Topical antioxidant application enhances the effects of facial microdermabrasion

Bruce M. Freedman *

* Plastic Surgery Associates of Northern Virginia, McLean, Virginia, USA

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BRUCE M. FREEDMAN

Plastic Surgery Associates of Northern Virginia, McLean, Virginia, USA

Abstract

Background: Microdermabrasion has been accepted as a reliable, non-invasive method for facial rejuvenation. Recently, there has been interest in combining this technique with other modalities to increase its efficacy. The purpose of this study was to determine whether the addition of an antioxidant-based serum enhanced the dermatologic changes seen following microdermabrasion.

Methods: Ten female volunteers, aged 38-52 years, underwent a series of six diamond tip crystal-free microdermabrasion facial treatments spaced 7-10 days apart. An antioxidant serum rich in polyphenols was pneumatically applied to half the face immediately after each microdermabrasion treatment. Skin biopsies and skin polyphenolic antioxidant levels, determined by Raman spectroscopy, were obtained prior to and after the study period. Investigator ratings for efficacy were analyzed after the study period and compared to baseline.

Results: Compared with the skin treated with microdermabrasion only, the skin treated with microdermabrasion plus antioxidant demonstrated significantly increased epidermal and papillary dermal thickness, and increased fibroblast density (p < 0.01). There was increased hyalinization of the papillary dermis with newly deposited collagen fibers. Skin polyphenolic antioxidant levels increased 32% in the skin treated with the polyphenolic antioxidant serum after microdermabrasion (p < 0.01). Clinical efficacy variables were significantly more improved in the antioxidant group when compared to baseline (p < 0.01). These changes were supported clinically via digital photography.

Conclusion: The addition of a polyphenolic antioxidant serum to a facial microdermabrasion regimen enhanced the clinical and histological changes seen following microdermabrasion alone. This combination should strengthen the use of microdermabrasion as a non-invasive facial rejuvenation tool and support the role of topical antioxidants as anti-aging factors.

Key words: Facial rejuvenation, microdermabrasion, topical antioxidants

Introduction

Microdermabrasion has become an accepted, reliable technique for non-ablative skin rejuvenation. The clinical and histological effects seen following microdermabrasion have been shown to include improvements in dermal collagen matrix, thickening of the epidermis and papillary dermis, and clinical lessening of fine lines, hyperpigmentation and blotchiness (1–4). Recently, the molecular mechanisms associated with microdermabrasion have been studied and include activation of transcription factors, primary cytokines, and matrix metalloproteinases (5,6). All of these findings suggest that microdermabrasion initiates a metabolically active dermal remodeling cascade, important in reversing photodamage and improving skin structure.

There has been great interest in improving the efficacy of the non-ablative technologies by combining them with other modalities. Some of the common multimodal approaches include combining cosmeceutical products with microdermabrasion and intense pulsed light (7,8). Recently, there has been great interest in the impact of topical antioxidants on the skin. Clinically, there is evidence that certain topically applied antioxidants (i.e. vitamins C and E) have anti-aging activity and can decrease periorbital wrinkles and lighten solar lentigines (9–11). The polyphenolic antioxidants such as those found in green tea extracts have been shown to prevent ultraviolet radiation-induced
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oxidation of lipids and proteins by decreasing oxidative stress (12). In murine models, the polyphenolic compounds have also demonstrated significant protection against ultraviolet radiation-induced DNA damage (13). However, to date, there have been few in vivo studies to investigate the clinical and histological changes associated with the topical application of the polyphenolic antioxidants.

The intention of this study was to determine whether the addition of a topical antioxidant-rich serum could enhance the effects of facial microdermabrasion and thus validate the safety and efficacy of combining these modalities. The study design also facilitated whether the effects of the polyphenolic antioxidants could be identified and measured.

