa. Alpha-hydroxy acids are a group of organic acids widely found in fruits and vegetables. They act by reducing the cohesiveness of corneocytes through the inhibition of enzymes involved in the formation of ionic bonds, and they stimulate the biosynthesis of glycosaminoglycans. Glycolic acid is the most widely used alpha-hydroxy acid. At 50% to 80% concentrations, glycolic acid produces epidermolysis, so physicians should perform the peel only as an office procedure. Glycolic acid should be applied for a few minutes, followed immediately by rinsing with plain water or 1% sodium bicarbonate. The risk of side effects and complications such as dyspigmentation increases according to the depth of the chemical peeling agent and skin type. The greater melanin in skin of patients of color is associated with greater susceptibility to postinflammatory hyperpigmentation and hypopigmentation.[27] Therefore, appropriate candidates and chemical agents should be selected before the procedure.

Lasers

In recent decades, lasers have increasingly been used in cosmetic dermatology.[28] Dark circles due to excessive pigmentation have been successfully treated with various pigment lasers, including the Q-switched ruby (694-nm) laser,[4,9,29] Q-switched alexandrite (755-nm) laser, and neodymium-doped yttrium aluminium garnet (Nd:YAG) (1,064-nm) laser.[30] In a study of 17 patients with dermal

infraorbital melanin deposition treated using a Q-switched ruby laser (694-nm), Lowe and colleagues demonstrated a lightening response of greater than 50% in 23.5% of patients after one laser treatment and in 88.9% of patients after two treatments.[4] Posttreatment histology demonstrated a reduction in dermal melanin deposition. In a study of 20 patients comparing Q-switched alexandrite (755-nm) and Nd:YAG (1,064-nm) lasers in the treatment of infraorbital dark circles, West and Alster reported that both lasers were capable of lightening hyperpigmentation, with some improvement seen after the first treatment and even more fading noted after the second laser treatment. This study revealed no significant clinical difference between the two pigment-specific laser systems.[30] Watanabe and colleagues conducted a study to clarify the nature of dark rings under the eyes and determined the efficacy of the Q-switched ruby laser.[9] Of the 54 patients who underwent a biopsy for pigmented macules of the face, 12 with bilateral homogenous pigment macules on suborbital regions were selected for study of dark rings. Histologically, all 12 patients indicated dermal melanocytosis, which was confirmed according to the Masson-Fontana silver stain and staining for S-100. Five of the patients with infraorbital dark circles received one to five treatments with Q-switched ruby laser (694-nm). Four patients showed good response, with excellent results seen in two of the four patients. Momosawa and colleagues conducted a study on periorbital skin hyperpigmentation of a combined treatment using a Q-switched ruby laser and bleaching treatment with tretinoin and hydroquinone.[29] Eighteen Japanese patients underwent combined therapy of initial topical bleaching treatment with tretinoin aqueous gel and hydroquinone ointment for 6 weeks to reduce epidermal melanin, followed by a Q-switched ruby laser to eliminate dermal pigmentation. Skin biopsies were done on three patients before the study and after the end of study. In this study, histologic examination showed obvious basal hyperpigmentation and dermal pigmentation that was not enough to be considered as dermal melanocytosis. After the treatment, seven of 19 patients (38.9%) showed excellent clearing, and eight (44.4%) were rated as good. Postinflammatory hyperpigmentation was observed in only two patients (11.1%). Remarkable reduction of dermal pigmentation was observed in the biopsy specimens of three patients after treatment. Based on these studies, it has been concluded that dermal pigment can be successfully removed using lasers using the concept of selective photothermolysis.[31] Of the lasers reviewed, we have successfully treated patients using a Q-switched Nd:YAG laser or Alexandrite laser for infraorbital dark circles due to pigmentation. The 1,064-nm Nd:YAG laser is effective in reducing the pigmentation as well as the vascular component of infraorbital dark circles.

Safety should be emphasized when treating infraorbital dark circles with lasers, because the eye is particularly vulnerable to laser injury. Therefore, use of proper eyewear (goggles, wrap-around glasses, or eye shields) is crucial. The retina and the choroid contain the highest concentration of melanin in the body, and eye damage is possible even through closed eyelids. When treatment is necessary near the eyes, a large metal eye shield should be inserted over the anterior eye.

Skin laxity and tear trough are age-related changes, and these changes can be treated with ablative and nonablative lasers and surgical methods. Alster treated 67 patients with dermatochalasia and periorbital rhytides using carbon dioxide (CO_2) laser resurfacing.[32] The global assessment scores of dermatochalasia and rhytides were determined using a side-by-side comparison of periocular photographs preoperatively and 1, 3, and 6 months postoperatively. Dermatochalasia and periorbital rhytides were significantly improved after periocular CO_2 laser skin resurfacing. Side effects were limited to erythema and transient hyperpigmentation. As the study results show, infraorbital dark circles due to skin laxity could be improved using ablative laser treatment (Figure 4), although with skin type III and IV, prolonged dyschromia could occur as a side effect. Although ablative laser resurfacing is a

