Enlarged Pores Treated with a Combination of Q-switched and Quasi Long-Pulsed 1064 nm Nd:YAG Laser with and without Topical Carbon Suspension

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Directed by Professor Kee Yang Chung

The Master’s Thesis
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ABSTRACT

Enlarged Pores Treated with a Combination of Q-switched and Quasi Long-Pulsed 1064 nm Nd:YAG Laser with and without Topical Carbon Suspension

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In the previous reports of enlarged pore treatment, the results have not been analyzed objectively. Moreover, the reports did not focus directly on the pore size. This study was attempted to assess and compare the efficacy of the Q-switched and quasi long-pulsed Nd:YAG laser treatments to reduce the size of the enlarged pores. Twenty-four subjects had carbon suspended solution applied to one side of the face (method 1), leaving the other side bare (method 2). One laser pass was made, at 2.3 J/cm² and 300 µsec. Then multiple laser passes were repeated, at 5 nsec and 2.5 J/cm². Patients were treated 5 times at a 3 week interval. Pore sizes were measured with a dermoscope and analyzed using an image analysis program. Three weeks after the final treatment, method 1 showed 75% improvement, while the method 2 showed 67%. We proved objectively that Q-switched and quasi long-pulsed Nd:YAG laser treatment could reduce the pore size, and use of the topical carbon suspension augmented the effect.

Key words: Nd:YAG laser, enlarged pore, carbon suspension
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I. INTRODUCTION

Enlarged or dilated pores are largely of significant cosmetic concern in Asians but have been considered an aspect of photoaging in the literature\(^1\)\(^-\)\(^5\). However, the number of patients with enlarged pores who seek treatment has increased recently and they are usually young without any signs of photodamage. A variety of different treatments have been used for the reduction of pore size, including intense pulsed light\(^1\)\(^,\)\(^2\), tazarotene cream\(^3\), radiofrequency\(^4\), oral isotretinoin\(^5\), isotretinoin iontophoresis\(^6\), and glycolic acid peeling\(^7\). However, the results of the previous reports concerning these treatment modalities have not been analyzed objectively, and most of them depended on subjective patient reports and the authors’ review of clinical pictures using scales. Furthermore, the reports did not focus on pore size but regarded them as a component of photoaging\(^1\)\(^-\)\(^5\) or only partially mentioned the reduction of pore size in the context of the improvement of acne scarring\(^6\)\(^,\)\(^7\).
The Q-switched Nd:YAG laser has been used for pigmented and vascular lesions, and for the removal of tattoo or unwanted hair, when topical carbon suspension is used\textsuperscript{8,9}. In addition, it has been shown that the 1064 nm Q-switched Nd:YAG laser provides satisfactory clinical results in the treatment of periocular and perioral rhytides\textsuperscript{8}. Another clinical study using topical carbon solution showed an improvement in post-acne scarring and facial wrinkles\textsuperscript{10}. In a recent unpublished study (Fujimoto T, special supplement of the Annual Meeting of the American Society for Laser Medicine and Surgery, 2004), the Q-switched and quasi long-pulsed Nd:YAG laser treatment using carbon suspended lotion was evaluated for the improvement of skin texture, especially the reduction of the pore size. However, this study also did not use objective parameters to measure the pore size.

The purpose of this study was to evaluate the efficacy of the Q-switched and quasi long-pulsed Nd:YAG laser to reduce the pore size. To objectively analyze this effect, accurate measurement of pore sizes was done with a dermoscope camera and an image analysis program. We compared the areas of the pore before and after treatment. Two methods of treatment were compared, one using a topical carbon suspension and the other not.

The areas of treatment were measured with a corneometer and a sebumeter before and after the treatment in order to evaluate the effect of the laser on skin hydration and sebaceous glands. Possible effect of the laser on epidermal melanin, which is its main target chromophore, was measured using a mexameter\textsuperscript{11}. 
II. PATIENTS AND METHODS

1. Patients

Twenty-five female volunteers with enlarged pores were included in this study. Their mean age was 34 years, ranging from 25 to 44. The volunteers had Fitzpatrick skin types III-IV. Whole face was treated, except for the upper eyelids, eyebrows, and lips. Exclusion criteria consisted of active herpes simplex or herpes zoster, bacterial folliculitis, current use of isotretinoin, history of keloid scarring, and photosensitivity disorders. Informed consent was obtained from each patient prior to participation and photographs were taken before each treatment and at certain times after the completion of the study.

