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# Sound Levels and Safety in Cosmetic Laser Surgery

**Daniel J. Callaghan III, MD,[1*] Lauren M. Bonati, MD,[1] Murad Alam, MD, MBA, MSCI,[2,3] Kimberly Jerdan, MD,[4] Mark B. Taylor, MD,[4] and Jeffrey S. Dover, MD, FRCPC[1,5]**

[1]*SkinCare Physicians, 1244 Boylston Street, Suite 103, Chestnut Hill, Massachusetts 02467*

[2]*Department of Dermatology, Feinberg School of Medicine, Northwestern University, 676 N. St Clair St, Ste 1600, Chicago, Illinois 60611*

[3]*Department of Otolaryngology, Feinberg School of Medicine, Northwestern University, 676 N. St Clair St, Ste 1600, Chicago, Illinois 60611*

[4]*Gateway Aesthetic Institute, Salt Lake City, Utah*

[5]*Department of Dermatology, Yale University School of Medicine, New Haven, Connecticut*

**Objectives:** Measure the sound levels produced by various lasers commonly used during routine outpatient cosmetic surgery to determine whether or not their use exceeds exposure levels set forth by the US National Institute for Occupational Safety and Health (NIOSH) and the US Occupational Safety and Health Administration (OSHA).
**Materials and Methods:** Using two different meters, the sound levels of lasers commonly used in cosmetic surgery were recorded during various procedures for several indications: tattoo removal, treatment of lentigines and pigmented lesions, facial erythema and vascular lesions, hair removal and resurfacing of acne scars, and photoaging.
**Results:** All but five lasers had a maximum sound level below 85 dBA, the limit proposed by NIOSH. The loudest laser examined was a fully ablative 2,940 nm Er:YAG during facial resurfacing, with an average maximum sound level of 101.5 decibels (dBA). Two other lasers used for resurfacing exceeded 85 dBA including a fractional ablative 1064 Nd:YAG with an average maximum of 97.8 and a different fully ablative 2,940 nm Er:YAG which had an average maximum of 96.3 nm. The two other lasers that exceeded 85 dBA were picosecond lasers used to treat black tattoos, including a 1,064 nm Nd:YAG with an average maximum of 93.7 dBA and a 755 nm alexandrite with an average maximum of 93.6 dBA.
**Conclusion:** Although some lasers in cosmetic surgery may be perceived as being quite loud, they remain safe. Even the loudest laser studied would have to be used for nearly 2 hours before exceeding the OSHA recommended exposure limit. Even physicians who spend a large amount of time using lasers in clinical practice should be reassured that these devices are not likely to produce noise-induced hearing loss (NIHL) hearing loss. Lasers Surg. Med. 51:491–494, 2019. © 2018 Wiley Periodicals, Inc.

**Key words:** laser; noise-induced hearing loss; safety; sound level

## INTRODUCTION

Eye protection has always been at the forefront of laser safety protocols, yet little is known about the risk of noise-induced hearing loss (NIHL) with laser use. NIHL is caused by a one-time exposure to an intense impulse sound or by a steady-state long-term exposure. Impulse noise is more deleterious [5] due to mechanical damage in the cochlea and overload of the cellular antioxidant system [6]. Irreversible hearing loss has been associated with a 30–40% rate of accelerated cognitive decline, and an increased risk of all cause dementia [2]. Noise exposures have also been linked to tinnitus, sleep disturbance, and cardiovascular disease [3,4].

Occupational hearing loss is one of the most common work-related illnesses in the United States. To combat this, the US National Institute for Occupational Safety and Health (NIOSH) and the US Occupational Safety and Health Administration (OSHA) have set forth recommended exposure limits of 85 and 90 decibels (dBA), respectively, as an 8-hour time-weighted average (TWA). Notably, the less stringent exposure limit mandated by OSHA, the official government agency charged with enforcing workplace safety rules, is the legal standard.

Literature from the dental community shows that dentists are at risk for hearing loss and tinnitus when exposed to loud, high-speed handpieces[7]. One study, which used an audiometer to measure the hearing of a total of 29 dental clinicians and dental professionals, found that those using equipment with peak sound intensities ranging from 88 to 102 dBA, for 30–45 minutes per day, routinely had worse hearing than those who did not [8].

Historically, physicians utilizing lasers for cosmetic procedures were believed to have negligible risk of occupational NIHL. However, with the advent of new

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*Correspondence to: Daniel J Callaghan III, MD, SkinCare Physicians, 1244 Boylston Street, Suite 103, Chestnut Hill, MA 02467. E-mail: danieljcallaghan3@gmail.com

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laser technology utilizing nano- and picosecond pulse durations and photoacoustic or photomechanical energy, clinicians may now be exposed to intermittent very loud “pops” during treatment, as well as consistently loud background sound while devices are on [1]. Currently there is no literature describing the sound level of such devices or their impact on hearing.

This study sought to objectively assess the auditory safety of currently available laser and energy devices for cutaneous use by using sound level meters during treatment of a number of different skin targets.

