Airborne Particulate Concentration During Laser Hair Removal: A Comparison Between Cold Sapphire With Aqueous Gel and Cryogen Skin Cooling

Edward V. Ross, MD,[1*] Gary S. Chuang, MD,[2] Arisa E. Ortiz, MD,[3] and Scott A. Davenport, BA[4]
[1]*Department of Laser and Cosmetic Dermatology, Scripps Clinic, San Diego, California*
[2]*Division of Dermatology, University of California Los Angeles School of Medicine, California*
[3]*Department of Dermatology, University of California San Diego, California*
[4]*Cutera Inc., Brisbane, California*

Background: High concentrations of sub-micron nanoparticles have been shown to be released during laser hair removal (LHR) procedures. These emissions pose a potential biohazard to healthcare workers that have prolonged exposure to LHR plume.
Objective: We sought to demonstrate that cold sapphire skin cooling done in contact mode might suppress plume dispersion during LHR.
Methods: A total of 11 patients were recruited for laser hair removal. They were treated on the legs and axilla with a 755 or 1064 nm millisecond-domain laser equipped with either (i) cryogen spray (CSC); (ii) refrigerated air (RA); or (iii) contact cooling with sapphire (CC). Concentration of ultrafine nanoparticles <1 μm were measured just before and during LHR with the three respective cooling methods.
Results: For contact cooling (CC), counts remained at baseline levels, below 3,500 parts per cubic centimeter (ppc) for all treatments. In contrast, the CSC system produced large levels of plume, peaking at times to over 400,000 ppc. The CA cooled system produced intermediate levels of plume, about 35,000 ppc (or about 10× baseline).
Conclusions: Cold Sapphire Skin cooling with gel suppresses plume during laser hair removal, potentially eliminating the need for smoke evacuators, custom ventilation systems, and respirators during LHR. Lasers Surg. Med. © 2017 Wiley Periodicals, Inc.

Key words: hair; laser; plume; cooling

INTRODUCTION

High concentrations of sub-micron nanoparticles have been shown to be released during laser hair removal (LHR) [1]. Prolonged low-level exposure to these sub-micron particles has been associated with reactive airway diseases. At high level exposure, there is increased mortality, lung cancer, and cardiopulmonary risks; accordingly, there is a potential biohazard to health care workers that have prolonged exposure to LHR plume. Chuang et al. [1] performed ultrafine nanoparticle (<1 μm) counts during LHR (GentleLase, Candela, Wayland, MA). These measurements showed an increase of particulates of eightfold as compared to baseline when a smoke evacuator was used continuously and nearly 30-fold when used intermittently.

In addition to the nanoparticles, Chuang et al. [1] had shown, by gas chromatography-mass spectrometry (GC-MS), that the hair plume contains 13 known or suspected carcinogens and at least 20 chemical irritants that are potentially hazardous for laser practitioners, warranting the need for smoke evacuators, good ventilation, and respiratory protection.

In laser hair reduction, the goal is to increase the bulb and bulge temperatures while preserving the epidermis [2]. Cooling enhances the ratio of the hair follicle temperature to the epidermal temperature. Surface cooling also decreases pain [3]. To prevent epidermal injury, the most common types of surface cooling are cryogen-spray cooling (CSC), refrigerated air (RA), and contact cooling (CC). To cool the epidermis, cryogen spray cooling involves spraying a cold cryogen liquid (normally for a time ranging from 40 to 120 ms before laser irradiation) [4]. There is usually a delay between the end of the spray and initiation of the laser pulse. The cold liquid cryogen evaporates on the skin, drawing heat from the skin, and thus cooling it. Refrigerated air is supplied by a nozzle attached to an air compressor. CC cools the skin with temperature-controlled sapphire glass and a topical gel, prior to the delivery of the laser. Contact cooling (CC) has been shown to be an efficient skin cooling method for laser dermatology procedures including LHR. [2,5,6] Contact cooling has also been shown to be clinically effective for epidermal protection and

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*Correspondence to: Edward V. Ross, MD, Department of Laser and Cosmetic Dermatology, Scripps Clinic, 3811 Valley Centre Dr, Suite 4B, San Diego, CA 92130. E-mail: ross.edward@scrippshealth.org
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analgesia [7]. Chuang et al. suggested that the cryogen spray from CSC may contribute to the wide dispersion of nanoparticles produced during LHR. Due to its contact with skin and use of topical gel, CC may have an additional benefit of plume suppression during LHR.

