Lasers, Light, and Acne

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Acne vulgaris is a highly prevalent disease with significant potential for physical and emotional scarring. Acne lesions have long been noted to improve after exposure to sunlight. This improvement may be secondary to activation of endogenous porphyrins produced by Propionibacterium acnes. *Recently, several investigators have presented studies in which light of particular wavelengths has been used to treat acne vulgaris. In this article, we review the results of these studies as we look to the future of light-based acne treatment.*

Acne vulgaris, a disease of multifactorial etiology, is known to involve excessive sebum production, as well as alterations in microbacterial flora.[1] This disease is the result of a complex series of pathophysiologic changes that include excessive sebum production, abnormalities of the follicular epithelium, proliferation of *Propionibacterium acnes*, and subsequent inflammation.[2] Evidence implicating bacteria is well known and has been evolving for decades.[3] *P acnes* produces proinflammatory cytokines, which in turn produce the inflammatory lesions of acne—papules, pustules, and nodules, some of which have a potential for scarring.

Many treatment modalities exist, but all have limitations. Topical acne preparations often irritate the skin, and more than 40% of acne bacteria are resistant to commonly used oral antibiotics. Isotretinoin, the only therapy that works against all the pathophysiologic etiologies involved, is extremely effective but has numerous adverse effects (particularly, risk for teratogenicity).[4] The adverse effects and high cost of isotretinoin limit widespread use.

Dermatologists in clinical practice have known for many decades that acne clinically improves during the summer months. Data reported in 2000 suggest that some of this improvement may be the result of absorption of light energy in the blue-light spectrum—that this absorbed energy has a photodestructive effect on *P acnes*.[5] Studies have shown that the bacteria produce porphyrins (coproporphyrin III) as a by-product of metabolism. Visible light activates the porphyrins and induces a photodynamic reaction that subsequently kills the pathogenic bacteria.[6] Moderate reductions in these bacteria were noted in early studies involving red light,[7] mixed violet and UV light,[8] and low-intensity fluorescent (blue and red) light.[9] A more recent study shows that a novel narrowband high-intensity blue-light source significantly reduced the number of *P acnes* lesions.[10]

In 1990, Kennedy et al[11] reported on the potential application of photodynamic therapy (PDT) in treating a variety of pathologic conditions. Since then, several studies of using PDT to treat nonmelanoma skin cancers have been conducted.[11-13] Endogenous protoporphyrin IX is produced from exogenous aminolevulinic acid (ALA), which is a compound used for PDT but is not itself a photosensitizer. The primary advantages of using PDT with ALA are that topical application (vs oral intake) greatly decreases the risk for photosensitization and that, when photosensitization does occur, it disappears more rapidly. This low risk for photosensitization led to using PDT in attempts to treat several other skin conditions, including acne vulgaris.[13] Itoh et al[13] had tried using 630-nm laser light and ALA, but this treatment was not efficacious, and their consensus opinion was that the 630-nm light source was unsatisfactory.

Hongcharu et al[14] conducted an open-label prospective study of acne treated with red light (550–700 nm) and topical ALA as a follow-up to the study by Peng et al.[12] Results showed that clearance lasted for 10 weeks after a single treatment and for 20 weeks after multiple treatments. Histology results showed severe damage to sebaceous follicles with prolonged depression of sebaceous gland function. The limiting factor with this treatment was significant associated side effects.[14] However, results of this study confirmed an earlier finding that applying light directly to the sebaceous follicle was an effective therapy.[5]

Meffert et al[8] used a high-energy broad-spectrum blue-light source that encompassed both visible blue light and

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UVA. They reported marked improvement in patients with pustular acne after 10 dose treatments (cumulative dose, 325 J/cm^2). However, several problems developed with the UV light produced by this system, and the system was deemed unsuitable for widespread use.

In 1997, Sigurdsson et al[15]—using a system that filtered most but not all harmful UVA rays and emitted an admixture of UVA, violet, blue, and green light—reported a 50% decrease in the number of inflammatory acne lesions in their 30-person study. In 2000, Papageorgiou et al[16] described treating acne with phototherapy combining red and blue light (peaks at 415 and 660 nm). Daily treatment over 3 months (cumulative dose, 200 J/cm^2) reduced the number of inflammatory lesions by 58%. The need to provide daily treatments leaves this modality unsuited for widespread use.

In 2002, Ross et al[17] reported on treating acne with a 1450-nm diode laser with cryogen spray cooling. Four treatments were given at 3- to 4-week intervals, and lesions were counted at each session. In addition, biopsy specimens were obtained from 4 of the 24 study participants. Mean number of lesions decreased from 5.43 to 0.43 at the treated sites, and biopsy results showed necrosis of the duct epithelium and sebocytes of the sebaceous gland.

In 2003, Ashkenazi et al[18] reported on the efficacy of the Curelight system, a high-intensity narrowband blue-light source. Twenty-five patients with moderate papulopustular acne were given 8 treatments over 4 weeks (cumulative dose, 288 J/cm^2); the number of lesions decreased by 67%. Ashkenazi et al[18] concluded that a narrowband system with a highly specific wavelength targeting the porphyrins produced by *P acnes* maximized treatment efficacy and that the ability to provide doses at high fluences over very short periods protected unintended targets. These results have been confirmed in worldwide multicenter clinical trials.[19,20]

In conclusion, *P acnes* is a bacterium with a major etiologic role in inflammatory acne. *P acnes* produces high levels of endogenous porphyrins (specifically, coproporphyrin III) that can be specifically targeted with light of various wavelengths. Acne therapy involving light represents a promising noninvasive alternative to current therapeutic modalities. We have only begun to apply these therapeutic innovations and are actively working to develop and perfect applications that use and advance these technologies.

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