Skin Barrier Changes Induced by Aluminum Oxide and Sodium Chloride Microdermabrasion

Poonam Rajan, MD* and Pearl E. Grimes, MD†‡

*University of British Columbia, Vancouver, British Columbia, Canada, and †Vitiligo and Pigmentation Institute of Southern California and ‡Division of Dermatology, UCLA School of Medicine, Los Angeles, California

BACKGROUND. **Microdermabrasion has become an extremely popular method for superficial resurfacing. Despite the popularity of this technique, published studies of skin barrier function changes following microdermabrasion are lacking.**

OBJECTIVE. **To study assessed transepidermal water loss (TEWL), hydration, pH, and sebum production following aluminum oxide (Al_2O_3) and sodium chloride (NaCl) microdermabrasion.**

METHODS. **Eight patients were included in this split face study. Transepidermal water loss, stratum corneum hydration, skin pH, and sebum production measurements were taken from the right and left sides of the face at baseline. One side of the face was treated with Al_2O_3 microdermabrasion and the other side with NaCl microdermabrasion. Measurements were repeated at 24 hours and 7 days.**

RESULTS. **Both NaCl and Al_2O_3 microdermabrasion was associated with a statistically significant increase in TEWL at 24 hours. In contrast, at 7 days, levels of TEWL were decreased to less than baseline. In addition, an increase in hydration was observed 24 hours after NaCl and Al_2O_3 microdermabrasion. Hydration in NaCl-treated areas remained significantly increased at 7 days.**

CONCLUSION. **The results of this investigation suggest that both NaCl and Al_2O_3 microdermabrasion alter the epidermal barrier. These changes in epidermal barrier function may be responsible for the clinical improvement following microdermabrasion.**

P. RAJAN, MD AND P.E. GRIMES, MD HAVE INDICATED NO SIGNIFICANT INTEREST WITH COMMERCIAL SUPPORTERS.

MICRODERMABRASION HAS become an extremely popular form of superficial skin resurfacing. The technique of microdermabrasion was first developed in Italy in 1985. Multiple units were subsequently marketed in Europe. Microdermabrasion units were introduced to North America by Mattioli Engineering in 1996–1997. Most units are closed-loop, negative-pressure systems which pass aluminum oxide (Al_2O_3) crystals onto the skin, while simultaneously vacuuming the used crystals. Other systems utilize sodium chloride (NaCl) and positive pressure for superficial skin resurfacing. Indications for microdermabrasion include acne, acne scarring, hyperpigmentation, textural changes, and striae. Despite the popularity of microdermabrasion, we are aware of only a few studies published in peer-reviewed journals.[1–3] Tsai et al.[1] reported good to excellent results in 41 patients treated with microdermabrasion for facial scarring. Shim et al.[2] reported a statistically significant improvement in roughness, mottled pigmentation, and overall improvement in skin appearance in 14 patients. Currently we are not aware of any published study assessing changes in skin barrier function induced by microdermabrasion. Hence in this investigation, we proposed to evaluate transepidermal water loss (TEWL), hydration, pH, and sebum production following Al_2O_3 and NaCl microdermabrasion.

Address correspondence and reprint requests to: Pearl E. Grimes, MD, 321 North Larchmont Blvd., Suite 609, Los Angeles, CA 90004.

Methods

Patients

Eight patients were included in this pilot study. There were four women and four men. Three were African American, three were Hispanic, and two were Caucasian. Their mean age was 32 years. Subjects were instructed to not wash their faces on the morning of study evaluation.

Informed consent was obtained from each patient. Patients were evaluated and treated at the Vitiligo and Pigmentation Institute of Southern California. Transepidermal water loss, stratum corneum hydration, skin pH, and sebum production were measured on the right and left side of the face at baseline and at 24 hours and 7 days after microdermabrasion. Sebum measurements and skin pH were taken on the forehead. TEWL and hydration were measured on the cheeks. All measurements were performed in a controlled environment with a room temperature of 20°C and humidity of 50–60%. All measurements were performed in triplicate.

Measurements

Transepidermal water loss was measured with a tewameter.[4–7] The probe consisted of a hollow cylinder (10 mm in diameter, 20 mm in height) which was held in contact with

the facial skin surface until stable TEWL was established at 3 minutes. The results were expressed as grams per square millimeter per hour.

