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Phototherapy in cosmetic dermatology

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Abstract Light therapy has been incorporated into the art of healing and cosmesis for thousands of years and currently has found utility in many areas of medicine. Various modalities of cosmetic phototherapy are detailed, as well as the indications and mechanism of action for each modality. These modalities can be used to treat many common cosmetic conditions, including acne vulgaris, solar lentigo, and melasma. Phototherapy is considered a safe and effective option in the treatment of many of these disorders.

Introduction

Light therapy has been incorporated into the art of healing and cosmesis for thousands of years. Ancient cultures understood the value of sun and took the first steps in understanding the science behind it, as it secured life and energy on the planet. Ancient mythology and monuments are dedicated to sun because humans realized its key role into health and life (eg, the Greek god Apollo and his temples, Stonehenge, and the ancient city of Petra). Hippocrates and Herodotus addressed the therapeutic properties of light on skin, muscle, and joint illness. The Egyptians and Indians stressed the importance of different colors of light in the therapy of skin diseases, whereas the Chinese expanded their knowledge of the therapeutic effect of light on mental disorders.

Modern photomedicine has evolved to have utility in medical diagnosis and therapy, using a broad spectrum of visible and nonvisible electromagnetic radiation. We review the contribution of light therapy (excluding laser devices) in cosmesis, as it is commonly applied to medical and esthetic practices.

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Acne vulgaris

Red light

Cleavage of sebum by *Propionibacterium acnes* is an important step in the pathogenesis of inflammation within the sebaceous gland. *P acnes* creates lipases that cleave sebum into free fatty acids, which stimulate the release of antimicrobial peptides and proinflammatory mediators. *P acnes* also activates toll-like receptors that activate the proinflammatory nf-kB. This process ultimately leads to hyperkeratinization of the gland, forming a comedone.[1] In an *in vitro* study, 630-nm light was shown to have a statistically significant effect in decreasing lipid production in sebocytes. Squalene, a lipid component of sebum, was decreased the most. This effect may be due to regulation of Peroxisome proliferator-activated receptor gamma PPAR-γ by 630-nm light and was dose dependent.[2] Because squalene is exclusively found in sebum, red light may have an inhibiting effect on sebum production.[3]

Blue light

Blue light has been shown to have an antiproliferative effect on cell lines,[4] which can be used in the treatment of acne.

An *in vitro* study found that irradiation of human sebocytes with 415-nm light reduced their proliferation, and this effect was dose dependent.[2] In reducing the number of sebocytes, the amount of sebum available to *P acnes* is reduced, thus decreasing the ability of *P acnes* to induce inflammation.[1]

Blue light is also known to have a direct antimicrobial effect on *P acnes*. *P acnes* naturally produces photosensitizing porphyrins. Bacteria exposed to high doses of 407- to 420-nm light showed decreased culture viability. Exposed cells had an increased coproporphyrin production, indicating that photoinactivation of these cells may be mediated by this endogenous porphyrin production.[5] Blue light is believed to excite these endogenous porphyrins, leading to the production of cytotoxic reactive oxygen species that cause the death of the bacterium.[6]

These studies suggest that the effect of blue light is due to effects at two separate points in the pathogenesis of acne: colonization by *P acnes* and the production of sebum. This has shown therapeutic efficacy. In one prospective study of 21 patients, 4 weeks of biweekly phototherapy sessions, using exclusively blue light, led to a 13% decrease in inflammatory lesion counts and an 11% decrease in acne grade; these changes were statistically significant.[7]

Photopneumatic devices for acne

Photopneumatic delivery of phototherapy facilitates penetration of light. The depth of penetration of light is dependent on two factors: the wavelength of light and the amount of skin pigmentation. Blue wavelengths do not penetrate as deeply as red, and even in fair skin, these wavelengths are quickly absorbed. One study found that 90% of light at 405 nm is absorbed within 0.3 mm of the skin surface in skin rated as "very fair," and darker skin types had a higher ratio of absorption. These data were generated by a computer model, however, and were not performed *in vivo*. Instead, absorption of light by skin was simulated through a modeled volume fraction of melanosomes.[8] This study was sufficient to estimate light absorption by skin, but it may be important to consider that there may be more variation in penetration *in vivo*. The limited penetration of blue light is important to remember when prescribing treatment because sebaceous glands may be located at a depth of up to 1 mm.[2]

The photopneumatic device resolves this issue by mechanically lifting the sebaceous gland toward the surface, opening the pore, and removing contents through the use of a vacuum. Phototherapy is then applied. One prospective study of 41 patients applied photopneumatic therapy for four sessions at 1- to 2-week intervals. This study found a statistically significant decrease in number of lesions after the four sessions were complete, and this improvement remained through 3 months of follow-up.[9]

Home devices for acne

A common difficulty with phototherapy regimens is maintaining patient compliance for the length of time needed to see results. Home units can theoretically increase compliance by decreasing the time commitment required of the patient. One randomized controlled study of 15 patients with grade 2 to 4 acne investigated the use of a home phototherapy unit (OCimple Light Therapy System MP 200; Ceragem Medisys, Korea). Patients in the experimental group received treatment with both red and blue light, whereas those in the control group received a sham device that delivered nontherapeutic light. The experimental group showed a decrease in inflammatory lesions by 26.3% and noninflammatory lesions by 22.3%; both reductions were statistically significant. Additionally, patients in the experimental group had a statistically significant decline in acne grade and visual assessment scale compared with the control.[10]

Another study investigated the Silk'n Blue home device (Home Skinovations, Canada), which delivers light at the 405- to 460-nm range. This study enrolled 15 patients and found a statistically significant 42% decrease in inflammatory lesion counts after 1 month of treatment. This decrease was sustained for 3 months.[11] The success of these trials indicates that home phototherapy units are viable options for patients who are unable to attend regular office visits.

Intense pulsed light therapy for acne

Intense pulsed light (IPL) therapy appears to be an effective mechanism for delivering phototherapy for treatment of acne. A study of 50 patients compared a mainstay of treatment, benzoyl peroxide, to IPL at a 530-nm filter with a pulse duration of 35 ms and a fluence of 35 J/cm^2. Both the benzoyl peroxide and the IPL groups showed a statistically significant decrease in inflammatory lesions at the end of five sessions, at 69.40% and 61.56%, respectively. The difference between these two was not significant. Additionally, patients treated with IPL experienced less irritation of the skin during the study duration, indicating that it may be a favorable option for patients who experience discomfort from topical pharmacotherapy.[12]

Acne vulgaris and pregnancy

Several commonly used treatments for acne have teratogenic effects and are contraindicated in pregnant patients, including fluoroquinolones, tetracyclines, spironolactone, and isotretinoin. This can limit the options available to control acne. Phototherapy has been shown to be safe for use in pregnancy and should be considered in pregnant patients with severe lesions.[13]

Onychomycosis

Onychomycosis with discoloration and thickening is extremely common. The incidence increases with age; the prevalence among those aged 70 years and above is near 50%. Onychomycosis is caused by infection by any of various fungal species, with 80% to 90% of cases being caused by