Device treatment of acne: what’s true and what’s new

Emil A. Tanghetti, M.D.

Center for Dermatology and Laser Surgery, Sacramento, CA

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Consultant and investigator for Ortho Dermatologics, Galderma and Allergan

Fernanda Sakamoto, M.D., R. Rox Anderson M.D. Marco Tagliaferri Ph.D., Henrik Hofvander Ph.D., Mike Estes, Ph.D. Rafael Sierra Ph.D.
Acne Vulgaris

- Devices to control acne
  - Visible lasers and light devices which mediate their activity by targeting porphyrins produced by bacteria on the skin and vascular targets
  - PDT with short incubation period – red and blue light or with IPL, PDL and green light lasers
  - 1320nm and 1450nm laser light which heats water and not a lesser extent sebum
  - Gold nanoshells + Infrared light

- Devices to ultimately cure acne
  - High dose, long incubation period - red light PDT
  - Gold nanoshells + Infrared light
  - 1200nm and 1700nm laser light that can target sebum
Visible Light Devices

- Targets porphyrins produced by P. Acnes
- Blue, red and IPL. However, blue light has unique anti-inflammatory properties and appears to normalize differentiation of keratinocytes
- Modest improvements
- No long term studies
The optical penetration depth is the distance through tissue over which diffuse light decreases 37% of its initial value. (Adapted from Dahan et al)
PDT - Sensitizers

- 5-aminolevulinic acid (ALA)
  - Levulan® Kerastick®
  - Dusa Pharmaceuticals

- Methylaminolevulinat (MAL)
  - Metvix®
  - PhotoCure, Galderma

- FDA approved for Aks
- Acne treatments are off-label
Suggested mechanisms

- Antibacterial activity against *P. acnes*
- Selective damage to sebaceous gland?
- **Reduction in follicular obstruction by keratinocyte shedding**
- Secondary host responses

Destruction of Sebaceous Glands

- Our hope is that the destruction or damage of these glands will cure acne.
- High dose red light PDT; This appears to be effective, but results in significant epidermal damage and an unacceptably long recovery.
- Gold and silver nanoshells with infrared light; usually these particles do not get into the sebaceous glands and appear to result in temporary improvement by wounding the infra-infundibular region of the sebaceous gland complex.
- It has been shown that 1726nm laser light can target sebum and might be able to selectively damage sebaceous glands.
Acne Vulgaris and ALA PDT

Topical ALA PDT protocol for mild-moderate acne of the back

- Study patients received:
  - 20% aminolevulinic acid application under occlusion for 3 hours
  - Activation by broadband (550-700nm) light to a total fluence of 150 J/cm²

Fluorescence microscopy showing PpIX production greater in sebaceous gland (s) than in hair follicle (f)

Levulan PDT of the back - partially and completely destroyed sebaceous glands

If the nanoshells can get into the sebaceous glands they can be selectively heated and result in destruction of these glands.

Unfortunately, they usually do not penetrate to that region and are largely deposited in the infra-infundibular region of the hair follicle.

They appear to result in a temporary improvement, but not in a permanent clearance of acne.
Fig. 1. Measured absorption coefficients ($\mu_a$) in cm$^{-1}$ of artificial sebum (AS) and water. For AS the 28% (w/w) solution and 1 mm pathlength cuvette used, $\mu_a = 23$ OD/0.25, where OD is the measured optical density.
What should the device look like?

- 1726nm
- Robust and precise cooling
- Active, real time monitoring since the therapeutic window is very narrow. The device must be constructed to turn off if a safe temperature is exceeded.
- Creative pulsing strategy to enhance the differential sebum to water absorption
- Reasonable downtime
Cold Air Cooling

- While this type of cooling is not as efficient in removing heat as contact cooling or cryogen cooling, it does permit thermal imaging during a treatment.
- By using a new unit with improved air flow and cooling we can maintain a stable temperature in the unit for 2-3 hours.
- We also have a thermal sensor at the end of the hose to ensure that the delivered air is within spec and maintained at a constant temperature throughout the treatment.
Real Time monitoring Requires a Thermal Camera and Cooling That can be Accomplished Without a Visual Barrier
Challenge 3: Uniform Cooling

- Uniform cooling profile
- More challenging with air-cooling than contact-cooling
- Extensive Computational Fluid Dynamics (CFD) modeling
- Careful design of handpiece-to-skin interface
Air Cooling + Thermal monitoring

- Engineering and sensors allow for stable, uniform, cooling
- Air-cooling enables temperature monitoring
- Monitoring provides ability to stop the device if temperatures are reaching potentially dangerous values
Treatment System
Temperature Safety Limit

- Based upon the DDP process a target temperature is set and the treatment is initiated.
- Pulse train protocol + temperature monitoring enables laser shutdown if potentially dangerous temperatures are reached (Pat. Pend.)
- This active temperature monitoring during a pulse train can have applicability to many energy-based treatments (Pat. Pend.)
What does a normal sebaceous gland look like?
Selective sebaceous gland destruction with no obvious damage to the surrounding dermis or other follicular structures

Back 24 hours after treatment
Neck 72 hours after treatment
Neck 72 hours after treatment
WHAT 1726NM LASER TREATMENT W/COOLING SHOULD LOOK LIKE

- Epidermal sparing
- Selective damage to sebaceous gland without damage to adjacent collagen or the hair follicle

Back 72 hours after treatment
Where are we at with this 1726nm laser?

- With this “novel” device we can selectively target sebaceous glands without damaging the surrounding dermis
- We have a unique cooling system, which is robust and controllable
- We have developed a model which permits us to predict safe and effective treatment parameters
- We implemented real-time monitoring with precise delivery of the laser emissions which I believe will be used for other thermal-based device procedures
- We’re in the process of studying acne and fine-tuning the device