Treatment of lichen pilaris with a Q-switched Nd:YAG laser in quasi long-pulsed mode: A case report (a secondary publication)

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Background and Aims: Lichen pilaris is a very common disease typically seen among young adults on their upper arms as a manifestation of hyperkeratotic lesions occurring in the pores. Only a few treatments have been reported as significantly effective, so often natural resolution over time is the only option. The present study examined the use of a 1064 nm Q-switched Nd:YAG laser (QSNY) in quasi long-pulsed mode, in an attempt to treat a case of lichen pilaris.

Subject and Methods: A 33-year-old male presented with light-brown aggregated papules observed on both sides of the upper arms. The affected areas were treated every other week (QSNY, pulse width 300 µs, pulse energy 3.0 J/cm², spot size 6 mm and repetition rate 10 Hz). Clinical photography was taken of the lesions at baseline and three months after the final treatment in addition to macrophotography and 3-D photography, biopsies being taken at both time points for histological comparison.

Results: The clinical photography and objective image evaluation demonstrated shrinking of the pores and improvement of the unevenness of the skin. Histological examination suggested that the effect of the micropulsed QSNY on the horny layer, epidermal keratinocytes and dermal collagen resulted in a peeling effect and increased dermal collagen density, which eventually led to the shrinkage of the pores and improvement of the skin condition.

Conclusions: The results of this single patient case report suggest that the micropulsed QSNY could be an effective treatment option for lichen pilaris, improvement of which is often difficult. Further studies with an appropriately-sized population are merited to confirm these preliminary results.

Key words: Lichen pilaris · Q-switched Nd:YAG Laser · Quasi long-pulsed mode · Histological examination

Introduction

Even though lichen pilaris has been conventionally treated with topical preparations such as urea ointment, salicylic acid, petrolatum and vitamin A ointment and the like, none of these therapeutic approaches has been reported to achieve good and consistent results. In addition, this may be a disorder for which the necessity for treatment tends to be underestimated since the symptoms are said to decrease with age and almost disappear spontaneously by the time the patients are in their 30s. However, spontaneous regression can take a longer period of time till full disappearance, prompting quite a few patients to visit clinics from the cosmetic perspective of the condition. The Q-switched Nd:YAG laser (QSNY) has been well-reported for the successful treatment of pigmented cutaneous lesions and for skin rejuvenation. The present study therefore trialled the application of the QSNY in a case of lichen pilaris.

Subject and Methods

Subject and condition

A 33-year-old male presented with the typical manifes-
tation of lichen pilaris seen as light-brown aggregated papules observed on both sides of the upper arms. Light-brown aggregated keratotic papules were observed on the extension side of both upper arms up to millet size at his first visit (Figure 1a). Repeated applications of topical agents had failed to deliver any improvement since the onset of the condition.

Detailed observation showed mildly raised papules consistent with the follicles and surrounded with fine scales (Figure 1b). Biopsies were taken of the keratotic papules with follicular consistency on the right upper arm, and the specimens were prepared to clearly show the keratotic lesion sites. With dilation in the follicular site, the horny layer at the upper part of the hair follicles had expanded and thickened on to the cystoma and formed keratin plugs, causing follicular occlusion. The horny layer around the follicles had also thickened (Figure 2). Papules with follicular consistency, which often clinically appear on the extension side of both upper arms, were macro- and

Fig. 1: Clinical findings
a: whole image
b: extended image

Fig. 2: Histopathology of skin biopsy at the initial visit

Fig. 3: Irradiation of hair follicles after staining with black maker pen
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Fig. 4: Clinical findings
a, b: Pretreatment
c, d: 3 months after 12 sessions of treatment

Fig. 5: 30 times microscope image
a, b: Pretreatment
c, d: 3 months after 12 sessions of treatment
CASE REPORT

microscopically observed in our present case, and the appearance was believed to be typical. Taking these findings together with the histological findings associated with thick keratin plugs on the follicular area with cyst-like dilation, the diagnosis of lichen pilaris was confirmed.

Laser system

The laser system we used was a QSNY (MedLite C6, ConBio, US). The system can emit at both 1064 nm in the near-infrared, and with frequency-doubling technology, at 532 nm in the visible green. The 1064 nm wavelength is associated with the treatment of deeper dermal lesions, such as tattoos, and skin rejuvenation whereas the 532 nm is used for superficial lesions. The 1064 nm beam can be delivered in nanosecond Q-switched mode, and in quasi long-pulsed mode in the microsecond domain at 300 µs.

