Epidermal and dermal effects of topical lactic acid

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**Background:** Many α-hydroxy acid products, containing low- or high-acid concentrations, are being used. It is not known whether different products perform differently or whether they modulate changes in both the epidermis and dermis.

**Objective:** The purpose was to examine whether treatment with 5% and 12% lactic acid produces different cosmetic results and produces changes in the epidermis and dermis.

**Methods:** Test participants applied either 5% or 12% lactic acid twice a day for 3 months. Changes in skin smoothness and texture, the depth and number of lines and wrinkles, and epidermal and dermal firmness and thickness were determined.

**Results:** Treatment with 12% lactic acid resulted in increased epidermal and dermal firmness and thickness and clinical improvement in skin smoothness and in the appearance of lines and wrinkles. No dermal changes were observed after treatment with 5% lactic acid; however, similar clinical and epidermal changes were noted.

**Conclusion:** The results demonstrate that cosmetic benefits from the use of α-hydroxy acids are caused by modification of the skin surface, the epidermis and the dermis. Although 5% lactic acid modulates surface and epidermal changes, 12% lactic acid influences both the epidermis and the dermis.

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α-Hydroxy acids (AHAs) have been used for many years as exfoliants, moisturizers, and emollients. Lactic acid salts, most notably sodium lactate, have been hypothesized to be part of the skin's own natural moisturizing system. In addition, AHAs and salicylic acid, a structurally similar β-hydroxy acid, have been used for at least 40 years as peeling agents.

Studies have shown that several AHAs (as well as β-hydroxy and carboxylic acids) in low concentrations (5%) stimulate epidermal turnover or cell renewal (exfoliation) and have the potential to irritate the skin. This activity is closely linked to pH as neutralized acids lost their ability to exfoliate the skin.

Van Scott and Yu have also documented the moisturizing activity of AHAs and their ability to exfoliate the skin and interfere with intercellular cohesion in the outer epidermis. They also suggested that AHAs interfere with cohesion in the stratum granulosum, unlike salicylic acid and other exfoliants.

Several studies on the activity of a buffered 12% ammonium lactate lotion have documented its moisturizing activity. Lavker, Kaidbey, and Leyden found that it caused an increase in dermal ground substance and increased glycosaminoglycan synthesis. Murad, Shamian, and Premo demonstrated that aggressive glycolic acid peels significantly increase collagen and dermal ground substance. Precisely how and why AHAs produce these effects is not known.

The purpose of this study is to determine whether high- and low-concentration AHAs behave qualitatively similarly and the effects they have within the epidermis and dermis.

**METHODS**

**Ballistometry firmness measurements**

Ballistometry was used to measure both superficial (epidermal) and integral (dermal) skin firmness. For the measurement of superficial firmness a small lightweight probe with a relatively blunt tip (4 mm² contact area) was used.

To measure integral skin firmness, (predominantly dermal) the probe tip was changed to a more pointed structure to encourage penetration into the skin (0.05 mm² contact area) and a 2 gm weight was attached to the probe before it was dropped on the skin surface. Integral firmness was calculated as the inverse of the depth of indentation with a fixed load.
Ultrasound

A 20 MHz resolution Dermascan C Ultrasound (Cortex Technology, Hadsund, Denmark) was used to measure skin thickness, both epidermal and dermal as published elsewhere.\textsuperscript{21, 22} No stratum corneum resolution is possible with this instrument.

Clinical grading

Two clinicians independently examined each subject at 0, 4, 8, 12, and 16 weeks for the following evaluation of the variables: skin moisturization, skin smoothness, skin irritation, and superficial lines and wrinkles around the eyes according to the Packman method.\textsuperscript{23} Scores were averaged and reported as percentage change from baseline.

Product use

Test subjects whose ages ranged from 35 to 50 years, with normal to dry skin and no history of sensitive skin, were enrolled. Before acceptance into the study, subjects were required to pass a lactic acid sting assay in the nasal fold area. Stinging was rated on a 0 to 5 scale, and subjects were required to have a total cumulative stinging score of less than 25 when stinging was graded every minute for 15 minutes after application of test material.

Subjects applied 12\% or 5\% lactic acid test solutions, adjusted to pH 2.8 with triethanolamine and containing 5\% glycerin and 5\% butylene glycol twice a day to the full face, except the eyelids. After application subjects were instructed to apply a moisturizer (Nivea cream). Subjects were allowed to use cosmetics during the study but no other moisturizer. Subjects were encouraged to avoid excess sun exposure, but were supplied with a titanium dioxide–based facial sun product with a sun protection factor of 15 to use when necessary. Subjects were examined at the start of the study and after 4, 8, 12, and 16 weeks of product use. Ten subjects completed all phases of the 5\% lactic acid protocol and 14 completed the 12\% lactic acid protocol.