Materials and methods

Patients

Ten female volunteers, with Fitzpatrick skin types I–IV, aged 38–52 years, consented to participate in a split-face, prospective study to evaluate the effects of microdermabrasion and antioxidant application on facial skin. The study conformed to the guidelines of the 1975 Declaration of Helsinki. The participants were healthy and had no evidence of skin malignancy or were not being treated for acne.

Digital photographs, a 2-mm full-thickness pre-auricular skin biopsy, and skin polyphenolic antioxidant levels were obtained prior to treatment (Control). Skin polyphenolic antioxidant levels were obtained from the left cheek using a non-invasive optical device (Biophotonic Scanner; Pharmanex, Provo, UT, USA). This technology employed laser energy at 473 nm and 10 mW power to stimulate molecules containing carbon–carbon double bonds generating an optical fingerprint. The emitted backscattered light was captured by a highly sensitive light detector, which was then processed and calculated using a Raman scattering spectroscopic technique that has been validated in humans in vivo (14). A linear relationship has been established between antioxidant concentration and Raman intensity, indicating that absolute Raman intensity counts are a biomarker for skin antioxidant levels. These polyphenolic compounds were most likely the biomarkers responsible for the increase. This is due to the fact that these polyphenolic compounds and the carotenoids, which were the biomarkers used by Hata et al., have a comparable spectral Raman peak at 1520 cm⁻¹ (15,16).

A crystal free microdermabrasion unit (HydraFacial Wave System; Edge Systems Corporation, Signal Hill, CA, USA) was utilized by a single operator during the study. A series of six full-facial microdermabrasion treatments were performed at 7–10 day intervals on each of the 10 patients. The standard protocol for each treatment included cleansing and degreasing the face followed by 2 passes with the diamond tip microdermabrasion handpiece at 180 mmHg. Immediately afterwards, a polyphenolic antioxidant serum (AntiOx® 6; Edge Systems Corporation) containing polyphenolic flavonoids and polyphenolic diterpenes (e.g. epigallocatechin, ursolic acid) was applied to the left side of each patient’s face via the vacuum delivery system. The average treatment lasted approximately 30 minutes. After each treatment, patients were advised to avoid direct sun exposure for 24 hours and to use moisturizers as needed. Daily activities were not restricted following treatment. Home skin care products such as antioxidants, triretinoin and glycolic acid agents were avoided 6 weeks prior to and during the treatment period. Two weeks following the sixth treatment, digital photographs were repeated. Skin polyphenolic antioxidant levels and 2-mm skin biopsies were taken from the right pre-auricular area treated only with microdermabrasion (MDA) and from the left pre-auricular area treated with microdermabrasion and polyphenolic antioxidant serum (HDA).

Clinical changes were obtained via investigator evaluations of both sides of the face prior to the study (Control) and at the conclusion of the study period. Efficacy variables were scored on a 0–9 scale (0 = none, 9 = severe) and included: (1) fine lines; (2) skin dullness; (3) hyperpigmentation; (4) size of pores; (5) dryness; and (6) skin texture (17).

Three independent medical evaluators blindly reviewed before and after treatment digital photographs to determine changes in global skin texture, tone and overall appearance. A scale of 1–5 (1 = no improvement, 5 = significant improvement) was used to grade the photographs.

Each biopsy was fixed in a 10% buffered formaldehyde solution, embedded in paraffin, and cut in 4-μm sections. Sections were stained with standard hematoxylin and eosin for light microscopy. The slides were reviewed in a blinded fashion to evaluate epidermal and papillary dermal thickness, epidermal and dermal cellular and extracellular elements and vascular appearance. The slides were examined with an Olympus microscope and precision measurements were performed using an Olympus micrometer at 40× magnification. Fibroblast density in the papillary dermis was determined by randomly viewing five fields under 100× magnification with oil immersion and averaging the number of fibroblasts per high-powered field.
Statistical analysis

Statistical comparisons of the epidermal and papillary dermal thickness, fibroblast density and skin polyphenolic antioxidant levels between Control and treated tissues were performed using a two-sided paired t-test. The Wilcoxon signed rank test was used to evaluate changes from baseline (Control) in the clinical efficacy variables and in the global skin changes observed in the digital photographs. Statistical significance was set a priori at $p < 0.01$.