Stratum corneum hydration measurements were taken with a corneometer, which measured electrical capacitance of the skin as an indicator of stratum corneum hydration.[4–7] Capacitance was expressed digitally in arbitrary units. Water has the highest dielectric constant. Therefore as stratum corneum hydration increases, capacitance values also increase.

Skin surface pH was measured with a pH meter using a glass electrode filled with a buffered measuring channel.[4–8] The inner buffer is separated from the measuring channel by a glass membrane.

Forehead sebum measurements were taken with a sebumeter.[4–7] The sebumeter utilizes a cassette tape applied to the forehead for 30 seconds. Sebum measurements were expressed as micrograms of sebum per square centimeter.

Microdermabrasion Procedure

Prior to performing microdermabrasion, the patients' faces were cleansed with skin cleanser and water. One side of the face was microdermabraded with an Al_2O_3 unit. The contralateral side was treated with an NaCl unit. Three passes were performed with each machine. Skin cleanser and moisturizer were applied on the treated areas by the patients after microdermabrasion. Barrier function measurements and microdermabrasion were performed by blinded and separate investigators.

Statistical Analysis

Mean values were calculated based on measurements of TEWL, hydration (expressed as capacitance), skin surface pH, and sebum. Paired *t*-test was employed to compare mean values.

Results

Compared to baseline, a statistically significant increase in TEWL was observed at 24 hours following both NaCl ($P = .01$) and Al_2O_3 microdermabrasion ($P = .02$; Figure 1). Seven days after microdermabrasion there was a decrease in the mean values for TEWL to levels below baseline for both NaCl and Al_2O_3 ($P < .05$). There were no statistically significant differences between the values attained for NaCl and Al_2O_3 groups at baseline 24 hours or 7 days following microdermabrasion.

Compared to baseline, both the NaCl and Al_2O_3 groups demonstrated an increase in the mean values for hydration (expressed as capacitance) at 24 hours following microdermabrasion ($P < .05$; Figure 2). Compared to baseline, NaCl demonstrated a statisti-

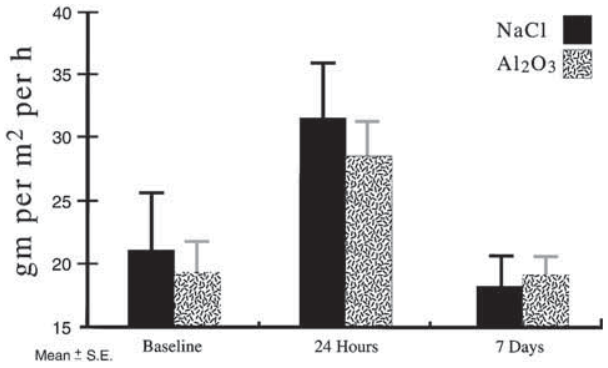

Figure 1. Comparison of baseline with 24-hour and 7-day mean values (± standard error) for TEWL following NaCl and Al_2O_3 microdermabrasion. Differences were statistically significant at 24 hours compared to baseline; NaCl ($P = .01$), Al_2O_3 ($P = .02$).

at 7 days compared to baseline ($P = .07$). There was no statistically significant difference between the NaCl group and the Al_2O_3-treated groups at baseline, 24 hours, and 7 days.

The mean pH measurements for both NaCl and Al_2O_3 groups decreased (ie, more acidic) at 24 hours after microdermabrasion compared to baseline (Figure 3). At 7 days after microdermabrasion there was a slight increase in pH values for both the NaCl and Al_2O_3 groups compared to the values at 24 hours. However, the differences among the baseline, 24-hour, and 7-day levels were not statistically significant. There also was no statistically significant difference between the NaCl and Al_2O_3 groups at baseline, 24 hours, and 7 days.

