

Selective Electrothermolysis of the Sebaceous Glands: Treatment of Facial Seborrhea

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BACKGROUND There are few publications on facial seborrhea treatment. A focused therapy is needed.

OBJECTIVE Our aim was to evaluate the efficacy of electrothermolysis of the sebaceous glands.

METHODS In the preliminary studies, histologic changes in the cheek skin by electrothermolysis were examined by light microscopy. In the clinical studies, 15 adult women subjects with facial seborrhea were treated four times by the same procedure. A 1.50-mm-long needle with a 0.45-mm base insulation was inserted into pores in the forehead and cheeks, and a high-frequency electrical current was applied for 0.25 to 0.50 seconds with an output of 40W. Each treatment took 60 to 90 minutes. The subjects returned for 6-months follow-up after their fourth treatment.

RESULTS Histology 1 and 6 months later showed fewer sebaceous glands and the development of fibrosis. All 12 subjects who completed the 6-month follow-up gave a subjective assessment of continuous reduction of facial seborrhea. On a scale of 0.0 to 3.0, the mean improvement score was 1.67 ± 0.75 . The mean reduction rate of skin surface lipids was 31.5% by sebumeter ($p < .01$).

CONCLUSIONS Even though this is a pilot, uncontrolled clinical assessment study, electrothermolysis of sebaceous glands may be an effective and safe approach for facial seborrhea treatment.

Toshio Kobayashi, MD, and Shinji Tamada, MD, have indicated no significant interest with commercial supporters.

Seborrhea is a physiologic condition of increased sebum on the skin rather than a disease. Heredity seems to play an important role in the etiology. Sebum is continuously produced by the sebaceous glands and is secreted to the skin surface through the follicular pore. Sebum excretion reaches a peak at about the age of 16 to 20 years. Thereafter the level remains constant until a gradual decrease begins around the age of 40 years.¹ Many people with greasy skin worry about their condition, especially in the facial area. It is natural and proper for medical professionals to perform research into therapies that will provide relief for these anxious persons.

Oral isotretinoin reduces sebum production and is considered the regimen of choice in severe seborrhea.^{2,3} There are patients who are unwilling to take oral isotretinoin, however, due to the long-term commitment as well as the possibility

of serious side effects.⁴ Recently, new modalities targeting the sebaceous glands have been developed for the treatment of acne. These are photodynamic therapies,^{5,6} diode laser devices,^{7,8} and nonablative radio frequency devices,^{9,10} most of which have been adopted recently for use in Japan. None of these therapies, however, seem to have shown successful results in the continuous reduction of facial seborrhea, possibly due to the impermanent nature of the damage to the sebaceous glands.

We have been researching the use of selective electrothermolysis using insulated needles targeting hair follicles, veins, and sweat glands (Kobayashi's method).¹¹⁻¹⁴ The latest research has been focused on the hyperactive sebaceous glands. We describe the histologic and clinical studies in the treatment of facial seborrhea using insulated needles.

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Preliminary Histologic Studies

Preceding the clinical trials, the histologic changes induced by electrothermolysis, from the cheek skin of one of the authors (55-year-old man), were studied by light microscopy. The studies were as follows:

After one perpendicular insertion of the 1.50-mm-long needle with a 0.45-mm base insulation through the follicular pore on the cheek skin, 40 W of high-frequency current was applied for 0.50 seconds using an electrosurgical apparatus (IME-HR 5000, IME Co. Ltd., Tokyo, Japan). An excisional biopsy was performed 15 minutes after the procedure. The specimen was formalin-fixed, serial-sectioned horizontally to the skin surface, and stained with hematoxylin and eosin.

Approximately 300 insertions of the same needle and high-frequency applications were performed into 100 follicular pores on the cheek skin. This meant that a total of three needle insertions and current applications at an angle of 60° to 70° from different directions were performed on each of the pores. The histologic changes at 1 and 6 months after the procedure were studied. The specimens were perpendicularly sectioned to the surface and stained with hematoxylin and eosin.