## MATERIALS AND METHODS

The sound level of multiple types of lasers was measured in various treatment settings using two different sound level meters (R8060 Sound Level Meter, Reed Instruments, Wilmington, NC; and Advanced Decibel Meter, BAFX Products, Milwaukee, WI). Both devices meet the US American National Standards Institute (ANSI) and the International Electrotechnical Commission (IEC) “Type 2” standards and can measure to within 1.5 dBA.

During each laser procedure, both sound level meters were held adjacent to the closest ear of the treating physician. The laser sound levels and duration of the procedure were recorded by a third party not involved in the treatment. Each laser-target combination was measured for three patients (with the exception of one laser, in which only one measurement was obtained due to device malfunction, as indicated below). The average for each sound level meter was determined, as was the overall average of the 2 meters. Laser types and treatment targets are outlined in Table 1.

## RESULTS

Only five laser-target combinations exceeded an average sound level of 85 dBA, including the 1,064-nm neodymium-doped yttrium aluminum garnet (Nd:YAG) picosecond laser when treating black tattoos, the 755-nm alexandrite picosecond laser when treating black tattoos, two different fully ablative erbium-doped yttrium aluminum garnet (Erbium:YAG) lasers used for facial resurfacing and a fractional ablative Nd:YAG used for facial resurfacing. The remaining lasers were all below 85 dBA when treating their respective targets (see Table 1).

## DISCUSSION

The NIOSH recommended exposure limit is 85 dBA as an 8-hour time-weighted average, with a 3 dBA exchange rate. This means for every 3 dBA increase, allowable exposure time is reduced by half. OSHA by contrast is a regulatory agency that dictates a less conservative but legally enforceable exposure limitation of 90 dBA over an 8-hour time-weighted average. For every 5 dBA increase, allowable exposure time is reduced by half.

This study demonstrates that the vast majority of lasers used for cosmetic procedures produce a sound that is far below the threshold of 85 dBA set forth by NIOSH and the 90 dBA limit set forth by OSHA. The five lasers that exceeded this limit included the picosecond 1,064 nm Nd:YAG for treating black tattoos, the picosecond 755 nm alexandrite for treating black tattoos, a fractional ablative 1,064 nm Nd:YAG for facial resurfacing and two different fully ablative Er:YAG lasers for facial resurfacing. Given that the length of treatments for which these devices are used for seldom exceeds several minutes, even they are unlikely to put clinicians at risk. As per OSHA guidelines, a treating physician would need to use the 2,940 nm Er:YAG tested in this study for just under 2-hours in a single day, at a sound level of 101.5 dBA, to exceed the allowable exposure. As per NIOSH, treating physicians should avoid using these devices (without ear protection) for more than 15 minutes if sound levels routinely surpass 100 dBA, or for more than 60 minutes if sound levels routinely surpass 94 dBA. It is important to note that this is referring to the actual time the laser is firing which often only represents a portion of the actual procedure time.

Given the study results and regulatory guidelines, it is unlikely that a physician utilizing lasers for cosmetic procedures would be at risk for NIHL. It is hard to conceive of treatments that would exceed recommended exposure times for a particular decibel level, even when treating large tattoos or a high volume of patients in a given day. However, ear protection may be warranted in certain unusual situations, such the use of a 1,064 nm picosecond laser for a very large black tattoo comprised of high density ink.

This study is limited by the quality of the sound level meters used. Although both sound level meters used met ANSI and IEC “Type 2” standards (the minimum requirement by OSHA for noise measurements), and can reportedly measure to within 1.5 dBA, average readings across the two meters differed by more than 1.5 dBA for certain lasers. This may be explained by the meters’ labelled indication for measuring continuous sound, such as the background noise in a factory, rather than sporadic loud sounds such as with short-pulsed lasers. Harmful noise from the use of lasers may be: (a) impulse noise, a sound peak of very short duration best measured with highly specialized equipment in dedicated facilities; or (b) the harmful noise associated with prolonged, recurrent laser pulsing, which may be more easily measured with conventional, portable sound level monitors, such as those used in this study. As impulse testing would have required moving the assessed laser devices to specific university laboratories, which was infeasible, we were unable to obtain these measurements, which is a limitation of this study. The authors did consult with OSHA regarding this limitation and were informed that “normally laser noise is not impact/impulse noise, but it would have to be evaluated specifically. Generally, if the noise peaks occur less than once per second and are of short duration, it would be considered impact noise” (written communication, October 2018). Although several lasers in this study are routinely fired less than once per second, the lasers that were found to be the loudest and used for resurfacing or tattoo removal typically are fired in clinical practice faster than once per second and therefore might be classified as continuous sound.

