Development of a Multifunctional Laser Hair Removal Patch

Rahib Islam, LSU Health Sciences Center, New Orleans, Louisiana, USA.
Yakir Levin, MD, PhD, Department of Dermatology and Wellman-Center for Photomedicine, Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts, USA.

Background
The objective of this study was to develop a patch that can be placed on the skin during laser hair removal and similar procedures, that serves to reduce the laser-induced plume, provides a ready indicator to the laser surgeon of where pulses have been applied, and cools the skin.

Methods
A two-layer patch composed of a cooling hydrogel layer and an indicator layer was optimized and tested ex vivo. The hydrogel was composed of gelatin and glycerin. The concentration of each hydrogel component was optimized to determine the minimum gelatin concentration at which the gel can be handled without breakage and the minimum glycerin concentration that allows for storage at −20°C without crystallization. This is the temperature of a conventional freezer; application of the cooling layer to the skin would help prevent epidermal injury. The indicator layer was composed of a plastic transparency sheet with small dots of black ink particles printed onto its surface. Transparency sheets were printed from templates created in Adobe Photoshop in which dots are at a specified density; additionally, Photoshop's opacity function was used to vary the opacity of the dots themselves. Performance was tested using a 755 nm alexandrite laser used clinically for hair removal by measuring light transmission through the patch and observing the sheet's ability to indicate the location of laser exposures. The transmittance of patch components across a broad spectrum was also measured using a microplate reader. Several adhesives, including a two-part epoxy, silicone rubber, and cyanoacrylate, were tested for their ability to adhere to the hydrogel and indicator layers. Assembled patches composed of the hydrogel layer, indicator layer, and adhesive were tested ex vivo for their ability to mitigate the laser hair removal plume by measuring airborne particulate matter during simulated laser hair removal.

Results
A minimum gelatin concentration of 5% was found to enable easy handling of the hydrogel. A mixture composed of 60% water and 40% glycerin by volume consistently allowed storage at −20°C without crystallization. For the indicator layer, ink particle density of 50% and opacity of 5% provided a readily apparent indicator function following laser exposure. Transmission through the sheet measured during alexandrite laser exposures was 90% and was not different than transmission through the sheet alone without ink particles. A cyanoacrylate glue was found to adhere to the hydrogel and indicator layers, while the other adhesives proved inadequate. Measurements using a microplate reader confirmed that the reflection from the transparency sheet itself was the primary contributor to energy loss. In experiments exposing hair clippings to the laser with and without the patch, the patch allowed an increase of 5000 particles/cc relative to baseline particles in the environmental air, while the absence of the

patch allowed an increase of 150,000 particles/cc relative to baseline, indicating that the patch decreased particle debris in the plume by 97%.

Conclusions

A two-layer patch composed of hydrogel and plastic indicator layer with cyanoacrylate adhesive can be stored in a conventional freezer without crystallization, then placed over an area of skin to be treated for laser hair removal. The patch clearly indicates the pattern and sites of laser exposure, while blocking almost all (97%) of particles in the laser-induced plume. Future work will include safety validation and in vivo testing of efficacy, as these were not undertaken in this study.