Treatment protocol: Following staining with a black marker pen as an absorption enhancer, the lesions were irradiated with the Q-switched Nd:YAG at 1064 nm, 6 mmØ spot size, pulse energy of 3.0 J/cm², pulse width 300 µsec, and a repetition rate of 10 Hz. Twelve sessions were given every other week (Figure 3). All persons in charge including the operator and helpers wore protective glasses and the eyes of patient were protected with a metal eye shield during laser irradiation. Treatment was performed without any anesthesia.

Evaluation method:

Digital photography, photomicroscopy (Scalar M3: 30-fold magnification) and 3D photography (Skin Analyzer ANTERA 3DTM, Miravex, Ireland) were used for the gross observation, and skin biopsies were taken and routinely prepared for light microscopy with hematoxylin and eosin, Melan A, elastica van Giesen and Azan staining. All assessment methods were performed at baseline and after the final 12th treatment, and the findings compared.

Results

1) Clinical findings

Figure 4 shows the findings of the papules at baseline (4a, b) aggregated on the extension side of both upper arms, but some improvement in the severity of the papules was recognized after the treatment. The magnified images also showed improvement in the severity of every single keratotic papule resulting in shrinkage of the follicles themselves (Figure 4c, d).

2) Microscopic findings

Clearly apparent and severe keratotic papules were observed before treatment (Figure 5a, b), whereas shrinkage of the keratotic papules and improvement of their appearance were recognized after the treatment (Figure 5c, d).

3D images

In contrast to the distinctive light-brown keratotic papules before treatment (Figure 6a), the keratotic papules became less distinct giving an impression after the treatment that the surface of the skin had become overall plump and firm (Figure 6b).

Histological findings

Hematoxylin and eosin staining: With dilation in the follicular site, the horny cell layer at the upper part of the hair follicles had thickened to form a keratin plug, causing follicular occlusion (Figure 7a) as seen at baseline, whereas after treatment the thickened horny cell layer around the follicles became thinner with exfoliation of the keratin plug that caused follicular occlusion. Further, thick eosinophilic fibers grew thickly around the follicles (Figure 7b). With increased thickness of the epidermis in areas other than the follicles, the density of eosinophilic tissues increased from the superficial to deep dermis (Figure 8a, b, c and d) after the treatment.

Melan A staining: The number of melaniferous epidermal keratinocytes in the basal layer was evaluated before and after treatment. The number of visual melanocytes decreased from 30 (Figure 9a) before treatment to 6 (Figure 9b) after the treatment.

Elastica van Giesen staining: Elastic fibers were evaluated before and after the treatment. The elastic fibers had assumed an elongated and rod-like shape (Figure 10a) before treatment, whereas dispersed and finely ruptured and fibers with apparent contraction are recognized (Figure 10b) after the treatment.

Azan staining: Dermal collagen was evaluated before and after treatment. Thick and elongated collagen fibers were observed (Figure 11a) before treatment, whereas congested, short and contractile fibers were observed in the superficial dermis, and increased growth of stained thick fibers was recognized in the deep dermis (Figure 11b) after the treatment.

Discussion

Lichen pilaris presents as keratotic lesions with follicu-
lar consistency often observed on the upper arms of young individuals. It is a fairly common disorder, quite often encountered in daily dermatological practice. Autosomal dominant inheritance is assumed to be one of the causes and the incidence rate in children with atopic dermatitis and obesity is believed to be higher. In addition, even though it is believed to develop in association with hormone metabolic abnormality or sebaceous gland function and lipid metabolism disorder and follicular deformity $^1$), no single conclusive etiology has yet to be proved, although it does show the common characteristic regarding the site of onset in that it appears more commonly on such sites as the extension side of the extremities which are prone to be affected by external stimuli. In addition to a report on the frequency of occurrence that it is recognized in 50% of all races $^2$), there is a report in Japan by Yamamoto et al. $^3$) whereby it was observed in patients in their 10s, 20s, and 30s by 34.1%, 47.85% and 10.1% respectively and 88.4% of those were shared with women. Common sites for onset other than the upper arm include the thigh, shoulders, back, hips and preauricular areas. Each eruption clinically exhibits keratotic papules of a millet-like size associated with follicular consistency and solidarity, and these papules are characterized by their scattered development without gathering in a faceted manner. Subjective symptoms are not usually observed. The color of the papules appears normal or yellowish white in some cases and reddish brown in others. With remarkable keratotic plug formation at infundibular parts of the follicles observed as a histological finding, capillary dilatation and cellular lymphocytic infiltration may be recognized on erythematous parts of the papules some cases.