MATERIALS AND METHODS

A total of 11 patients were recruited for laser hair removal. Seven patients were treated for LHR at Scripps Clinic and four patients at the Cutera Clinic. All of the patients from Scripps were for LHR in the axilla. At this study site, four patients were treated by a laser with cryogen-spray system (CSC) and three treated by a laser with Sapphire contact-cooling system (CC). The patients treated at the Cutera clinic were for LHR on the backs and legs. At the Cutera site, three of the patients received bilateral LHR treatments with CSC system on one side and the CC system on the other. The fourth patient treated at the Cutera Clinic was treated using refrigerated air (RA) only. This patient was added to expand the data to include RA cooling.

Skin types ranged from II to V. Both 755 and 1064 nm wavelengths were used at both study sites. Table 1 lists all of the parameters for each patient. Two physicians performed the treatments at the Scripps Clinic. Two laser practitioners performed the treatments at the Cutera Clinic. All physicians and practitioners used both CSC and CC systems. Consent was received from all patients prior to the procedure. The 755 nm laser was applied to patients with skin types II–III and the 1064 nm laser was applied to skin types IV–V. The rationale was that the 1,064 laser enjoys a greater tolerance for epidermal pigmentation but also tends to be more painful than 755 nm when adjusted for the same hair density, anatomic area, and hair color. Therefore, we applied the 755 laser when there was greater contrast between the hair and skin colors. The ages of the patients ranged from 24 to 58, the mean age being 38. The patient demographics are summarized in Table 1.

Concentration of ultrafine nanoparticles $<1\,\mu m$ were measured using a TSI 8525 (TSI, Shoreview, NM) portable condensation particle counter during LHR. Condensation particle counters detect and count aerosol particles by enlarging them *via* condensation around the particles which increases their size so they can be detected; this allows detection down to $0.02\,\mu$ [8]. The portable instrument used in this study is very accurate for particles above 80 nm, but has been shown to underestimate counts of particles smaller than 30 nm [9]. This device limitation is acceptable for this comparative study. The units used for readings are parts per cubic centimeter (ppc).

Two laser systems were used for LHR treatment. The GentleMax (Candela, Wayland, MA) with cryogen skin cooling (CSC) or refrigerated air (RA) was employed to represent these two cooling methods. In the case of RA, a Zimmer air chiller (model Cryo 5) was applied at level 6 (1,000 l/minute at $-30^\circ C$ at the source hose and about $-10^\circ C$ at the skin, Zimmer MedizinSysteme, Ulm, Germany). The Excel HR (Cutera, Brisbane, CA) with sapphire contact cooling (CC) was employed to represent contact cooling. The patient demographics are summarized in Table 1.

The particle counts of the treatment room were measured before and during LHR at the level of the laser practitioner's face. The typical distance between the operator's face and skin surface was 18 inches. The particle counter sampling wand followed the laser operator during treatments.

All treatment sites were shaved prior to treatment. For the CC treatment, clear aqueous gel was used with a thin layer applied *via* a tongue depressor. The Sapphire window temperature was constant at $4^\circ C$. The CSC was set for 40 ms of spray application and then a 20 ms delay before onset of the laser pulse. To measure true nanoparticle emission, smoke evacuators were not used during any of the treatments.

RESULTS

Post treatment perifollicular edema was observed with all systems. For LHR with CC system, there was no additional detectable plume. Counts remained at baseline levels, below 3550 ppc for all treatments.

