The effect of physically applied alpha hydroxyl acids on the skin pore and comedone

S. J. Kim*, J. H. Baek*, J. S. Koh*, M. I. Bae†, S. J. Lee‡ and M. K. Shin‡
*DERMAPRO LTD., Skin Research Center, 30, Bangbaejoongang-Ro, Seocho Gu, Seoul, Korea, †Department of Dermatology, College of Medicine, Kyung Hee University, Seoul, Korea and ‡Arundaun Nara Dermatologic Clinic, Seoul, Korea

Received 13 October 2014, Accepted 6 March 2015

Keywords: AHA peeling, chemodermabrasion, comedone, hydadermabrasion

Abstract

OBJECTIVE: Alpha hydroxy acids (AHA) have been recognized as commonly used therapy for acne. Our studies examined whether an additional effect of physical treatment using chemical peeling combined with negative pressure and compared with AHA treatment only occurs in acne-prone subjects.

METHODS: The chemical peeling agent used 4% of an AHA solution (mixture of 1000 mL of carbonated water, 20 mL of glycolic acid and 20 mL of lactic acid). All subjects’ faces were randomly divided into test and control groups. The test group was treated with chemical peeling combined with a physical effect, and the control group applied chemical peeling alone. For the 23 healthy females (average age: 30.17 ± 5.06 year), we measured sebum output level by light transmission, pore area and number by optical image analyser, and comedone counting before treatment and at 1, 2 and 4 weeks after a single treatment.

RESULTS: Compared to the before treatment, whiteheads and blackheads were significantly decreased at 1, 2 and 4 weeks in the test group (P < 0.05), but for the control group, whiteheads and blackheads showed a tendency to decrease at 1, 2 and 4 weeks. Also at 1 week, whiteheads and blackheads of the test group significantly decreased compared to the control group (P < 0.05). Pore area and number significantly decreased at 1 week (P < 0.05), and the sebum output level was significantly decreased at 4 weeks (P < 0.05) only in the test group, which did not show any significant group difference for individual parameters.

CONCLUSION: 4% AHA solution combined with a physical effect had rapidly improving effects on whiteheads and blackheads synergistically. Combined physical therapy may have more impact on pore size and seborrhoea.

Résumé

OBJECTIF: Les acides alpha-hydroxy (AHA) sont reconnus en tant que thérapie couramment utilisée contre l’acné. Nos études ont examiné si un effet supplémentaire par un traitement physique, utilisant le peeling chimique combiné avec une pression négative et comparé au seul traitement AHA peut être obtenue chez les sujets à peau acnéique.

MÉTHODES: L’agent de peeling chimique est composé d’une solution à 4% d’AHA (mélange de 1000 mL d’eau gazeuse, 20 mL d’acide glycolique et de 20 mL d’acide lactique). Les visages de tous les sujets ont été répartis au hasard en groupes d’essai et de contrôle. Le groupe de test a été traité avec peeling chimique combiné à un effet physique, et le groupe de contrôle seulement au peeling chimique appliqué.

Pour les 23 femmes en bonne santé (âge moyen: 30.17 ± 5.06 ans), nous avons mesuré le niveau de sécrétion de sébum par transmission de la lumière, la zone et le nombre de pores par l’analyse d’images optique et les comédons par comptage avant le traitement, et à 1, 2 et 4 semaines après un seul traitement.

RÉSULTATS: Par rapport à l’état avant le traitement, les comédons blancs et noirs étaient significativement diminués à 1, 2 et 4 semaines dans le groupe de test (P < 0.05), mais pour le groupe de contrôle, blancs et noirs ont montré juste une tendance à diminuer à 1, 2, et 4 semaines. A 1 semaine, la différence par rapport au groupe témoin était significative (P < 0.05).

Les surfaces des pores et leur nombre diminuaient de façon significative à 1 semaine (P < 0.05), et le niveau de sécrétion de sébum a été significativement diminué à 4 semaines (P < 0.05) dans le groupe de test, mais qui n’a pas montré de différence significative entre groupes pour les paramètres individuels.

CONCLUSION: Une solution à 4% AHA combinée à un effet physique conduit à l’amélioration rapide des effets sur comédons blancs et noirs en synergie. Une thérapie physique combiné le traitement chimique peut avoir plus d’impact sur la taille des pores et la séborrhée.

Introduction

Chemical peels cause loosening of corneocyte adhesion or epidermalysis to the stratum granulosum layer. The purpose of the superficial peels in patients with acne is to clear comedones quickly because the resolution of comedones ranges between 2 and 6 weeks; thus, the treatment is preferred in patients with comedonal-type acne [1, 2].

