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Plume Effect of Fractional Radiofrequency Verus Laser Resurfacing: Considerations in the COVID-19 Pandemic

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Introduction: The COVID-19 pandemic requires us all to re-evaluate aesthetic practices to ensure optimal patient safety during elective procedures. Specifically, energy-based devices and lasers require special consideration, as they may emit plume which has been shown to contain tissue debris and aerosolized biological materials. Prior studies have shown transmission of viruses and bacteria via plume (i.e., HIV and papillomavirus). The purpose of this study was to evaluate plume characteristics of the Er:YAG resurfacing laser (Sciton; Palo Alto, CA) and compare it to the Morpheus8 fractional radiofrequency device (InMode; Lake Forest, CA).

Methods: Five patients who underwent aesthetic resurfacing and/or skin tightening of the face and neck were treated with the Er:YAG (Sciton Joule, Palo Alto, CA) and/or fractional radiofrequency (Morpheus8, Lake Forest, CA) between April 1 and May 11, 2020. Data collected included patient demographics, past medical history, treatment parameters, adverse events, particle counter data, as well as high magnification video equiptment. Patients were evaluated during treatment with a calibrated particle meter (PCE; Jupiter, FL). The particle meter was used at a consistent focal distance (612 inches) to sample the surrounding environment during treatment at 2.83 L/min to a counting efficiency of 50% at 0.3 μm and 100% at >0.45 μm. Recordings were obtained with and without a smoke evacuator.

Results: Of our cohort ($n = 5$), average age was 58 years old (STD ±7.2). Average Fitzpatrick type was between 2 and 3. Two patients received Er:YAG fractional resurfacing in addition to fractional radiofrequency during the same treatment session. Two patients had fractional radiofrequency only, and one patient had laser treatment with the Er:YAG only. There were no adverse events recorded. The particle counter demonstrated ambient baseline particles/second (pps) at 8 (STD ±6). During fractional radiofrequency treatment at 1-mm depth, the mean recording was 8 pps (STD ±8). At the more superficial depth of 0.5 mm, recordings showed 10 pps (STD ±6). The Er:YAG laser resurfacing laser had mean readings of 44 pps (STD ±11). When the particle sizes were broken down by size, the fractional radiofrequency device had overall smaller particle sizes with a count of 251 for 0.3 μm (STD ±147) compared with Er:YAG laser with a count of 112 for 0.3 μm (STD ±84). The fractional radiofrequency did not appear to emit particles >5 μm throughout the treatment, however, the Er:YAG laser consistently recorded majority of particles in the range of 510 μm. The addition of the smoke evacuator demonstrated a 50% reduction in both particles per second recorded as well as all particle sizes.

Conclusion: Re-evaluation of the plume effect from aesthetic devices has become important during the COVID-19 pandemic. Further studies are required to characterize viability of COVID-19 viability and transmissibility in plume specimens. Based on this pilot study, we recommend that devices that generate little to no plume such as fractional radiofrequency devices be used in Phase I reopening of practice while devices that generate a visible plume such as Er:YAG laser resurfacing devices be avoided and only used with appropriate personal protective equipment in addition to a smoke evacuator in Phase IV reopening.

Key words: COVID19; laser plume; radiofrequency; predictive

INTRODUCTION

The COVID-19 pandemic requires us to re-evaluate aesthetic practices to ensure optimal patient safety during elective procedures [1]. Specifically, the energy-based devices and lasers require special consideration, as they may emit plume, which has been shown to contain tissue debris and aerosolized biological materials [1–9].

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

[Correction added on 19 November 2020, after first online publication: Dr. A. Jay Burns name is removed from author byline]

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The U.S. Occupational Safety and Health Administration (OSHA) currently has no regulatory requirements for protection against plume emission from these devices. However, several professional societies, including the American Society for Lasers in Medicine and Surgery (ASLMS) have recommended guidelines to protect patients and practitioners.

For over 40 years, the plume from electrosurgical units, commonly known as Bovie (Bovie Medical Corp., Melville, NY) has been shown to be similar to other pathogenic smoke, behaving as a carcinogen, mutagen, as well as a vector for active aerosolized biologic material [10–14]. Despite this, there has been a long-standing complacency among providers regarding this smoke and its potential toxicity. Most aesthetic energy-based devices function by generating heat (e.g., ultrasound, radiofrequency, and ablative lasers) [15–20]. Depending on the duration of exposure and temperatures generated, tissue proteins may coagulate and eventually vaporize by superheating intracellular water content. The result is the disintegration of cell integrity and aerosolization of cellular debris [18,19,21,22]. Studies have shown that smoke generated from ablative laser resurfacing of 1 g of tissue to be equivalent to smoking three unfiltered cigarettes [23]. The plume of laser devices has been shown to contain both inert and biologically active particulate matter, such as viruses [2,6–8]. For example, papillomavirus has been identified in vapor from bovine warts treated with laser-derived material as well as electrosurgical cautery [7]. Of the two, more viral load was present in the laser-derived material. Smaller particulate matter is considered to be most harmful and typically bypasses surgical masks, reaching the alveolar level of the respiratory system. These particles are usually less than 5 μm in size [1,5,8,23].