The following histologic changes occurred after 15 minutes (1), 1 month (2), and 6 months (3).

1. At the level of the follicular infundibulum, an irregular-shaped space within the wall, caused by the penetration of the needle, was observed (Figure 1A). No electrothermal damage was observed. At the level of the sebaceous ducts, electrothermal coagulation was observed at the sebaceous duct and lobule (Figure 1B). At the level of the sebaceous lobules, electrothermal coagulation was still observed (Figure 1C).
2. A biopsied specimen showed fewer sebaceous glands in the upper to middle dermis, which were replaced by fibrosis (Figure 2). The sebaceous glands in the lower dermis were preserved. The epidermis and papillary dermis were not affected. No granulomatous change was observed.
3. From the middle to lower dermis, fibrous tissue was observed (Figure 3). In the upper to middle dermis above the fibrous tissue, the mean numbers of sebaceous glands were observed.

Clinical Studies

Subjects and Methods

Fifteen subjects (all Japanese women, aged 23–36 years) with facial seborrhea were enrolled in the study. All subjects were treated in one of the authors' clinics. Treated regions in this study were on the forehead and the cheeks. Eleven of 15 subjects were associated with comedonal and/or mild inflammatory acne lesions at the first seborrhea treatment. None of them had received any therapy for seborrhea before this study. All subjects gave their informed consent to treatment.

Our electrothermolysis method was aimed at a permanent reduction of sebum excretion by the precise destruction of hyperactive sebaceous glands using sufficient electrical heat without causing skin surface damage. From our histologic studies, the sebaceous glands were located at depths within the range of roughly 0.3 to 1.7 mm below the skin surface. Accordingly, the length of the newly developed needle that was inserted into the skin was fixed at 1.50 mm. The upper 0.45 mm of the needle base that might come into contact with the epidermis and papillary dermis was insulated. The needle diameter was 0.10 mm.

In most cases, this treatment required no local anesthetic, but for patients with sensitive skin, a topical anesthetic cream with 4% lidocaine was applied under occlusion for 60 minutes. Cooling during treatment was effective for reducing electrical pain. The proper insertion of the needle was crucial to the success of this treatment (Figure 4). The operator used 2 × to 3 × magnifying lenses during this procedure. After the skin was stretched between the fingers, the needle was inserted into the center of a