2. Treatment

Preoperative skin preparation was performed with a sheet type nose pack (Charcol nose pack, Nesura, Seongnam, Korea). After washing the face, the patient’s nose and cheeks were wetted thoroughly. A clear sheet of film was then applied with dry hands which adhered completely conforming to the contour of the area. The sheet was allowed to dry for about 20 minutes to remove as much keratotic plugs from enlarged pores as possible. After its
removal, a warm, wet towel was placed on the patient’s face for 1 minute to open up the pores.

Topical carbon suspension was then applied to one half of the face (Method 1), except the upper eyelid, eyebrow, and lips. Topical carbon suspension was not applied to the other side (Method 2). Carbon suspension was massaged and allowed to be absorbed for 20 minutes. Excess solution was then gently wiped away with gauze.

Laser treatment with a 1064 nm Nd:YAG laser (Spectra VRM Laser, Max Engineering, Goyang, Korea) was performed. Laser energy was delivered in a 7 mm diameter spot at repetition rate of 10 Hz. Eyelids were protected by external plastic shields. As the first step, one pass was done on the entire face with a fluence of 2.3 J/cm² and quasi long-pulse of 300 µsec. Then multiple passes were repeated with a fluence of 2.5 J/cm² and Q-switched pulse of 5 nsec until the carbon suspension was completely removed. After the treatment, face was cooled down with cold compresses and 1% hydrocortisone lotion was applied. Patients were treated 5 times at a 3 week interval.

3. Assessment

Photographs were taken using a digital camera (CoolPix 990, Nikon, Tokyo, Japan) prior to each treatment and 3 and 12 weeks after the last treatment. In addition, 100 times magnified pictures of the nose and cheek
surfaces were taken with a dermoscope video camera (Coscam CCL-205, Sometech Cosmetic, Seoul, Korea) at a fixed distance. Using the magnified images, areas of randomly selected 30 to 40 enlarged pores from each side were measured with an image analysis program (Simple PCIp®, Compix Inc., C-Imaging Systems, PA, USA). Pore size reduction was classified into one of the following five categories, no improvement, 1-25%, 26-50%, 51-75%, or 76-100% and all the participants were rated 3 and 12 weeks after the last treatment. Other parameters were also checked with a Corneometer (CM 820 PC, Courage-Khazaka, Köln, Germany), Sebumeter (SM 815, Courage-Khazaka, Köln, Germany), and Mexameter (MX-18, Courage-Khazaka, Köln, Germany) at baseline, and at 3 and 12 weeks after the last treatment. Subjects were asked to evaluate the degree of change visible in their skin for each of the following criteria: pore size reduction, preference of treatment, as well as any adverse outcomes. At the 12th week evaluation, patients completed an anonymous satisfaction questionnaire, in which they rated their perceived improvement and satisfaction on a 1-5 scale (1: worse, 2: no improvement, 3: mild improvement, 4: moderate improvement, 5: significant improvement).

4. Statistical analysis

ANOVA, ANCOVA, and paired t tests were used to compare pore size reduction, sebum production, pigmentation, and hydration at baseline, and at 3 and 12 weeks after the last treatment.
III. RESULTS

1. Degree of improvement

Of the 25 subjects who participated in this study, 24 completed the series of treatments and five could not answer the questionnaire 12 weeks after the last treatment. Photograph of a representative subject who showed an excellent response can be seen in Figure 1.

Figure 1. Significant visual improvement in the pore size. Before treatment (A) and 3 weeks after treatment (B) using method 1 and before treatment (C) and 3 weeks after treatment (D) using method 2.
As can be seen in Table 1, 75% of the subjects treated with method 1 showed improvement whereas subjects treated with method 2 showed 67% improvement.