Mean values for sebum secretion for both NaCl and Al_2O_3 groups were decreased at 24 hours com-

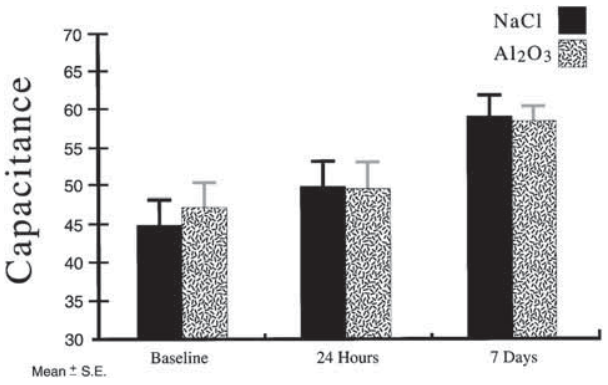

Figure 2. Comparison of baseline with 24-hour and 7-day mean values (± standard error) for capacitance (reflecting hydration) following NaCl and Al_2O_3 microdermabrasion. Capacitance is mea-

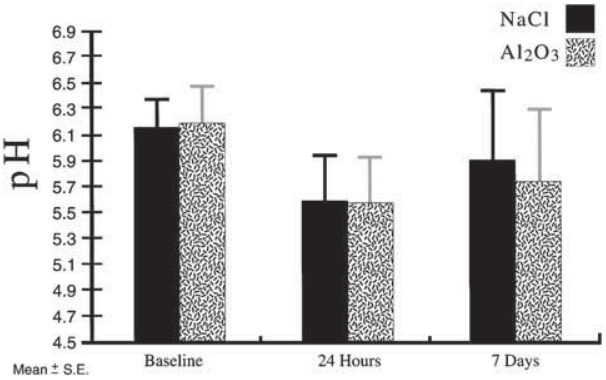

Figure 3. Mean pH values (± standard error) at baseline and at 24 hours and 7 days following NaCl and Al_2O_3 microdermabrasion ($p > .05$).

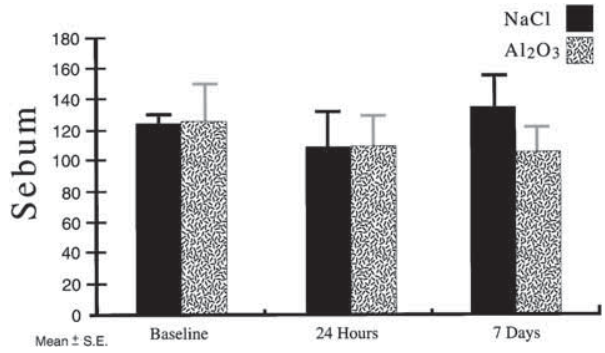

Figure 4. Mean sebum secretion in micrograms per square centimeter (± standard error) at baseline and at 24 hours and 7 days following NaCl and Al_2O_3 microdermabrasion ($p > .05$).

pared to baseline (Figure 4). At 7 days, NaCl demonstrated increased levels of sebum secretion compared to baseline. Sebum secretion at 7 days after Al_2O_3 microdermabrasion was slightly less than the values at 24 hours. However, the differences among the baseline, 24-hour, and 7-day levels were not statistically significant. There also was no statistically significant difference between the NaCl and Al_2O_3 groups at baseline, 24 hours, and 7 days.

Conclusion

Microdermabrasion is one of the most recent additions to the dermatologist's armamentarium of resurfacing techniques. There are currently several units available on the market, most of which are closed-loop systems that pass Al_2O_3 crystals onto the skin while simultaneously vacuuming the used crystals. Other systems utilize NaCl and positive pressure for superficial resurfacing. To date, there are only a few published studies regarding the science of microdermabrasion. Several clinical studies have reported the efficacy of microdermabrasion for treatment of hyperpigmentation, acne scarring, postsurgical scarring, striae, and fine wrinkles.[1–3] We are not aware of published studies on the physiologic changes induced by microdermabrasion in the stratum corneum and epidermis. The present investigation assessed alterations in the skin barrier following microdermabrasion. In order to measure physiologic changes, we employed methodology currently accepted as the gold standard for measuring epidermal barrier parameters.[4–7]

At baseline there were no statistically significant differences between either side of the patients' face. This demonstrates matched baseline controls for the

observed a statistically significant increase in TEWL. This provides evidence for disruption of the lipid barrier of the epidermis by microdermabrasion. At 7 days there was a drop in TEWL to mean values slightly less than those seen at baseline. This suggests that restoration of barrier function has occurred, with a trend toward improvement in the lipid barrier function over baseline. A statistically significant increase in stratum corneum hydration was observed at 7 days with NaCl microdermabrasion, and a similar trend was seen with Al_2O_3. Taken together, our results suggest enhanced lipid barrier function through decreased TEWL and increased hydration in the regenerated stratum corneum 7 days after both NaCl and Al_2O_3 microdermabrasion. These findings likely underlie the improved clinical appearance of supple and more hydrated-looking skin after microdermabrasion.