RESULTS

Effects of 5\% and 12\% lactic acid treatment of skin thickness

Significant increases in superficial skin firmness were noted at each visit in the test subjects using the 5\% lactic acid. After 4 weeks an 11.2\% increase was observed; this increased to 13\%, 14\%, and 14.5\% after 8, 12, and 16 weeks, respectively. Subjects, however, did not show any significant increase in integral skin firmness at any point during the study.

The subjects using the 12\% lactic acid cream also exhibited significant increases in skin firmness at each visit. After 4 weeks an 15.3\% increase was observed, and this increased to 17.4\%, 20.6\%, and 23.1\% after 8, 12, and 16 weeks, respectively. Significant increases in integral skin firmness (3.7\%, 5.7\%, 10.1\%, and 12\%) were observed after 4, 8, 12, and 16 weeks of treatment, respectively.

Effects of 5\% and 12\% lactic acid treatment of skin thickness

Increases in epidermal thickness (4.6\%, 6.4\%, 8.2\%, and 9.1\%) were noted after 4, 8, 12, and 16 weeks, respectively, in subjects using the 5\% lactic acid formulation. The increases were not from increased water content of the epidermis because the density of the epidermal region did not decrease and no clinical signs of inflammation were noted.

Subjects using the 12\% lactic acid treatment showed increases in both epidermal and dermal thickness throughout treatment. Epidermal thickness increased 5.6\%, 7.4\%, 9.3\%, and 12\% after 4, 8, 12, and 16 weeks of treatment, respectively. Dermal thickness increased slightly after 8 weeks (4.5\%) and substantially after 12 and 16 weeks of treatment (7.4\% and 9\%) and was not accompanied by any decrease in tissue density.

Clinical grading

Significant improvement in skin texture or smoothness and moisturization were noted in the groups using the 5\% and 12\% lactic acid, but no differences between the two treatments were observed. Improvements in moisturization were noted after 4 weeks and remained constant throughout the 16-week study, and improvements in skin smoothness increased through the 16-week test at least for the 12\% treatment. More irritation responses were observed in the group using the 12\% lactic acid product (46 individual reactions) compared with 16 in the 5\% lactic acid group. Irritation, however, was not severe enough for any of the subjects to withdraw from this study.

After 4 weeks of treatment both the 5\% and 12\% lactic acid product showed similar improvements in the appearance of lines and wrinkles (18\% and 22\% increases, respectively). However, after 8, 12, and 16 weeks the 12\% lactic acid treatment showed more improvements with reductions of 29\%, 38\%, and 45\%, respectively, compared with improvement of about 20\% with the 5\% lactic acid product.
DISCUSSION

The effects of a low (5%) and a higher (12%) concentration lactic acid on various properties of the skin have been documented. Treatment with 5% lactic acid resulted in considerable cosmetic benefits and an increase in superficial skin firmness after 4 weeks of treatment. No appreciable changes in dermal properties, dermal thickness, or integral skin firmness were observed at any time. Even with continued long-term use, additional benefits are unlikely because it has been shown\(^\text{a,}\) that with continued use of 5% lactic acid, accommodation is observed. The skin apparently becomes more resistant to AHA action by becoming a better acid buffer, effectively neutralizing the effects of the acids.

Treatment with a 12% lactic acid product resulted in significant epidermal and dermal effects and cosmetic benefits. Although the improvements were numerically greater than those with 5% lactic acid, the qualitative and quantitative aspects of these observations were similar.

Of most importance were significant increases in dermal thickness after 8, 12, and 16 weeks of treatment with 12% lactic acid in contrast to the lack of effect from 5% lactic acid.

Why 12% lactic acid affects the skin qualitatively differently than the 5% lactic acid formula is unknown. AHA treatment results in the breakdown of cellular adhesion at the surface or within the outermost layers of the epidermis.\(^9,\)\(^12,\)\(^24\) This results in accelerated cell loss and exfoliation and occurs without a disruption of barrier function\(^25\) or inflammation. Low-concentration AHA products may simply increase exfoliation, and this increased cell loss triggers a faster replacement rate. Whatever the trigger, an increased replacement rate results in cosmetically improved skin, seemingly limited to the epidermis.

With higher concentrations of AHAs, both epidermal and dermal effects are observed. Preliminary data suggest that prolonged disruption of barrier integrity may cause the dermal effects. Some preliminary work by Elias and Menon\(^26\) and Feingold\(^27\) suggests that the stratum corneum is essentially a macrobiologic membrane. It is possible that the maintenance of calcium and other ionic gradients across it are important to normal skin function. Although an acute disruption of the stratum corneum water barrier, via tape stripping, can trigger cytokine release, it is not known whether less significant alterations (i.e., alterations that do not measurably increase transepidermal water loss but disrupt ionic gradients) can have similar effects. It is possible that long-term treatment with high-concentration AHA products can alter the stratum corneum and stimulate epidermal metabolism without measurable increases in transepidermal water loss.

REFERENCES