Table 1. Comparison of improvement achieved by method 1 and 2 at 3 weeks after last treatment.

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Method 1</th>
<th>Method 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>76 - 100%</td>
<td>18 (75%)</td>
<td>16 (67%)</td>
</tr>
<tr>
<td>51 - 75%</td>
<td>10 (42%)</td>
<td>9 (38%)</td>
</tr>
<tr>
<td>26 - 50%</td>
<td>5 (21%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>1 - 25%</td>
<td>1 (4%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>No improvement</td>
<td>6 (25%)</td>
<td>8 (33%)</td>
</tr>
<tr>
<td>Total</td>
<td>24 (100%)</td>
<td>24 (100%)</td>
</tr>
</tbody>
</table>
Figure 2 demonstrates that statistically significant (P<0.001) reduction of pore size was achieved using method 1 three weeks after the last treatment, but the pore size increased somewhat 12 weeks after the last treatment. Although the increase was statistically significant when compared to the 3 weeks after the last treatment, the maintenance of improvement was also significant as compared to before the treatment (P<0.05).

Figure 2. Measurement of pore size before treatment, and at 3 and 12 weeks after last treatment using method 1.
Method 2 also resulted in a statistically similar pattern of improvement and re-enlargement (Figure 3).

![Pore size measurement over time](image)

Figure 3. Measurement of pore size before treatment, and at 3 and 12 weeks after last treatment using method 2.
The pore size reduction tended to be greater on the nose than the cheeks (Figure 4 and 5).

Figure 4. Grade of improvement at 3 weeks after treatment using method 1.

Figure 5. Grade of improvement at 3 weeks after treatment using method 2.
2. Comparison of the two methods

When the two methods were compared, method 1 showed more improvement than method 2 at 3 weeks after the last treatment, but neither could maintain the improvement until 12 weeks after the last treatment (Figure 6).

Figure 6. Measurement of pore size at 3 and 12 weeks after last treatment comparing method 1 and method 2.
3. Mexameter, corneometer, and sebumeter measurements

M (Melanin) and E (Erythema) values determined by the mexameter did not show any difference before and after the treatment (data not shown). However, sebum production in both method 1 and 2 decreased significantly after the treatment. Furthermore, unlike pore size, sebum production 12 weeks after the last treatment was less than 3 weeks after the last treatment (Figure 7).

![Figure 7](image-url)

Figure 7. Sebum level measured with a sebumeter before treatment, and at 3 and 12 weeks after last treatment.
Corneometer readings of both method 1 and 2 showed a statistically significant decrease 12 weeks after the last treatment compared to before the treatment. However, a decrease was not observed 3 weeks after the last treatment (Figure 8).

Figure 8. Corneometer parameter before treatment, and at 3 and 12 weeks after last treatment.
4. Patient Satisfaction

Upon being asked which treatment they preferred, taking into account overall effectiveness and discomfort, at 3 weeks after the last treatment, 23 subjects (95.8%) reported at least a mild improvement (Figure 9). Twenty-two subjects (91.7%) reported they would recommend this treatment to others.

Twenty of the 24 subjects (83%) stated a preference for the carbon suspension-assisted Q-switched Nd:YAG laser technique (method 1), while the remaining subjects (17%) stated that both methods seemed to have the same degree of improvement.

![Figure 9. Patient satisfaction at 3 weeks and 12 weeks after last treatment.](image-url)
5. Complications

Whereas immediate erythema and swelling were common on the side treated with the method 1, they generally resolved within 12-48 hours after the treatment. Mild desquamation developed 3 days after the treatment and resolved within 7 days. These side effects were so mild that subjects did not experience any limitations in their activities. Seven subjects reported vesicle formation on the side treated with the method 1. Folliculitis developed in three patients and aggravation of the pre-existing melasma occurred in one subject, but they were observed on both sides, independent of the treatment methods.
IV. DISCUSSION