**TABLE 1. Average Maximum Sound Level Produced by Various Lasers and Their Given Treatment Target**

| Device | Target | Average sound level with the BAFX Products® Advanced—Decibel Meter (dBA) | Average sound level with the Reed R8050 Sound Level Meter (dBA) | Average sound level of the two meters combined (dBA) |
|---|---|---|---|---|
| Alex Lazr (Syneron-Candela, Yokneam, Israel) QS 755 nm alexandrite with a pulse width of 50 ns | Black tattoo | 68.6 | 62.6 | 65.6 |
| Alex Lazr (Syneron-Candela, Yokneam, Israel) QS 755 nm alexandrite with a pulse width of 50 ns | Lentigines | 67.5 | 64.5 | 66 |
| Enlighten (Cutera, Brisbane, CA) 532 nm Nd:YAG with a pulse width of 750 ps | Lentigines | 63.2 | 58.5 | 60.9 |
| Enlighten (Cutera, Brisbane, CA) 1064 nm Nd:YAG with a pulse width of 750 ps | Black tattoo | 97.6 | 89.7 | 93.7 |
| excel V (Cutera, Brisbane, CA) 532 nm KTP with a pulse width of 10 ms | Facial erythema | 61.7 | 58 | 59.8 |
| excel V (Cutera, Brisbane, CA) 1,064 nm Nd:YAG with a pulse width of 10 ms | Vascular lesions | 63.2 | 58.5 | 60.9 |
| Fraxel Dual (Solta, Hayward, CA) 1,550 nm Er:Glass | Laser resurfacing | 80.6 | 71.6 | 76.1 |
| Fraxel Re:pair (Solta, Hayward, CA) 10,600 nm CO2 | Laser resurfacing | 79 | 75.8 | 77.4 |
| GentleLase (Syneron-Candela, Yokneam, Israel) 755 nm alexandrite with a pulse width of 3 ms | Laser hair removal | 77.6 | 72.4 | 75 |
| GentleYag (Syneron-Candela, Yokneam, Israel) 1,064 nm Nd: YAG with a pulse width of 3 ms | Vascular lesions | 67.6 | 64.7 | 66.2 |
| LightSheer DUET (Lumenis, Santa Clara, CA) 810 nm diode with a custom pulse width[a] | Laser hair removal | 65.1 | 60.8 | 62.9 |
| Picosure (Cynosure, Westford, MA) 755 nm alexandrite with a pulse width of 750 ps | Black tattoo | 96.9 | 90.3 | 93.6 |
| Picosure (Cynosure, Westford, MA) 755 nm alexandrite with a pulse width of 750 ps | Lentigines | 63.3 | 60.7 | 62 |
| RevLite (Cynosure, Westford, MA) QS 1064 nm Nd:YAG with a pulse width of 15 ns | Melasma | 67.1 | 64 | 65.5 |
| SmartXide DOT (DEKA, Florence, Italy) 10,600 nm CO2 | Laser resurfacing | 75.4 | 71.4 | 73.4 |
| SP Dynamis (Fotona, Ljubljana, Slovenia) 2,940 Er:YAG on microsecond pulse mode | Laser resurfacing | 105 | 98.5 | 101.5 |
| Starwalker (Fotona, Ljubljana, Slovenia) 1,064 Nd:YAG on FracTatt mode | Laser resurfacing | 105.7 | 89.9 | 97.8 |

(*Continued*)

**TABLE 1.** (*Continued*)

| Device | Target | Average sound level with the BAFX Products® Advanced—Decibel Meter (dBA) | Average sound level with the Reed R8050 Sound Level Meter (dBA) | Average sound level of the two meters combined (dBA) |
|---|---|---|---|---|
| UltraPulse (Lumenis, Santa Clara, CA) 10,600 nm CO2 | Laser resurfacing | 80.6 | 71.6 | 76.1 |
| Venus-i (Cutera, Brisbane, CA) 2,940 nm Er:YAG | Laser resurfacing | 99.3 | 93.2 | 96.3[b] |
| VBeam Perfecta (Syneron-Candela, Yokneam, Israel) 595 nm PDL with a pulse width of 10 ms | Facial erythema | 78.6 | 73.7 | 76.1 |

[a]Pulse duration is machine derived.
[b]Average is a reflection of only one reading due to device malfunction.

A second limitation of this study is the acoustics and sound transmission can differ based in room size and layout, as well as operator height and position relative to the laser. A more specific and personally relevant measurement may be acquired by a body-worn dosimeter, which calculates average noise exposure for a given period of time.

Finally, this study is meant to be observational only. As demonstrated, lasers with the same wavelength but from different manufactures were found to produce different sound levels. Similarly, the sound levels produced by a single laser can also vary based on the target. For this reason, clinicians should not assume these sound levels can be applicable to their own devices and may want to have them tested if they are concerned about the sound levels they are being exposed to.

## CONCLUSIONS

The vast majority of lasers used for cosmetic procedures produce a sound level below 85 dBA, the threshold for NIHL as per regulatory bodies. Laser-target combinations that produce sound above 85 dBA include the 1,064 nm picosecond Nd:YAG and the 755 nm picosecond alexandrite when treating black tattoos, a fractional ablative 1,064 nm Nd:YAG for laser resurfacing, and two different fully ablative Er:YAG devices for laser resurfacing of the face. If the exposure time is expected to exceed 15 minutes in 1 day, with dBA levels above 100, ear protection may be considered. Otherwise, physicians may feel safe utilizing lasers of all types without concern for NIHL.

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