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Optimization of Laser Treatment Safety in Conjunction With Cryogen Spray Cooling

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Selective epidermal cooling during laser dermatologic surgery provides great benefit, allowing the use of higher fluences, permitting treatment of darker skin types, and decreasing procedure discomfort. Three main approaches to epidermal cooling have included contact cooling, cryogen spray cooling (CSC), and air cooling, all of which improve the margin of safety associated with laser procedures by increasing the threshold for epidermal damage.

To be effective, the cooling medium should be placed in direct contact with the skin surface or the intervening layer between the cooling medium and skin will impair heat extraction. We have reviewed several cases of pitted scarring after laser treatment in conjunction with contact cooling, which presumably occurred because direct contact was not maintained between the cooling handpiece and skin surface.

Cryogen spray cooling and air cooling similarly require that the cooling medium be in direct skin contact with complete coverage of the laser-irradiated area to ensure adequate epidermal protection. Recently, concern has been raised at symposia[1] and in the literature with respect to a few patients with Fitzpatrick skin type IV or V who sustained prolonged or permanent skin dyspigmentation after laser-assisted hair removal in conjunction with CSC (Figure 1). It was initially hypothesized that the cryogen spray might have caused cryoinjury resulting in the observed dyspigmentation. However, we have recently demonstrated, using an in vitro model of human skin, that cryogen spurts of 80 milliseconds or less do not result in significant epidermal injury.[2] In addition, extensive clinical use of CSC with exposure of human skin to cryogen spurt durations of 100 milliseconds or more has not resulted in significant cryoinjury.[3-5] It would appear that laser-induced thermal injury was the most likely cause of the observed dyspigmentation.

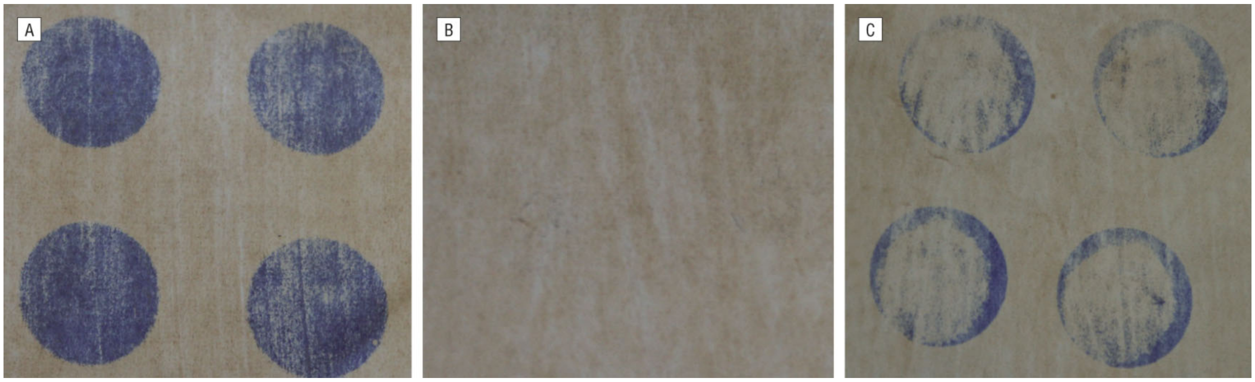
Figure 1.

Patients with skin dyspigmentation 6 months after laser-assisted hair removal in conjunction with cryogen spray cooling.

We performed a series of experiments to investigate laser spot size in relation to cryogen coverage, in an effort to provide guidelines to maximize the protective effect of CSC. We evaluated a range of devices that utilize CSC and are produced by several different commercial laser manufacturers. One cryogen spurt was directed onto thermal-sensitive test paper, which allowed measurement of cryogen coverage for various spurt durations. The handpiece was held perpendicular to the target surface for these measurements. Coverage provided by the coolant spray was strongly dependent upon spurt duration, ranging from 12 to 22 mm diameter for 20 and 80 milliseconds, respectively.

Subsequently, we evaluated coincident cryogen coverage and laser spot size. Thermal-sensitive test paper was again used. No CSC in conjunction with laser irradiation resulted in obvious burns on the test paper (Figure 2A). With the handpiece held perpendicular to the target (proper technique), spurt durations of 20 to 80 milliseconds provided adequate coverage for laser spot sizes of 12 mm or less (Figure 2B). Laser spot sizes of 15 and 18 mm required spurt durations of 40 and 50 milliseconds, respectively, for complete cryogen coverage.

Figure 2.



Burn patterns on thermal-sensitive paper. A, Burns caused by laser irradiation (18-mm spot) without cryogen spray cooling. B, Complete cryogen coverage (50-millisecond spurt) of the laser spot (18 mm) when the handpiece was maintained in a strictly perpendicular position relative to the target, resulting in no burn. C, Incomplete cryogen coverage (50-millisecond spurt) of the laser spot (18 mm) created by 6° angling of the handpiece relative to the target, resulting in crescent-shaped burns.

When the handpiece was angled slightly (6° or 12° from the perpendicular normal), crescent-shaped burn patterns were noted on the test paper with cryogen spurts that had previously been shown to cover completely a given laser spot size (Figure 2C). We believe such angling of the handpiece may occur during laser treatment, especially involving procedures on curved surfaces such as the upper and lower extremities.

During one set of measurements, we noted crescent-shaped burns when the handpiece was held perpendicular to the skin. Further investigation revealed that the cryogen nozzle was off alignment in the handpiece (the center of the cryogen coverage was 2-3 mm off the optical center). This misalignment was not obvious during clinical use and was discovered retrospectively when the CSC handpiece was inspected and tested ex vivo and the resultant crescent-shaped burn noted. Such misalignment could occur with mishandling during shipment or movement between treatment areas.

In summary, we found 3 potential factors that alone, or in combination, could produce skin injury secondary to incomplete coverage of the laser spot by the protective cryogen spray: (1) selection of too short a cryogen spurt duration during use of larger laser spot sizes; (2) angling of the handpiece during laser treatment; and (3) cryogen nozzle misalignment within the handpiece. We believe complete cryogen coverage of the laser spot can be predictably achieved by choosing adequate spurt durations and attention to proper technique, including maintaining the handpiece in a strictly perpendicular position relative to the skin throughout treatment, as indicated in the manufacturer's published guidelines. Adequate cryogen coverage can be confirmed before treatment by testing on ordinary cardboard (for visible wavelength lasers) and watching for a burn pattern. This simple procedure alone can help identify nozzle misalignment.

Lasers offer an effective and safe method for treatment of a wide range of dermatologic conditions. Epidermal cooling increases the margin of safety and permits clinicians to use higher light energies necessary for enhanced therapeutic outcome. If situations exist where cryogen spray coverage and laser-irradiated area are not coincident, thermal injury to the skin may result. Such considerations are particularly important in the clinical management of patients with darker skin types. Recognition of this potential problem and proper attention to technique optimizes the safety and efficacy of laser treatment.

The authors have no relevant financial interest in this article.

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