Even though medical treatments for the disease are commonly performed including topical preparations such as urea ointment, salicylic acid petrolatum, vitamin A ointment, Vitamin A/D ointment, and Vitamin A ingested orally, these approaches, which are hard to be evaluated as successful from our experience, often result in forcing patients to wait until the spontaneous regression of the condition. In recent years, procedures using various types of low fluence lasers have been widely used with devices based on pulsed light sources, or radiofrequency (RF) energy, as a skin rejuvenation approach to refresh the skin and improve follicular dilatation, and the results have been reported $^4$-$^7$). Initially, the effect of low level laser therapy (LLLT) on skin had been reported as an action to enhance the treatment of recalcitrant ulcers and accidental or iatrogenic trauma $^8$) using the effect of biosimulation or photobioactivation $^9$) but it became to be referred to as photo-rejuvenation therapy $^{10, 11}$). Among various therapeutic instruments, the Q-switched Nd:YAG laser (QSNY) has attracted attention as a therapeutic method known as “laser toning” for melasma and often used in various aesthetic dermatology fields. Beneficial effects of the QSNY approach have been reported not only for improvement of the color tone, but also on the size of follicles, sebum secretion, facial skin texture, and normalization of skin color $^{12}$).

Considering the application of the quasi long-pulsed 300 µs mode of the QSNY in the treatment of lichen pilaris, a dyskeratosis of the follicles, the author has been irradiating patients in whom the lichen pilaris had not been improved by other conventional therapies, a typical example of which is reported herein. Shrinkage of the keratotic papules and improvement in their severity has been recognized in image assessment using clinical photography and objective instrumentation.

Five main factors have been recognized through histological investigation as follows: horny cell layer exfoliation at the follicular site; proliferation of epidermal keratinocytes; decrease in the number of melanin pigmented epidermal keratinocytes in the basal layer; contraction of the dermal collagen and elastic fibers; and growth of dermal collagen around the follicles.

Horny cell layer exfoliation at follicular site:
QSNY treatment was performed after staining the follicular surface black with an oil-based marking pen as an absorption enhancer. According to a report by Hayashi et al., 86% of the whole incident laser energy at 1064 nm is selectively and powerfully absorbed by the black pigment, whereas the Nd:YAG laser rarely reacts to other color tones proving its specificity to black $^{13, 14}$). In other words the author believes that the horny cell layer was exfoliated due to the potent photothermal thermal reaction and high impact on the horny cell layer due to the enhanced total absorption of the incident laser energy in the black pigment from the marker pen.

Proliferation of epidermal keratinocytes:
Proliferation of epidermal keratinocyte indicates enhancement of epidermal remodeling. In chemical peeling performed for skin rejuvenation, epidermal keratinocyte proliferates and intercellular lipid increases by applying the peeling agent to the horny cell layer $^{15}$). The underlying mechanism is believed to be due to the fact that since epidermal construction is controlled by the horny cell layer, so that the proliferation signal to basal cells is generated immediately after the horny cell layer.
Fig. 6: 3D image
a: Pretreatment
b: 3 months after 12 sessions of treatment

Fig. 7: HE staining (follicular site)
a: Pretreatment
b: 3 months after 12 sessions of treatment

c, d: 3 months after the start of treatment (after 12-time irradiation)

Fig. 8: HE staining (sites other than follicular)
a, b: pretreatment
c, d: 3 months after the start of treatment (after 12-time irradiation)

Fig. 9: MelanA staining
a: Pretreatment
b: 3 months after 12 sessions of treatment
cell layer is peeled. The papillary layer fibroblasts immediately beneath the peeled stratum corneum and underlying epidermis produce connective tissue components. In the present study, epidermal modeling is believed to have been enhanced by the exfoliation of the stratum corneum caused by the interaction of the laser beam with the absorption enhancer.