Recent economic development has increased the number of people who desire cosmetic procedures for better appearance and enlarged pores are one of the most common cosmetic problems in Asian adults. However, previous reports regarded enlarged pores as a phenomenon of photoaging\textsuperscript{1-5} and some reports briefly mentioned the pore size reduction effect while focusing on the acne scar treatment\textsuperscript{6,7}. Admittedly, enlarged pores are one manifestation of photoaging. Solar elastotic collagen damage produces a sallow skin tone, dilated pore structure, crepe-paper like inelasticity of the eyelids and rhytids\textsuperscript{12}. However, patients with enlarged pores do not always have other photoaging phenotypes, such as pigmented lesions, vascular lesions, or rhytids. In general, Korean women are reluctant of sun exposure due to easy development of melasma and, therefore, severe photodamage in younger population is a rarity. Our subjects were of younger age with no evident manifestations of photodamage. Previous reports have an additional weakness by not using an objective method to analyze the pore size, and they depended on the patients’ subjective reports and the authors’ observations based on clinical pictures using scales.

This study was intended to objectively investigate the efficacy of a new application of Q-switched and quasi long-pulsed Nd:YAG laser for the treatment of enlarged pores, and also to establish an objective and reproducible method to measure the pore size. Two methods were used, one with and one without topical carbon suspension. The results showed that both
methods were very effective overall, showing a significant reduction of pore size in about 70% of the subjects. Our results also showed that using topical carbon suspension was more effective in reducing the pore size, and the participants also preferred using it.

Although all subjects experienced erythema and desquamation, recovery occurred within a week and they were mild so as not to disrupt everyday life. However, due to the hemifacial nature of this study, the nose tip was prone to overlapping laser beam which occasionally resulted in blisters. In a subject with melasma, careful adjustment of the laser fluence is needed as melasma can be aggravated, which happened in one of our subjects. However, a series of the laser treatments are safe and readily tolerated by subjects with minimal adverse effects, downtime, and risk of scarring.

Though the exact mechanism of the effect of the laser is not clear, we assumed the mechanism of method 1 to be as follows. A Nd:YAG laser has no specific strong chromophore in the skin. However, the major absorptive chromophore in the epidermis is melanin, which weakly absorbs the laser. The topical carbon suspension is a suspension of purified carbon particles in a base of mineral oil and it serves as an exogenous artificial chromophore. Nd:YAG laser light has been shown to be strongly absorbed by carbon in contrast to other cutaneous chromophores such as melanin. When carbon suspension is applied and excess solution is wiped away, the remaining carbon particles are located mainly in the enlarged pores and some are presumed to penetrate into the hair follicles. When activated by laser light, carbon undergoes a rapid temperature rise and thereby heating and damaging
the follicles and surrounding structures resulting in tightening of the pores. This proposed mechanism is identical to the previous reports, which removed unwanted hairs with a topical carbon suspension assisted Nd:YAG laser\textsuperscript{9,15}. In addition, sebum levels also significantly decreased after laser treatment and this effect was more prominent in the area treated by method 1. However, method 2 also showed good efficacy and effective decrease in sebum production but the mechanism of this direct effect of laser on the pore size reduction and sebum production is not clear. As mentioned before, long-pulsed 1064-nm Nd:YAG laser is used clinically to improve rhytid formation\textsuperscript{8}. Histological evaluation of the effect of this laser revealed that collagen formation occurred at the level of the reticular dermis\textsuperscript{13}. Other reports evaluating Q-switched Nd:YAG laser treatment showed slight fibrosis in the superficial papillary dermis with unremarkable epidermal changes\textsuperscript{14}. Recently, Schmults et al reported microsecond Nd:YAG lasers, of which pulse duration is identical to the quasi long pulsed Nd:YAG laser mode in this article, could also produce new collagen formation in the papillary dermis\textsuperscript{15}. No previous reports mentioned changes in or around the hair follicles. Therefore, we suggest that collagen formation in the reticular dermis or superficial papillary dermis could shrink pores, especially due to perifollicular collagen formation. Further investigation to confirm this effect using histologic study is needed.