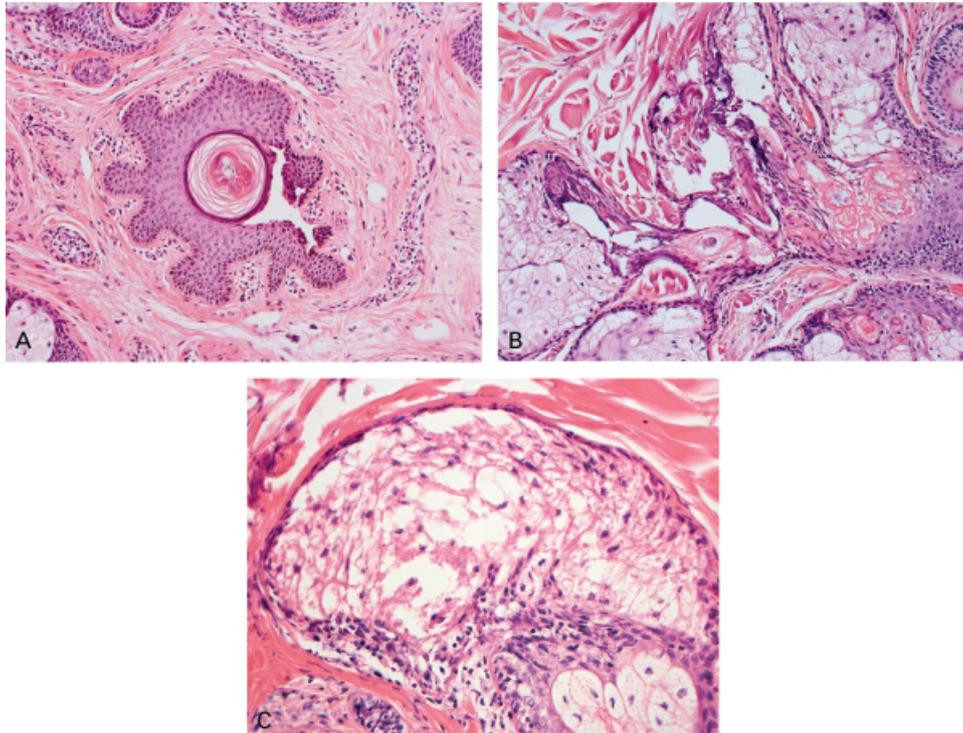


Figure 1. The histologic findings 15 minutes after the procedure (horizontal serial-section). (A) At the level of infrainfundibulum. An irregular-shaped space within the wall with no electrothermal damage (hematoxylin-eosin stain; $\times 200$ original magnification). (B) At the level of the sebaceous ducts. Electrothermal coagulation at the sebaceous duct and lobule (hematoxylin-eosin stain; $\times 200$ original magnification). (C) At the level of the sebaceous lobules. Electrothermal coagulation at the sebaceous lobules (hematoxylin-eosin stain; $\times 400$ original magnification).

dilated follicular pore at an angle of 60° to 70° until 0.45 mm of the insulated base was inserted into the skin. The thicker stem prevented further insertion of the needle. The high-frequency current was then

applied for a duration of 0.25 to 0.50 seconds at an intensity of approximately 40 W using the IME-HR 5000 electro-surgical apparatus. Generally, one needle insertion and the current application was



Figure 2. The histologic findings 1 month after the procedure. A decreased number of sebaceous glands and the formation of fibrosis are observed from the upper to middle dermis as indicated by arrows (hematoxylin-eosin stain; $\times 40$ original magnification).

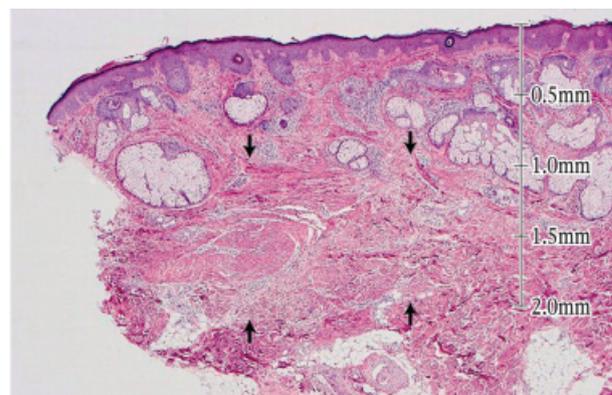


Figure 3. The histologic findings 6 months after the procedure. A decreased number of sebaceous glands and the formation of fibrosis are observed from the middle to lower dermis as indicated by arrows (hematoxylin-eosin stain; $\times 40$ original magnification).

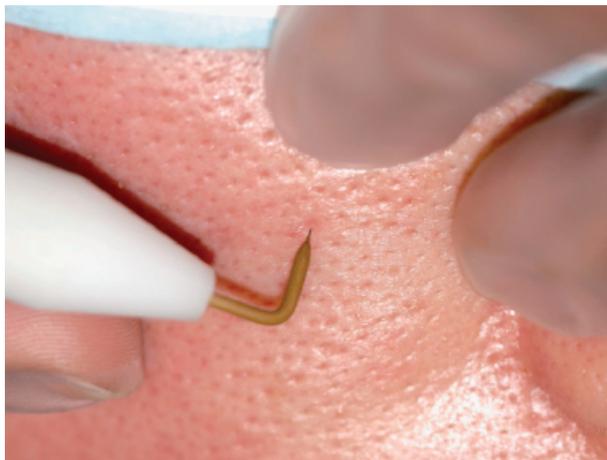


Figure 4. The technique for electrothermolysis of the sebaceous glands.