Alpha hydroxy acids (AHA) have been recognized as an adjuvant therapy in a variety of conditions (including acne, photodamage, actinic damage, melasma, hyperpigmentation disorders and rosacea) [3–6]. The most commonly used AHA is lactic or glycolic acid (GA), salicylic acid, etc. In low concentrations of 5–10%, desquamation properties, reductions in corneocyte cohesion and keratinocyte plugging enable the extrusion of inflammatory contents in inflammatory and hyperkeratotic acne [7].
Superficial chemical peels that use glycolic acid and aluminium oxide crystal microdermabrasion are popular because they remove the stratum corneum and are associated with low morbidity and prompt recovery [8–10]. Microdermabrasion has the advantages of less bleeding, fewer complications and no need for local anaesthesia in comparison with other superficial peeling techniques [11]. A combination of microdermabrasion and glycolic acid (GA) peels was found to give excellent results for acne treatment of skin [12]. Hydradermabrasion is a combined method that involves physical peeling using chemical agents. The concept of hydradermabrasion was introduced by Freedman in 2008 [13]. Hydradermabrasion is a term coined to describe a procedure that combines crystal-free microdermabrasion via abrading tip with the pneumatic application of chemical peeling.

In a previous study, we reported the additive effects of physical dermabrasion combined with chemical peeling in porcine skin [14]. Porcine skin treated with physical dermabrasion combined with chemical peeling showed prominent stratum corneum detachment and swelling as well as fluid collection in hair follicles. Compared to chemical peeling alone, physical dermabrasion combined with a chemical peeling agent resulted in significantly increased numbers of CD34-positive fibroblasts and mast cells. Additionally, the levels of epidermal growth factor, fibroblast growth factor-2, vascular endothelial growth factor and neurotensin significantly increased. These results imply that this therapy could be a more effective method to directly assess hair follicles.

In this study, we investigated that lower AHA concentration than traditional AHA peeling dose has more effective comedolytic actions’ aid by synergistic physical pressure for subjects with acne-prone skin.

Materials and Methods

The study was conducted in accordance with the intent and purpose of Good Clinical Practices (GCP) regulations that originated in the Declaration of Helsinki as appropriate.

All procedures involved in the study were explained in detail to the subjects, and written informed consent was obtained from all 25 subjects prior to the study. An IRB (internal review board) review was conducted, and approval to conduct the proposed clinical research was granted.

The criteria for exclusions are as follows: (i) pregnancy, breast feeding or planning pregnancy within 6 months; (ii) medication of antibiotics including steroids for over 1 month to treat skin diseases; (iii) within 3 months from participation of the same study; (iv) sensitive or hypersensitive skin; (v) abnormal findings such as red spots or haemotelaugnosis on the part to be tested; (vi) use of the same or similar cosmetic or medicine on the part to be tested within 1 month; (vii) surgical procedures (liposuction and skincare treatment, etc.) on the part to be tested or planning such procedure within 6 months; (viii) chronic wasting diseases such as asthma, diabetes, or hypertension, etc.; and (ix) atopic dermatitis.

For conducting this study, the 25 female subjects were recruited, but 2 subjects (subject No. 09, 14; protocol default) were dropped out. Therefore, 23 female subjects aged between 22 and 39 (average age: 30.17 ± 5.06 year) were completed in the study.

The chemical peeling agent used 4% AHA solution (mixture of 1000 mL of carbonated water, 20 mL of glycolic acid and 20 mL of lactic acid).

The chemical peeling agent was applied after measurement of the initial values. The faces of subjects were divided in half according to the block randomization. The treatment group applied the 4% AHA chemical peeling with a physical effect using water jet pressure, and the control group applied only the 4% AHA chemical peeling (Fig. 1).

This study was performed under a given relative temperature and humidity, which was controlled and maintained identically for each volunteer. The ambient temperature was maintained at 22 ± 2°C and the relative humidity in the range of 50 ± 5%.

Negative pressure device

A water jet skin delivery system (Affinite™, Tav-Tech Ltd., Yehud, Israel) was used for the physical peeling. The tip of this device consists of two 50-μm-diameter-sized nozzles which enable the expulsion of direct low-pressure liquid through nozzle arrangements that form thin streams. During the procedure, the skin is supported with the assistance of moderate negative pressure. This technique uses the smallest aperture ever created in a plastic injection moulding process. A mixture of peeling agents and carbonated water passes through an open converging-diverging venturi channel, and the produced supersonic flow accelerates the flow of the solution droplets to approximately 200 m s⁻¹. The droplets exit through the specialized nozzles onto the desired area of the skin. The peeling agent is connected to the control unit that is set to yield a negative pressure of 300 mmHg.