The purpose of this pilot study was to evaluate and compare plume particle emission and size between two popular types of aesthetic devices: Erbium:YAG laser ablative resurfacing (Sciton, Palo Alto, CA) and fractional radiofrequency needling (InMode, Lake Forest, CA). With the knowledge of the plume characteristics of these devices, we are able to assess the potential risks of these devices and better understand how to protect ourselves and the patients.

METHODS

Five patients underwent aesthetic resurfacing and/or skin tightening of the face and neck and were treated with the fractional Er:YAG (Sciton Joule) and/or fractional radiofrequency (Morpheus8; InMode) between April 1 and May 11, 2020. All patients signed informed consent for the treatments and for participation in the study. Data collected included patient demographics, past medical history, treatment parameters, adverse events, particle counter data, as well as high magnification video during treatment. All aesthetic device settings were standardized among the cohort based on the most typical treatment parameters. The fractional Er:YAG laser was set at 100 μm depth in coagulation mode with a density of 20% and scan area of 10 mm^2. The fractional radiofrequency treatment was performed at a depth of 0.5 mm, followed by 1 mm at level 30 energy and double-stacked pulses at 50% overlap. Patients were evaluated during treatment with a commercial-grade calibrated particle meter (PCE-PQC 10US, PCE Instruments, Jupiter, FL). The particle meter was used at a consistent focal distance (6–12 inches) to sample the surrounding environment during treatment at 2.83 L/min to a counting efficiency of 50% at 0.3 μm and 100% at >0.45 μm. The plume particle characteristics were recorded throughout the treatment and compared among the different technologies. Recordings included an overall reading of the number of particles per second (pps) as well as the categorization of particles by size range (0.30, 0.50, 1.00, 2.50, 5.00, and 10.00 μm). A 6 K camera (Blackmagic, Victoria, Australia) was utilized at ×10 magnification to visualize the plume during treatment for correlation to the particle meter data. The aforementioned recordings were obtained with and without the use of a Bovie Smoke Shark evacuator (Bovie Medical Corp.). The smoke evacuator had a 7/8″ tubing attachment and was set at "medium" with the efficacy of approximately 4.5 cubic feet per minute. The smoke evacuator was held within 1–3 inches of the treatment area.

RESULTS

Of our cohort ($n = 5$), the average subject age was 58 years old (STD ±7.2). There was one Fitzpatrick type I, two type II, and one type III subjects. Indications for treatment included cosmetic improvement of skin tone/texture and improvement of facial rhytids. Subjects were all deemed appropriate candidates for fractional radiofrequency and/or laser aesthetic treatments without significant past medical history, excluding them from treatment (such as autoimmune conditions or active infection). None of the subjects included had prior aesthetic facial treatment over the prior 4 months. Two subjects received Er:YAG fractional resurfacing in addition to fractional radiofrequency during the same treatment session. An approximate 30-minute interval passed between these two treatments for ambient room particle reading to return to baseline. The fractional radiofrequency was performed first in both cases. Both modalities were used because these subjects required correction of skin laxity primarily targeted by radiofrequency and resurfacing of deeper rhytids primarily targeted by the Er:YAG laser. Two subjects had fractional radiofrequency only, and one had laser treatment with the Er:YAG only. There were no adverse events recorded during or after treatment.

The particle counter demonstrated ambient baseline particles/second (PPS) at 8 (STD ±6). During fractional radiofrequency treatments at 1 mm depth, the mean recording was 8 pps (STD ±8). At the more superficial depth of 0.5 mm, recordings showed 10 pps (STD ±6). During the Er:YAG laser resurfacing laser treatments, the mean readings was 44 pps (STD ±11). When the particle sizes were broken down by size, the fractional radiofrequency device produced overall smaller particle sizes with a count of 251 for 0.3 μm (STD ±147) compared with Er:YAG laser with a count of 112 for 0.3 μm (STD ±84). The fractional radiofrequency did not appear to emit particles >5 μm throughout the treatment; however, the Er:YAG laser consistently recorded a majority of particles in the range of 5–10 μm. The addition of the smoke evacuator demonstrated a 50% reduction in both particles per second recorded as well as all particle sizes. High magnification videographic data of the treatments were analyzed and demonstrated a clearly visible plume from the Er:YAG laser compared with no visible plume from the fractional radiofrequency device.