performed on one follicular pore throughout the procedure. Needle insertions and high-frequency current applications into approximately 700 of the larger pores in 60 minutes was the mean rate. Acne lesions were also treated with this method. For comedonal acne lesions, multiple needle insertions and high-frequency applications were conducted. After the first needle insertion into the pore and current application, parts of the comedonal contents were discharged by gentle pressure. The subsequent needle insertions and current applications were performed to eliminate the comedonal epithelium and the sebaceous acini to prevent reencapsulation of the comedones. The procedures for mild inflammatory acne lesions were similar to those for the comedonal lesions. Pus was drained from superficial pustules as much as possible before treatment. Multiple needle insertions from different directions with current applications were performed to eliminate the inflammatory lesions in the dermis. The pain caused by current applications increased while treating inflammatory acne lesions, yet was in the tolerable range with the application of topical anesthetic cream. Minor bleeding inevitably occurred during treatment of inflammatory acne lesions. One session required 60 to 90 minute to treat both the forehead and the cheeks. Some subjects required a short rest between region treatments. After treatment, the subjects returned home with their usual makeup.

The subjects received four treatment sessions at 1- to 2-month intervals. During the second and subsequent seborrhea treatments, the operator consciously inserted the needles at slightly different directions from those performed during the previous session(s). Subjects returned for clinical assessment 6 months after their fourth treatment. None of the subjects were on concomitant therapy for seborrhea or acne vulgaris during the treatment and follow-up periods.

Clinical Evaluations Were Performed by Assessing the Following Criteria

- Skin surface lipids.
- Acne lesions.
- Skin tightening.
- Follicular pore size.

For the calculation of skin surface lipids, the photometric method using a sebumeter SM815 (Courage-Khazaka Co., Cologne, Germany) was employed. The sebumeter readings were performed before the first treatment, and at the follow-up visits, with the mid-forehead selected as the reading point. The subjects were advised not to wear any makeup to the clinic. After arriving at the clinic, the forehead of the subjects was degreased with an alcohol-soaked cotton swab. The subjects were asked to sit in a room that was air-conditioned to approximately 24°C and 40% humidity. Two hours later, sebumeter readings were taken by the clinic staff. Skin surface lipids readings were performed at two separate areas of the midforehead, and the mean value was used as the sebumeter count for the clinical evaluation. Sebumeter counts and the standard deviation at the baseline and at 6-month follow-up visits were compared using the paired Student's *t* test. Statistical analyses were performed with computer software (Microsoft Excel, Microsoft Corp., Redmond, WA). Frontal view photographs were taken before the first treatment, and at the 6-month follow-up visits. The subjects were given a questionnaire at the follow-up visit inquiring about their subjective assessment of greasiness and acne lesions over the previous

6-month period. Skin tightening and follicular pore size on the cheek skin were also assessed by the subjects. Photographs before the treatment and at follow-up visits were used for reference. The degrees of self-assessment were used as improvement scores and were categorized into four degrees (0–3) as shown in Table 1. This clinical research started in October 2003 and concluded in July 2005. There were no control groups in this study.

Results

By the end of July 2005, 12 of a total of 15 subjects returned for the 6-month follow-up after their fourth treatment. Three subjects failed to return for the follow-up. The mean age of subjects who completed the follow-up was 28.6 years (range, 23–36 years). Transient erythema faded within a few days, but persisted for 2 weeks at the treated inflammatory acne lesions. No noted side effects, such as pigmentary alteration, scarring, or infection, were observed in any of the subjects. The results of the sebumeter

counts and the patients' self-assessment (improvement scores) are listed in Table 1.