Assessment by comedone counting

Comedone counting was performed by 2 experts before treatment and after 1, 2 and 4 weeks. Lesions were recorded excluding the nose and jaw by individually counting the whiteheads (1-mm closed comedones in the initial inflammatory stage) and blackheads (opened comedones that darken as they oxidize). On visual assessment, the average was used for the analysis if there was statistical significance in intraclass correlation coefficient (ICC) between 2 researchers over 0.8.

Measurement of sebum output level by light transmission

Sebum output level was measured by Sebometer® SM815 (C+K, Germany). The measurement is based on grease spot photometry. The mat tape is brought into contact with the skin. It becomes transparent in relation to the sebum on the surface of the measurement area. Then, the tape is inserted into the aperture of the device, and the transparency is measured by a photocell. The light transmission represents the sebum content. In this study, sebum output level on the test site (next to nose) was measured before treatment and after 1, 2 and 4 weeks.

Measurement of pore area and number by optical image analyser

Skin pore area and number were measured by Facial Stage® DM3 (Moritex, Japan). This system enables a comparison in the change of the same part using ‘overlay’ functions at each time point. By using fluorescent lighting, this technique visualizes skin features and conditions including facial expressions and facial profile that cannot ordinarily be seen [15].

After photographing the front face, pore area (mm²) and number of the centre of the cheek (width = 80, height = 80 pixel) printed on the optical photo were analysed using the built-in software of the apparatus (Fig. 2).
Skin adverse reaction

Subjective and objective skin reactions were assessed by a clinical examination by interview and observations of investigator.

The assessment considered the elements reported by the subjects (subjective and objective signs) as well as those noted by the researcher (clinical signs). The frequency, the duration and the intensity of the sign and a possible or probable relationship with the test product were investigated. Subjective signs included itching, prickling, burning, stinging, stiffness, tightening, burning of eyes, weeping, etc. Objective signs included erythema, oedema, scale, papule, etc.

Statistical analysis

Statistical analysis was conducted using the SPSS® software program (IBM, Chicago, IL, U.S.A.).
To determine whether variables followed a normal distribution or not, we used the Shapiro–Wilk test and kurtosis and skewness for the normality test. Statistical analysis of variables for parametric values was conducted using the paired t-test. If the values were nonparametric, all of them were initially compared by the Wilcoxon’s signed-rank test. A statistically significant difference was set at $P < 0.05$.

Results of data expressed the per cent change based on the baseline change. Change of per cent was defined as:

\[
\text{Decrement or Increment rate } \left( \% \right) = \left( \frac{\text{Before treatment} - \text{Before treatment (1, 2, or 4 weeks)}}{\text{Before treatment}} \right) \times 100.
\]

### Results

#### Analysis of comedone counting

Compared to the before treatment, the comedone counting for the control group showed a tendency to decrease, and for the test group, the comedone counting significantly decreased at 1, 2 and 4 weeks ($P < 0.05$, Table I, Fig. 3). Compared to the control group, whiteheads and blackheads of the test group significantly decreased at 1 week ($P < 0.05$, Table II, Fig. 3).

#### Analysis of sebum output level by light transmission

Compared to the before treatment, the sebum output level of the test group significantly decreased at 4 weeks ($P < 0.05$, Table I, Fig. 4). Compared between both groups, no significant differences occurred (Table IV).

#### Analysis of the pore area and number using digital image

Compared to the before treatment, the pore area and number of the control group showed a tendency to decrease, and for the test group, they significantly decreased at 1 week ($P < 0.05$, Table V, Fig. 5). Compared between both groups, no significant differences occurred (Table VI).

### Skin adverse reaction

During this study, the results of the skin safety evaluation were summarized and presented in Table VII. Two of twenty-three subjects in the control group complained of subjective irritation (itching or stinging), but this irritation disappeared within 30 min. It seems that these reactions were transient. The other subjects did not observe any adverse reaction during the course of the study.

### Discussion

One of acne pathogenesis is follicular hyperkeratosis [16]. Alpha hydroxyl acids have comedolytic effects. 10% glycolic acid containing oil-in-water emulsion has been known to improve mild acne [17]. In the epidermis, glycolic acid increased epidermal thickness and accelerated epidermal turnover [18, 19]. In this study, we showed that lower AHA concentration (4%) than traditional AHA peeling dose (5–10%) has more effective comedolytic actions by synergistic physical pressure.