Results

After six treatments the epidermal thickness in the MDA group increased to $65 \pm 9 \mu m$ while it increased to $80 \pm 8 \mu m$ in the HDA group. These values were statistically greater than the Control epidermal thickness of $49 \pm 7 \mu m$ ($p < 0.01$). In addition, the epidermal thickness in the HDA group was statistically greater than that in the MDA group ($p < 0.01$). After six treatments the papillary dermal thickness in the MDA group increased to $354 \pm 21 \mu m$ while in the HDA group it increased to $418 \pm 25 \mu m$. These values were statistically greater than the Control papillary dermal thickness of $285 \pm 20 \mu m$ ($p < 0.01$). Also, the papillary dermal thickness in the HDA group was statistically greater than that in the MDA group ($p < 0.01$). Compared with the Control fibroblast density of $3.9 \pm 0.3$, the fibroblast density in the MDA group increased to $5.8 \pm 0.4$ and in the HDA group it increased to $8.0 \pm 0.5$ ($p < 0.01$). Fibroblast density in the HDA group was also statistically greater than that in the MDA group ($p < 0.01$). Raman intensity counts in the Control pre-treated tissue averaged $15 700 \pm 3000$. In the MDA group, Raman intensity counts averaged $16 500 \pm 4000$; this was not statistically different from the Control group. In the HDA group, Raman intensity counts averaged $24 000 \pm 4500$, a value statistically greater than those in the Control and MDA groups ($p < 0.01$) (Table I).

Histologically, tissue in the MDA and HDA groups demonstrated increased mitotic activity in the epidermis; increased collagen deposition and collagen hyalinization in the papillary dermis; ‘frothy’ appearing fibroblasts in the dermis; and replacement of elastotic tissue in the papillary dermis. However, the HDA group qualitatively exhibited more of these characteristics than the MDA group (Figure 1).

Clinically, at the end of the study, all efficacy variables showed a significant improvement from baseline in both the MDA and HDA groups ($p < 0.01$). In addition, the amount of improvement in the HDA group was statistically greater when compared to the improvement in the MDA group ($p < 0.01$) (Figure 2). Evaluation of the digital photographs by the independent examiners demonstrated that both the MDA and HDA groups were significantly improved from baseline (Control) in global skin tone, texture and overall appearance ($p < 0.01$). In addition, the improvements in the HDA group were statistically greater when compared to improvements noted in the MDA group for global skin tone, texture and overall appearance ($p < 0.01$). Figure 3 shows photographic results in one individual. Both treated sides of the face (Figure 3C: after MDA; Figure 3D: after HDA) reveal improved skin characteristics when compared to the before treatment photographs (Figures 3A and 3B). The clinical improvement noted on the HDA-treated side (Figure 3D) is notably greater than that on the MDA-treated side (Figure 3C).

Discussion

Recently, there has been increased consumer and media attention focused on antioxidants and their role in skin health. The antioxidants, specifically the botanically extracted polyphenols, are postulated to have anti-aging properties when applied topically. These compounds have been shown to scavenge superoxide anions and other radicals, preventing lipid oxidation, reducing antigenotoxicity and elevating antioxidative capacity in the skin (18). These effects are purported to include collagen stimulation, photodamage protection and reduction of fine lines,
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Hyperpigmentation, dryness and skin coarseness. However, most scientific studies have been in vitro and it has been difficult to ascertain whether adequate amounts of these compounds can be found in vivo to produce clinical and histological changes (19).