All 12 subjects demonstrated a reduction in their sebumeter counts. The mean sebumeter count decreased from a baseline of 191.3 ± 18.5 to 131.1 ± 16.3 at the follow-up period of 6 months after the fourth treatment ($p < .01$). This corresponds to a 31.5% reduction in the mean sebumeter count compared to the baseline. From the subjects' self-assessment in greasiness, all 12 of 12 patients reported a self-assessment of reduction in greasiness during the follow-up period of 6 months. The mean improvement score was 1.67 ± 0.75 .

All nine remaining subjects who had been treated for comedonal and/or mild inflammatory acne lesions at the first and subsequent treatments reported an assessment of continuous reduction in acne lesions during the follow-up period of 6 months. The mean improvement score was 2.33 ± 0.47 .

TABLE 1. Summary: 12 Cases Treated

Patient number/age (years)	6-month follow-up results									
	Baseline counts, S	Improvement scores							Dyspigmentation	Scarring
		S	G	AL	T	P				
1/29	233	132	3	2	2	1	None	None		
2/28	167	129	1	2	1	2	None	None		
3/31	208	140.5	2	3	0	0	None	None		
4/26	187.5	152.5	1	N	1	0	None	None		
5/34	192	104.5	2	2	1	1	None	None		
6/36	184.5	128	1	N	0	0	None	None		
7/23	191	125.5	2	3	1	1	None	None		
8/26	207	162	1	2	1	1	None	None		
9/26	183.5	102	2	3	2	2	None	None		
10/28	165.5	137.5	1	N	0	0	None	None		
11/24	164	135	1	2	1	1	None	None		
12/32	202.5	124.5	3	2	1	1	None	None		
Mean (SD)	191.3 (18.5)	131.1 (16.3)	1.67 (0.75)	2.33 (0.47)	0.92 (0.64)	0.83 (0.69)				

S, sebumeter counts ($\mu\text{g}/\text{cm}^2$); G, greasiness (0, no reduction; 1, slightly reduced; 2, reduced; 3, significantly reduced); AL, acne lesion (0, no reduction; 1, slightly reduced; 2, reduced; 3, significantly reduced); N, no acne lesion at baseline); T, tightening in cheek skin (0, no change; 1, slightly tightened; 2, tightened; 3, significantly tightened); P, pore size in cheek skin (0, no change; 1, slightly diminished; 2, diminished; 3, significantly diminished).



Figure 5. Patient 1 (photos taken by film camera). (A) Before treatment. (B) 6 months after fourth treatment. Patient's subjective assessment: greasiness—significantly reduced; acne lesions—reduced; tightening in cheek skin—tightened; pore size in cheek skin—slightly diminished.

Nine of 12 subjects assessed their cheek skin as tightened. The mean improvement score was 0.92 ± 0.64 . Eight of 12 subjects assessed their cheek skin pore size as diminished. The mean improvement score was 0.83 ± 0.69 . Clinical examples of the subjects are shown in Figures 5 and 6.

Discussion

We found that our electrothermolysis method targeting the sebaceous glands showed safe and effective results in reducing facial greasiness. Although the study was small, the results were consistent among all subjects. The mean reduction rate of skin surface lipids calculated with the sebumeter at the 6-month follow-up visit was 31.5%, which considering that not all the sebaceous follicles were treated with this method, might be a reasonably acceptable value. The crucial reason for attaining prolonged reduction of greasiness with our method might be attributable to the accurate, irreversible electrothermal destruction of the sebaceous glands. From the histologic studies, the sebaceous glands were replaced by fibrosis,

which may have resulted in dermal contraction, leading to skin tightening and diminution in pore size. Reduction of sebum in the follicular canal may also have resulted in the diminution in pore size. The serial-sectioned biopsied specimen taken 1 month after the procedure showed fibrosis from the upper to middle dermis, whereas the specimen taken at 6 months showed fibrosis from the middle to lower dermis. The reason for this difference is unclear at this time. The specimen at 6 months after the procedure showed a mean number of sebaceous glands in the upper dermis. Whether these glands were regenerated or preserved also remains unclear. To provide further clarification, we are currently undertaking longer-term research with multiple samples.