We combined Q-switched and quasi long-pulsed Nd:YAG laser instead of using a single laser, because we thought the combination treatment would result in more improvement. The pulse duration of quasi long-pulsed Nd:YAG laser was 300 µsec, whereas that of Q-switched Nd:YAG laser was
5 nsec. As two different pulse durations were used, the reaction of surrounding tissue was thought to be different. Chryslain et al reported dermal coagulation depth was linearly related to the function of pulse duration\textsuperscript{16}. Therefore we assumed that quasi long-pulsed Nd:YAG laser might react with deeper dermis and Q-switched laser might react with more superficial dermis. In addition, we can think of an association between the size of a carbon particle as an exogenous chromophore and the pulse duration of the laser. Due to the thermal relaxation time, quasi long-pulsed Nd:YAG laser causes heat radiation from the heated carbon particles but cannot completely destroy the particles, whereas Q-switched Nd:YAG laser causes explosion and complete clearance of the carbon particles. Accordingly, two different mechanisms were thought to increase the efficacy of the combination treatment.

Though it is not known whether additional treatments beyond the five described in this study would produce substantially greater results, this observation suggests that a maintenance therapy would be needed, since the pore size at 12 weeks was larger than at 3 weeks after the last treatment.
V. CONCLUSION

Twenty-four subjects with enlarged pores were treated with combination of Q-switched and Quasi long pulsed Nd:YAG Laser. Two methods of treatment were compared, one using a topical carbon suspension (method 1) and the other not (method 2).

From this pilot study, the results are summarized as;

1. Three weeks after the final treatment, method 1 showed 75% improvement, while the method 2 showed 67%.

2. Method 1 showed more improvement than method 2 at 3 weeks after the last treatment, but neither could maintain the improvement until 12 weeks after the last treatment.

3. At 3 weeks after the last treatment, 23 subjects (95.8%) reported improvement. Twenty subjects (83%) stated a preference for method 1.

4. Immediate erythema, swelling, mild desquamation, folliculitis, and aggravation of the preexisting melasma developed.

Based on this study, we have determined that Q-switched and quasi long-pulsed Nd:YAG laser treatment is effective in reducing the size of the enlarged pores and using topical carbon suspension augmented the effect of the laser.
REFERENCES


확장된 모공을 축소하기 위한 기존 치료들은 객관적 분석 방법을 이용하지 않았다. 본 연구에서 객관적인 방법을 이용하여 Q-switched와 quasi long-pulsed Nd:YAG laser의 모공 축소 효과를 관찰하고자 하였으며 카본 로션을 사용한 방법과 사용하지 않은 방법을 비교하고자 하였다.

확장된 모공으로 세브란스 병원 피부과에 내원한 24명의 여자 환자를 대상으로 하였다. 대상환자의 얼굴을 반으로 나누어 레이저 치료 전에 한쪽은 카본 로션을 바르고 (방법 1) 반대쪽은 카본 로션을 바르지 않았다 (방법 2). 양쪽 모두 첫번째 단계에는 quasi long pulse (300 μsec), 2.3 J/cm^2 로 일회 치료한 후, 두번째 단계에는 Q switch (5 nsec), 2.5 J/cm^2 로 수차례 반복 치료하였다. 3주 간격으로 총 5회 치료하였다. 피부 표면을 dermoscope camera로 100배 확대 사진을 촬영한 후 이미지 분석 프로그램으로 모공의 면적을 측정하였다.

연구결과, 5차례 치료 종료 3주 후, 방법 1로 치료한 군은 75%의 환자에서 통계적으로 유의한 모공 축소 효과를 보였고 방법 2로 치료한 군은 67%에서 모공 축소 효과를 보였다. 치료 종료 3주 후에는 방법 1이 방법 2에 비해 통계적으로 유의한 좋은 치료 효과를 보였으나 이 차이는 치료 종료 12주 후에는 지속되지 않았다.

이상의 결과로 Q-switched와 quasi long-pulsed Nd:YAG laser가 확장된 모공의 치료에 효과가 있음을 관찰하였으며 국소 카본 로션을 사용하는 방법이 더 좋은 효과가 있음을 알 수 있었다.