The clinical, histological and molecular changes seen following microdermabrasion have been well described. Recent research has demonstrated that microdermabrasion can effectively increase the permeability of the skin to vitamin C (20). Microdermabrasion

Figure 1. Histological features observed prior to treatment (Control) following a microdermabrasion (MDA) and following microdermabrasion plus topical application of polyphenolic antioxidant serum (HDA). Hematoxylin + eosin: original magnification ×20.

Figure 2. Mean decreases from baseline score in the efficacy variables scored by the clinician.

Changes from baseline (mean score)
B. M. Freedman has also been shown to reduce the incubation time of levulanic acid in photodynamic therapy (21). By changing the barrier properties of the skin, microdermabrasion appears to activate multiple cellular mechanisms that result in skin rejuvenation.

In an effort to leverage the values of independent modalities, clinicians have combined microdermabrasion with other procedures such as the topical application of chemical acids and antioxidants. The goal of multimodal therapy is to create synergy, to optimize results, and to reduce cost and recovery time. To date, there has been a paucity of research quantifying the effects and outcomes associated with multimodal skin care regimens.

This study demonstrated that the topical application of a polyphenolic serum immediately following microdermabrasion enhanced the known effects of the microdermabrasion process. Epidermal thickness, papillary thickness and fibroblast density were measurably increased following polyphenolic antioxidant supplementation. Qualitatively, collagen hyalinization and replacement of elastotic tissue were more pronounced in the group treated with antioxidants. Clinically, fine lines, texture, hyperpigmentation and overall appearance were improved to a greater extent in skin treated with the polyphenolic antioxidants.

Furthermore, the topical application of the polyphenol-rich serum to the microdermabrasion regimen increased the measured polyphenolic antioxidant levels by 32% when compared to pre-treated skin. Since skin treated by microdermabrasion alone had the same polyphenolic level as pre-treated skin, the microdermabrasion procedure in and of itself did not alter measured antioxidant levels. The addition of the polyphenolic compounds was required to increase the levels (Figure 4). The changes in skin permeability immediately following microdermabrasion are most likely responsible for the increased uptake of the polyphenolic antioxidants into the skin. It has been estimated that the back-scattered Raman light originates from a maximum sampling depth of 250 μm (15). This would place the polyphenolic compounds applied in this study within the papillary dermis. The papillary dermis is the anatomical structure where the majority of new fibroblasts and extracellular matrix are deposited during the skin rejuvenation. Any modality that further stimulates the papillary dermis should

Figure 3. Clinical changes observed in a 45-year-old woman before treatment (A and B) and following treatment with microdermabrasion (MDA) on the right side of the face (C) and treatment with microdermabrasion plus topical application of polyphenolic antioxidant serum (HDA) on the left side of the face (D).

Figure 4. Skin polyphenolic antioxidant levels as determined by changes in Raman intensity counts before treatment (Control), after microdermabrasion (MDA) and following microdermabrasion plus topical application of polyphenolic antioxidant serum (HDA).
enhance the already activated metabolic processes. It has been postulated that increased resident levels of polyphenols in the skin reduce photodamage and improve skin quality; the findings in this study support that hypothesis.

We believe that cellular mechanisms that have been activated in the skin during the microdermabrasion process are amplified by the addition of polyphenolic antioxidants. It has been shown that microdermabrasion increases the fibroblast population in the papillary dermis. Fujimura et al. demonstrated that the polyphenols in horse chestnut seed extract induced contraction forces in fibroblasts resulting in decreased periorbital rhytids (22). This effect could account for the enhanced histological changes seen following polyphenolic antioxidant addition to microdermabraded skin. The augmented results were documented clinically as all skin efficacy variables were significantly improved in skin treated with the polyphenolic antioxidant serum.

The findings in this study advance the reasoning that topically applied antioxidants are effective in skin rejuvenation. Additional research may elucidate other mechanisms of action and synergistic effects associated with these compounds. This is a promising area of study that may lead to breakthroughs in skin photoprotection and anti-aging.

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