Microdermabrasion is a more superficial physical abrasion than dermabrasion with a high-pressure flow of crystals or suction machine due to gently lifting up the skin during exfoliation [20]. Hydradermabrasion is a procedure that combines crystal-free microdermabrasion with pneumatic jet. Oxygen and microdroplets of fluid (saline) are accelerated to supersonic velocities. A synergetic effect is due to the high-pressure access through various skin appendages. We determined that these physical effects combined with chemical peeling could have a more keratolytic impact through deeper follicles. Freeman defined these combined methods as hydradermabrasion. He reported that hydradermabrasion resulted in increased epidermal thickness, papillary dermal thickness, polyphenolic antioxidant levels, replacement of elastic dermal tissue, collagen

### Table I Statistical analysis of whiteheads and blackheads by lesion counting

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
<th>Week</th>
<th>$N$</th>
<th>Mean $^1$</th>
<th>SD</th>
<th>SEM</th>
<th>$P$-value</th>
<th>Decrement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whiteheads</td>
<td>Control group</td>
<td>0</td>
<td>23</td>
<td>31.57</td>
<td>14.81</td>
<td>3.09</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>23</td>
<td>30.63</td>
<td>13.21</td>
<td>2.76</td>
<td>0.162*</td>
<td>2.96▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>23</td>
<td>29.04</td>
<td>12.96</td>
<td>2.70</td>
<td>0.063*</td>
<td>7.99▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>23</td>
<td>28.61</td>
<td>12.79</td>
<td>2.67</td>
<td>0.206*</td>
<td>6.20▼</td>
</tr>
<tr>
<td></td>
<td>Test group</td>
<td>0</td>
<td>23</td>
<td>31.72</td>
<td>12.66</td>
<td>2.64</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>23</td>
<td>29.00</td>
<td>11.96</td>
<td>2.49</td>
<td>0.000**</td>
<td>8.57▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>23</td>
<td>27.74</td>
<td>10.50</td>
<td>2.19</td>
<td>0.000**</td>
<td>12.54▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>23</td>
<td>26.89</td>
<td>10.25</td>
<td>2.14</td>
<td>0.004**</td>
<td>8.91▼</td>
</tr>
<tr>
<td>Blackheads</td>
<td>Control group</td>
<td>0</td>
<td>23</td>
<td>12.46</td>
<td>9.98</td>
<td>2.08</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>23</td>
<td>11.78</td>
<td>9.22</td>
<td>1.92</td>
<td>0.125*</td>
<td>5.41▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>23</td>
<td>11.76</td>
<td>9.26</td>
<td>1.93</td>
<td>0.428*</td>
<td>5.58▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>23</td>
<td>11.07</td>
<td>9.04</td>
<td>1.89</td>
<td>0.072*</td>
<td>11.17▼</td>
</tr>
<tr>
<td></td>
<td>Test group</td>
<td>0</td>
<td>23</td>
<td>13.74</td>
<td>9.86</td>
<td>2.06</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>23</td>
<td>12.04</td>
<td>9.77</td>
<td>2.04</td>
<td>0.000**</td>
<td>12.34▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>23</td>
<td>11.67</td>
<td>9.60</td>
<td>2.00</td>
<td>0.000**</td>
<td>15.03▼</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td>23</td>
<td>10.98</td>
<td>9.93</td>
<td>2.07</td>
<td>0.000**</td>
<td>20.09▼</td>
</tr>
</tbody>
</table>

$^1$Decrease in the mean value represents reduction in whiteheads and blackheads number (▼).

$^*$Significantly different at $P < 0.05$ compared with the before treatment.

$^*$Wilcoxon signed rank test.
Our results demonstrate that these synergistic methods are more comedolytic. Clinically, the most superficial peeling using a low percentage of chemical agent is practiced in repetitive sessions. Superficial peeling has been performed in multiple sessions to achieve the desirable clinical effects. However, in this study, we conducted a single treatment to analyse the additional physical effect with combined chemical and mechanical peeling.