DISCUSSION

The risk of plume exposure generated by electrosurgical devices has been investigated since the 1980s [24]. It has been shown that as particle size increases, so does the risk for pathogen transmission. Laser tissue ablation has been shown to generate particles with a mean size of 0.31 μm, which is larger than traditional surgical electrocautery devices [12,13,25]. This is consistent with clinical findings, suggesting that the plume from resurfacing lasers is more hazardous than electrocautery smoke [1,5,8,23]. To our knowledge, the plume profile from fractional radiofrequency has not been reported in the literature.

This study is timely given the COVID-19 pandemic, as the biologic transmission of pathogens has been shown to occur through plume particles [1]. As a group of providers, we are actively seeking reentry guidelines to best serve patients [26]. Clinical and animal studies on the dangers of plume exposure have shown mutagenic and potentially carcinogenic effects, as well as infectious risks by the transmission of biologic pathogens [2,3,6,7,8,11,13,23]. Concern about the transmission of pathogens led to a study that identified human immunodeficiency virus DNA in laser smoke plume, demonstrating its transmission to cultured cells [2]. Furthermore, reports of human papillomavirus DNA developing on unusual sites (i.e., face, nasopharynx, and larynx) of laser operators who removed plantar and anal warts [7]. In addition to viruses, in vitro experiments have cultured bacteria from laser plume [3].

In this study, we used a commercial-grade particle analyzer to indicate the rate of particle emission (i.e., particles per second) as well as to categorize particle sizes. Our data demonstrated that the Er:YAG resurfacing laser emits more than four times the particles when compared with fractional radiofrequency (Er:YAG; 44 pps vs. fractional radiofrequency; 10 pps). Fractional radiofrequency treatment did not emit plume significantly above ambient baseline particle readings of the exam room environment. When recordings were performed at two different depths of the fractional radiofrequency, there was a slight trend toward more particles in the 0.5 mm treatment depth compared with the 1.0 mm treatment depth, suggesting that the more superficial the treatment, the more potential particle emission. This appears to be a logical finding as fractional radiofrequency treatment focuses energy at the deeper portion of the applicator. In the bipolar configuration of the device tested, the radiofrequency energy travels half the distance between the subdermal electrode and the external electrode. The temperatures generated are not high enough and the duration of each pulse not long enough to cause vaporization of cellular water content and proteins. In contrast, the Er:YAG laser functions to target the skin surface water chromophore at 2940 nm wavelength energy. This wavelength is absorbed by water 20 times more than the predecessor CO_2 laser, which led to more collateral heat generation. Both the particle reader, as well as the videographic data, show a more substantial plume visualized during treatment, with a larger number and size of particles emitted. Consistent with previous studies, the smoke evacuator did favorably reduce particle emission recordings as well as all sizes of particles by approximately 50% [12,13].

There are a number of limitations to this study. A larger cohort subdivided by age would have provided statistical substantiation to the data and a better understanding of age/dermal thickness relationship to plume emission. The recordings obtained were useful to understand the number of particles emitted per unit time as well as the size of these particles. However, further analysis of the composition of particles beyond particle size would best elucidate the potential biologic activity of the plume, clarifying the risk of pathogenic transmission. In relation to COVID-19, much is left unknown in terms of transmission patterns and viral temperature tolerance. Namely, a more thorough understanding of COVID-19 transmissibility via cutaneous particles is critical. This information is a key component of risk assessment during these treatments.

The aim of this pilot study was to evaluate the particle sizes emitted during treatment with Er:YAG laser resurfacing and compare it to fractional radiofrequency. Our data do suggest that plume emission is greater using a resurfacing laser compared with fractional radiofrequency. Based on this preliminary data, we recommend that all providers working with resurfacing lasers use a smoke evacuator in addition to appropriate personal protective equipment (mask, eye protection) to minimize the risk of plume-associated pathogen transmission.

CONCLUSION

Re-evaluation of the plume effect from aesthetic devices has become important during the COVID-19 pandemic. Further studies are required to characterize the viability of COVID-19 and transmissibility in plume specimens. Based on this pilot study and prior studies, personal protective equipment such as masks, eye protection, and smoke evacuation systems should be used with Er:YAG laser resurfacing due to potential viral and bacterial transmissibility via plume particles.

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SUPPORTING INFORMATION

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