*Decrease of melanin-pigmented epidermal keratinocytes in the basal layer:* This is believed to be the result of the fact that pigmentation existing in the epidermal stratum basale in the area affected by the lichen pilaris was photothermally damaged by the Nd:YAG laser through selective photothermolysis. In treatment using intense pulsed light systems which are typically used for less-invasive treatment, epidermal pigmentation in the basal layer has been shown to be photothermally damaged by the same mechanism11,16) and it has also been reported that epidermal mother keratinocytes are induced to enter a higher proliferative state, thereby forcing daughter melanocytes with

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**Fig. 10:** Elasticavan Giesonstaining  
*a:* Pretreatment  
*b:* 3 months after 12 sessions of treatment

**Fig. 11:** Azan staining  
*a:* Pretreatment  
*b:* 3 months after 12 sessions of treatment
remarkable melanin deposition up towards the surface of the epidermis (increased epidermal turnover) and thus reducing both hyperkeratosis and hyperpigmentation. 

**Contraction of the dermal collagen and elastic fibers:** Contraction of and damage to epidermal collagen and elastic fibers occur as a direct result of the photothermal response in the dermis caused by the incident laser energy. When dermal collagen fibers are swiftly heated to around 60 to 70°C, thermal contraction appears, and full collagen coagulation occurs at around 70 to 90°C. As the affected area retains heat immediately after irradiation, it is assumed that adequate heat has been generated to cause contraction and coagulation, which will in turn trigger the body’s wound healing process.

**Growth of dermal collagen around the follicles:** According to previous reports, many non-ablative or sub-ablative laser treatment approaches are understood to be based on the mechanism by which dermal damage may triggers neocollagenesis followed by remodelling of the new collagen fibers. Taking images in the present study into consideration, which demonstrated the build-up of dermal corium collagen and elastic fibers around the follicles the same mechanism seems to have worked. Further, as shown in Figure 12, it could also be surmised that not only the photothermal contraction of dermal collagen occurred, but there was also a photothermally-linked action in the case of the horny cell layer, so that a peeling effect could occur based on increased epidermal keratinocyte turnover and this, combined with the formation of new dermal collagen, led to shrinkage of the follicles and improvement in the severity of the lichen pilaris nodules. Up until now, the action mechanism of treatment approaches using non-ablative or subablative laser systems has been based on the production and remodelling of collagen in the wake of photothermal damage, whereas the findings in about the present study on the microsecond pulsed Q-switched Nd:YAG laser, where an effect was also noted on the reformation of the stratum corneum and keratinocytes might suggest the...
existence of new or adjunctive action mechanism.

To the best of the author's knowledge, based on the few reports found on lichen pilaris treated with lasers, the present study is the first one reporting treatment based on the quasi long-pulsed Q-switched Nd:YAG laser. With its mid-infrared wavelength of 1064 nm, the Nd:YAG laser is capable of penetrating deep into the skin. In addition, it is possible to provide treatments with reduced accessory symptoms such as pain and pigment deposition by treating at low fluences through the use of the marking pen ink as an absorption enhancer. Even though this procedure has several problems including a potentially heavy economic burden for patients due to exclusion of this treatment from health insurance coverage, and the necessity for multiple treatments to achieve the desired effect, this approach could be one of the options for treatment of those cases of lichen pilaris case in which a curative effect has been elusive using existing treatments.

The major limitation of this study is that only one patient was treated and it is therefore impossible to generalize the results of the present study to cover all lichen pilaris patients. The good results obtained, however, warrant further large-populations studies to confirm the results of the present study, to ascertain potential recurrence after treatment with long-term follow-up, and to optimize treatment parameters.

Conclusions

Improvement in the symptoms associated with lichen pilaris was observed following treatment with the 1064 nm Q-switched Nd:YAG laser used in the quasi long-pulsed mode, applied with a photoenhancer. Lesions on the bilateral upper arms of a patient, in whom no improvement had been achieved with existing therapies, was noted. Neither exacerbation nor accessory symptom have been recognized up to till the time of writing. From the results of the histological findings, it is possible that the laser treatment induced a reaction that linked activities of the stratum corneum, epidermal keratinocytes and dermal collagen which may have led to follicle shrinkage and improvement in the severity of the lichen pilaris papules.

Reference

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