### Table II: Comparison whiteheads and blackheads between test and control group

<table>
<thead>
<tr>
<th>Group</th>
<th>Week</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whiteheads</td>
<td>1 vs. 0</td>
<td>36.543</td>
<td>1</td>
<td>36.543</td>
<td>5.480</td>
<td>0.029*</td>
</tr>
<tr>
<td></td>
<td>2 vs. 0</td>
<td>24.397</td>
<td>1</td>
<td>24.397</td>
<td>2.149</td>
<td>0.157</td>
</tr>
<tr>
<td></td>
<td>4 vs. 0</td>
<td>8.696</td>
<td>1</td>
<td>8.696</td>
<td>0.703</td>
<td>0.411</td>
</tr>
<tr>
<td>Blackheads</td>
<td>1 vs. 0</td>
<td>12.005</td>
<td>1</td>
<td>12.005</td>
<td>5.296</td>
<td>0.031*</td>
</tr>
<tr>
<td></td>
<td>2 vs. 0</td>
<td>21.571</td>
<td>1</td>
<td>21.571</td>
<td>4.161</td>
<td>0.054</td>
</tr>
<tr>
<td></td>
<td>4 vs. 0</td>
<td>21.571</td>
<td>1</td>
<td>21.571</td>
<td>2.490</td>
<td>0.129</td>
</tr>
</tbody>
</table>

*Significantly different at $P < 0.05$.

Figure 3 Changes of comedone number by lesion counting ($^*P < 0.05$ after vs. before; $^{#}P < 0.05$ test group vs. control group).

### Table III: Statistical analysis of sebum output level by light transmission

<table>
<thead>
<tr>
<th>Group</th>
<th>Week</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>SEM</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0</td>
<td>23</td>
<td>20.35</td>
<td>14.21</td>
<td>2.96</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>23</td>
<td>20.51</td>
<td>14.21</td>
<td>2.96</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>23</td>
<td>22.61</td>
<td>17.71</td>
<td>3.69</td>
<td>0.244</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>23</td>
<td>19.57</td>
<td>17.81</td>
<td>3.71</td>
<td>0.699</td>
</tr>
<tr>
<td>Test</td>
<td>0</td>
<td>23</td>
<td>20.96</td>
<td>12.95</td>
<td>2.70</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>23</td>
<td>20.96</td>
<td>12.95</td>
<td>2.70</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>23</td>
<td>22.52</td>
<td>15.78</td>
<td>3.29</td>
<td>0.255</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>23</td>
<td>17.22</td>
<td>14.30</td>
<td>2.98</td>
<td>0.004*</td>
</tr>
</tbody>
</table>

$^1$Decrease in the mean value represents reduction in sebum secretion ($▼$).

$^*$Significantly different at $P < 0.05$ compared with the before treatment.

Table IV Comparison of sebum output level between test and control group

<table>
<thead>
<tr>
<th>Group</th>
<th>Week</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test vs. Control</td>
<td>1 vs. 0</td>
<td>54.348</td>
<td>1</td>
<td>54.348</td>
<td>1.991</td>
<td>0.172 (NS)</td>
</tr>
<tr>
<td></td>
<td>2 vs. 0</td>
<td>5.565</td>
<td>1</td>
<td>5.565</td>
<td>0.133</td>
<td>0.719 (NS)</td>
</tr>
<tr>
<td></td>
<td>4 vs. 0</td>
<td>100.522</td>
<td>1</td>
<td>100.522</td>
<td>3.677</td>
<td>0.068 (NS)</td>
</tr>
</tbody>
</table>

© 2015 Society of Cosmetic Scientists and the Société Française de Cosmétologie

International Journal of Cosmetic Science, 37, 519–525
ical peeling. In our results, the pore and comedone increased to a baseline level between 2 and 4 weeks. So, we would recommend repeated treatment at 2-week intervals. The pores and comedones will be able to maximize the improvement. Further studies on the patient with a large scale of acne with multiple sessions may be helpful to elucidate the potential treatment effects of acne and facial pores.

Interestingly, in this randomly assigned split study, the treatment side did not develop the itching and sting symptoms, only the chemically applied side developed these symptoms in 8.69% (n = 2). A temporary burning and sting sensation is a common side effect of AHA products. Subjects participated in this study did not complain of these symptom on the only physically applied side. So, we assumed that a depletion of neuropeptides in the sensory neuron could intercept the neurogenic symptoms in the pressure-stimulated dermal environments [20]. The further investigation of neurologic inflammation in the skin will be needed to be clarifying this phenomenon.

4% AHA solution combined with a physical effect had improving effects on the open and closed comedones synergistically. In conclusion, an additional effect of chemical peeling combined with a physical effect than chemical peeling alone led to an improvement of the sebum output level, pore and comedone.

Acknowledgements

None of the authors has any conflict of interest including any financial, personal or other relationships with other people or organizations within that could inappropriately influence this work.
References