In contrast, LHR with CSC system produced an increased level of detectable nanoparticle plume, peaking

TABLE 1. Summary of Demographics and Laser Parameters for Individual Patients

Patient	Skin type	Age	Sex	Tx area	Wavelength nm	Fluence J/cm^2	Pulse width ms	Spot size mm	Rep rate Hz	Cooling	Site
1	II	46	F	Ax	755	12	3	18	1	CC	S
2	IV	30	F	Ax	1064	30	10	15	1	CC	S
3	IV	24	F	Ax	1064	30	10	15	1	CC	S
4	IV	37	F	Ax	1064	30	10	15	1	CSC	S
5	V	35	F	Ax	1064	20	10	15	1	CSC	S
6	IV	34	F	Ax	1064	30	10	15	1	CSC	S
7	II	26	F	Ax	755	12	3	18	1	CSC	S
8	II	26	F	Leg	755	12	3	18	1	CC/CSC	C
9	IV	55	M	Back	1064	25	10	18	1	CC/CSC	C
10	V	52	M	Back	1064	20	10	18	1	CC/CSC	C
11	III	58	M	Back	755	8	3	18	1	RA	C

CC, contact cooling; RA, Refrigerated air; CSC, cryogen spray cooling; Ax, axilla; S, Scripps Clinic; C, Cutera Clinic.

at times to over 400,000 ppc. The RA system produced intermediate levels of plume, about 35,000 ppc (or about 10× baseline) (Fig. 1a and b).

DISCUSSION

LHR performed with CC produces significantly less nanoparticle plume when compared to treatments performed with CSC and RA. The use of ultrasound gel, absence of dynamic air movement, and the close contact of the laser handpiece to skin all contribute to trapping and reducing free-floating nanoparticles.

Each particle-count data point on the graphs (Fig. 1a and b) represents a one minute average reading. Patients 1–3 and 4–7 were treated sequentially in two rooms