Accomplishing satisfactory results with our methods was also due to the technology of developing very tight adhesion between the short, thin needle and the insulating material. The molecular structure of the insulation must have been strong and dense enough to prevent current leakage to the skin surface. This



Figure 6. Patient 3 (photos taken by digital camera). (A) Before treatment. (B) 6 months after fourth treatment. Patient's subjective assessment: greasiness—reduced; acne lesion—significantly reduced; tightening in cheek skin—no change; pore size in cheek skin—no change.

reliable, strong protection of insulation against skin surface damage enabled us to increase the electric power high enough to sufficiently eliminate the target tissue.

We used the quantity of skin surface lipids as an indicator of sebaceous gland activity, although skin surface lipids are different from lipids contained in the sebocytes due to contamination with epidermal lipids. The photometric method is based on the fact that the lipids became translucent on frosted glass.^{15,16} The sebumeter used in this study relies on a change in the transmission of light through an opaque plastic strip, which becomes transparent upon absorbing lipids.¹⁷ Before conducting the clinical studies, we measured the skin surface lipids immediately after and at 1-hour intervals after degreasing the cheek skin with alcohol. There was a significant increase in the skin surface lipid levels between the first measurement and 1 hour later and between the first and second hours, whereas there was no significant change between the second and third hours or the third and fourth hours. Therefore, we regarded the level of skin surface

lipids reached by the second hour after degreasing as relevant. Accordingly, we now wait 2 hours after degreasing before taking measurements in our clinical studies.

The subjects' acne conditions were also resolved and the subjective improvement score for acne (2.33) was the highest among the four criteria used in this study. This satisfactory result might be brought about by the adequate level of electrothermal destruction of the lesions in the dermis. Reduction of sebum excretion might be continuous with our method. Therefore, our method of eliminating the hyperactive sebaceous glands could be the choice for preventing or stopping the progression of severe acne. This would be relevant for teenagers as well who, along with their parents, tend to be anxious about a familiar predisposition, because acne in teenagers typically starts with seborrhea on the forehead and around the nose. These sites correspond to the treated areas in this study.

In the preliminary studies, a mean of three needle insertions and high-frequency current applications

were performed on each pore on the cheek skin of the authors. However, erythema remained for approximately 1 month after the procedure. Therefore, in our clinical study we adopted the policy of one needle insertion and the current application per pore and opted for repeat treatments instead. In actual future practice for seborrhea treatment, two insertions at different angles per pore for two treatment sessions may achieve the same results as this study, but with the possibility of some residual erythema.

To date, we are not aware of any published reports describing electrothermolysis of the sebaceous glands. Photothermal modalities have been developed, however. Lloyd and Mirkov⁸ reported on selective photothermolysis of the sebaceous glands for acne treatment.⁸ This study was to evaluate the efficacy of a long pulse diode laser with a wavelength of 810 nm to destroy enlarged sebaceous glands that were preloaded with indocyanine green chromophore. They reported that histologic examination of the back skin, taken 24 hours after the laser exposure, showed that the folliculosebaceous units had been largely destroyed with surrounding tissue necrosis. A biopsy seems to have been taken once in this study, and there were no comments concerning change in the skin surface lipids. We expect further studies to be conducted with this method.

In relation to the function of the pilosebaceous unit, recent articles suggest that the pilosebaceous unit is an element of the skin immune system and that damage may be undesirable.^{18,19} Our long-term conscious observation regarding this potential issue will be of vital importance.

One advantage of our method is that there have been no occurrences of noted side effects when the treatment has been performed by properly trained therapists. The operative results are much more dependent on the therapist's skill rather than on the quality of the apparatus, which is more

likely to affect the result when using laser machines. We are now in the process of preparing our next article on the treatment of acne vulgaris.

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