Berardesca et al.[8] demonstrated that partial removal of layers of the stratum corneum results in acidification of the stratum corneum, whereas complete removal of the stratum corneum leads to alkalinization. Mauru et al.[9] showed that certain enzymes required for lipid formation in the stratum corneum require an acidic environment, with an optimal pH of 5.5. Our results demonstrate a trend toward a decrease in pH at 24 hours after microdermabrasion, signifying partial removal of the stratum corneum. This decrease in pH likely contributes to an environment conducive to regeneration of the lipid barrier in the stratum corneum. At 7 days after NaCl microdermabrasion, we demonstrated a trend toward increased sebum secretion levels. This finding also may reflect restoration of the skin lipid barrier.

Following microdermabrasion, the physiologic changes in the epidermal barrier may be responsible for the observations of clinical improvement.[1–3] Multiple studies

feel and appearance of healthy skin.[10,11] Our findings provide the first evidence that a regenerated and/or altered stratum corneum following microdermabrasion likely stimulates enhanced skin hydration and less TEWL. These barrier alterations may result in the improved texture and overall appearance of microdermabraded skin. Longer-term prospective studies with an increased number of patients are indicated to provide further support for and elucidate the illustrated beneficial effects of microdermabrasion on skin.

Acknowledgment P. Rajan received a mentorship grant from the Women's Dermatologic Society.

References

1. Tsai RY, Wang CN, Chan HL. Aluminum oxide crystal microdermabrasion. Dermatol Surg 1995;21:539–42.
2. Shim EK, Barnette D, Hughes K, Greenway HT. Microdermabrasion: a clinical histopathologic study. Dermatol Surg 2001;27:524–9.
3. Bernard RW, Beran SJ, Rusin L. Microdermabrasion in clinical practice. Clin Plast Surg 2000;27:571–7.
4. Eberlein-Konig B, Schafer T, Huss-Marp J, et al. Skin surface pH, stratum corneum hydration, transepidermal water loss and skin roughness related to atopic eczema and skin dryness in a population of primary school children. Acta Derm Venereol 2000;80:188–91.
5. Yospotvitch G, Xiong GL, Haus E, Sackett-Lundeen L, Ashkenazi I, Maibach HI. Time-dependent variations of the skin barrier functions in humans: transepidermal water loss, stratum corneum hydration, skin surface pH and skin temperature. J Invest Dermatol 1998;110:20–23.
6. Szepietowski JC, Noxicka D, Reich A, Pasicka B, Kozera M, Strzelecka E. Transepidermal water loss (TEWL) measurements on the face. Contact Dermatitis 2000;43:123–4.
7. Fartasch M, Teal J, Menon GK. Mode of action of glycolic acid on human stratum corneum: ultrastructural and functional evaluation of the epidermal barrier. Arch Dermatol Res 1997;289:404–9.
8. Berardesca E, Pirot F, Singh M, Maibach H. Differences in stratum corneum pH gradient when comparing white Caucasian and black African-American skin. Br J Dermatol 1998;139:855–7.
9. Mauro T, Grayson S, Gao WN, et al. Barrier recover is impeded at neutral pH, independent of ionic effects: implications for extracellular lipid processing. Arch Dermatol Res 1998;290:215–22.
10. Wildnauer RH, Bothwell JW, Douglas AB. Stratum corneum biochemical properties. J Invest Dermatol 1971;56:72–8.
11. Wu MS, Yee DJ, Sullivan ME. Effects of a skin moisturizer on the water distribution in human stratum corneum. J Invest Dermatol 1983;81:446–8.