well-accepted treatment modality for improving the appearance of photo-induced rhytides, untoward side effects such as prolonged erythema, pigmentary alterations, and infections, and in rare cases, scarring, can occur. Therefore, great interest has been shown for less invasive methods to treat photo-induced rhytides effectively. These include the pulsed dye laser,[33] diode laser,[34] 1,064-nm Nd:YAG laser,[35] 1,320-nm Nd:YAG laser,[36–39] 1,540-nm erbium:glass laser,[40,41] and intense pulsed light sources.[35,42] Most systems combine epidermal surface cooling with deeply penetrating wavelengths that selectively target water-containing tissue, thereby creating a selective thermal injury in the dermis. Although the degree of wrinkle effacement has not equaled that seen after ablative laser skin resurfacing, nonablative laser systems are an ideal treatment choice for patients who are unwilling or unable to undergo the prolonged postoperative recovery associated with ablative cutaneous procedures. Fractional resurfacing is a newer concept of skin rejuvenation that produces a unique thermal damage pattern.[43,44] It produces discrete columns of thermal damage at specific depths, referred to as microthermal treatment zones. It characteristically spares the tissue surrounding each column, resulting in rapid epidermal regeneration due to fast migration of the surrounding viable keratinocytes present at the wound edges. Fractional resurfacing can be helpful in the treatment of epidermal pigmentation such as melasma and lentigines because of the process of microthermal treatment zone formation. It can also help in improving rhytides and scarring due to the process of collagen remodeling and new collagen formation induced by the dermal thermal damage.[45] Therefore, fractional resurfacing may also help improve infraorbital dark circles due to skin laxity and excessive hyperpigmentation.

Autologous Fat Transplantation

Another cause of infraorbital dark circles is thin and translucent lower eyelid skin overlying the orbicularis oculi muscle. This hypervascular appearance is due to a combination of increased vascularity of the subcutaneous vascular plexus or vasculature contained within the muscle and transparency of the overlying skin. The therapeutic modality for these cases is to restore the volume underneath the eyelid using autologous fat transplantation or soft tissue fillers. Autologous fat transplantation has long been used for soft-tissue augmentation.[46] Autologous fat is completely biocompatible and is therefore the safest choice for altering facial volume or contours. We present the results of a pilot study evaluating the efficacy of autologous fat transplantation in the treatment of infraorbital dark circles caused by increased vascularity of the subcutaneous fat and transparency of the overlying skin. Ten patients were treated in our study, and they showed excellent improvement of dark circles due to these factors (Figure 3). Patients received at least one autologous fat transplantation and had at least one 3-month follow-up evaluation. An average of 1.6 autologous fat transplantations was done in both infraorbital areas. Patients showed an average of 78% improvement, with decreased infraorbital darkening and improved contour of the lower eyelids. Although controversy exists regarding the long-term survival of transplanted fat in the subcutaneous layer,[47–49] clinical reports continue to be optimistic because fat is readily available, safe, noncarcinogenic, easily acquired, and autologous, which decreases host immune response. Because infraorbital dark circles in our patients were due to hypervascularity and skin translucency, transplanted fat allowed the vascular areas to be covered and reduced the transparency of the skin. Soft-tissue fillers are also widely used for improving volume loss and facial contours. Hyaluronic acid gel has been used with success as filler for three-dimensional reshaping of the periorbital complex.[16,50,51] Overall patient satisfaction was high, but patients with dark circles noticed dark pigmentation after hyaluronic acid gel filling.[50] Moreover, virtually every filler available—whether resorbable, biodegradable, or permanent—has been associated with cases of granulomatous reactions.[52–54] Given the thinness of the skin of the eyelid and cheek–eyelid junction, soft-tissue filler that is injected too superficially in these areas is at high risk of resulting in

visible or palpable nodules. On the other hand, deeper injection of the filler would not effectively cover the hypervascularity. Therefore, autologous fat would be the most suitable filler for the infraorbital area.

Surgery

Epstein[5] used transconjunctival blepharoplasty and deep-depth phenol chemical peel simultaneously to treat hyperpigmentation of the skin and pseudoherniation of the orbital fat, both contributing causes for infraorbital dark circles. The authors reported successful outcomes and a low incidence of complications.

Treatment of infraorbital dark circles related to tear trough is more complex. It may require invasive surgical procedures to elevate the soft tissues from the underlying maxilla, fat transplantation or fat extrusion, and septal resection.[55] We successfully treated a patient with infraorbital dark circles due to skin laxity and tear trough with autologous fat transplantation (Figure 5). The use of hyaluronic acid gel to fill the periorbital hollows and restore volume has emerged as a less invasive procedure with good results,[16,50,56] but because of the thinness of the skin of the eyelid and cheek–eyelid junction, soft-tissue filler that is injected too superficially in these areas is at high risk of resulting in visible or palpable nodules. Therefore, cautious injection is required.

Conclusion

Because various factors cause infraorbital dark circles, it is essential to identify the cause before appropriate treatment can be initiated. The brown and blue-gray color caused by dermal melanin deposition, bluish color secondary to the visible dermal capillary network, and shadowing secondary to skin laxity and bulging contour of the lower eyelid should be separately treated. If infraorbital dark circles are mainly due to excessive pigmentation, the dermal melanin pigment should be removed with treatment such as a topical bleaching agent, chemical peels, and lasers. Dark circles mainly due to the eyelid bulging caused by orbital fat pseudoherniation should be corrected primarily using transconjunctival blepharoplasty. If dark circles are combined with prominent skin laxity, modalities to improve the laxity are recommended. Autologous fat transplantation may be a treatment option for patients with infraorbital darkening due to prominent vascularity and thin skin.

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Address correspondence and reprint requests to: Kee Yang Chung, MD, PhD, Department of Dermatology and Cutaneous Biology Research Institute, Yonsei University College of Medicine, 134 Shinchon-Dong, Seodaemoon-Gu, Seoul 120-752, Korea, or e-mail: kychung@yuhs.ac