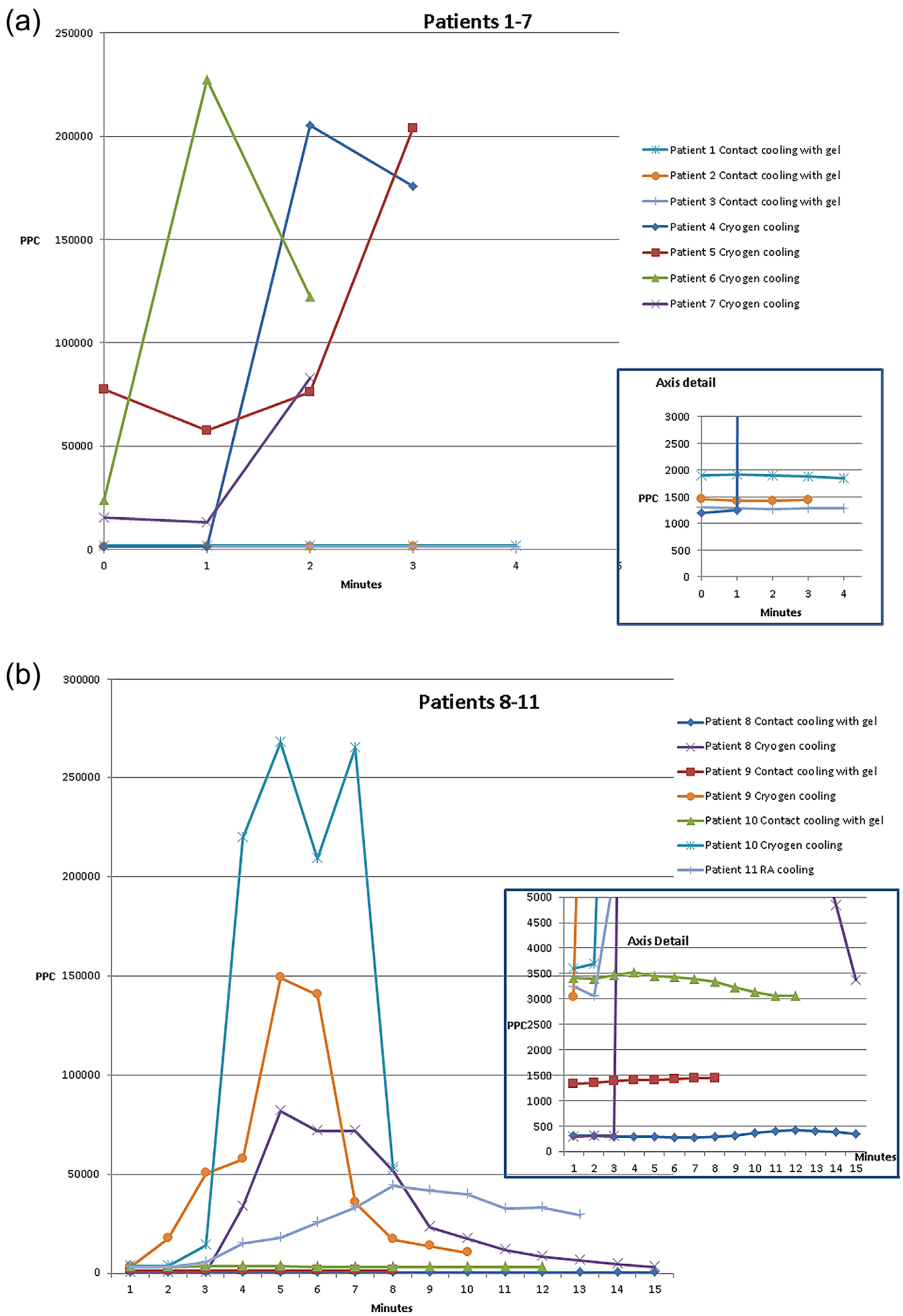

Fig. 1. (a and b) Parts per cubic centimeter (ppc) versus time. Each particle-count data point on the graphs represents a 1 minute average reading.

respectively. The elevated baseline levels of patients 5–7 represent the heavy particle concentrations and inability of the air circulating system to clear the air before the next patients. While these baseline elevations may have skewed the data, these baseline elevations do not affect the accuracy of the measurements and reflect the “real world” aspect of a LHR practice. Multiple practitioners were involved in this study to account for variations of technique in clinical practice. These variations may include amount of ultrasound gel applied for the treatments, variations in pressure applied on the sapphire window against the skin, etc.

While no increase in baseline ppc levels was detected during LHR with CC, a slight malodorous smell can be detected. In contrast, a stronger malodorous smell was present for LHR with CSC and RA. Chuang et al. [1] has shown that several potentially hazardous chemicals are produced in LHR. It is possible that the same mechanism in CC that reduces nanoparticle emission can also reduce the dispersion of these hazardous chemicals. However, chemical emission is not within the scope of this study and further research is needed to quantify chemical emission.

One limitation of this study is the absence of a smoke evacuator during LHR. Many LHR practitioners employ a smoke evacuator to reduce plume exposure. In this study, the smoke evacuator was removed to measure the true nanoparticle production in the plume.

CONCLUSION

Laser plume is a known potential health hazard to laser practitioners. Increasing awareness of laser plume may lead to an increase in the safe practice of laser hair removal and decrease harm to the user. Cold Sapphire Skin cooling with gel suppresses plume during laser hair removal, potentially eliminating the need for smoke evacuators, custom ventilation systems, and respirators during LHR. Thus, cold sapphire contact skin cooling may create a safer work environment for laser operators provided proper contact is maintained and gel is used. While this study shows that contact cooling is more protective from plume compared to other hair removal devices, it is prudent for laser operators to always wear a laser mask for maximum safety and protection.

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