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ORIGINAL ARTICLE

Evaluation of the vacuum-assisted handpiece compared with the sapphire-cooled handpiece of the 800-nm diode laser system for the use of hair removal and reduction

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Abstract

Background: A handpiece with a 35 × 22-mm treatment window that uses vacuum technology has been designed for the diode laser system. Vacuum suction stretches the skin and brings the hair follicle closer to the surface with the intent to damage the hair follicle at a lower surface fluence. The objective of this study was to compare the degree of follicular thermal damage between the sapphire-cooled smaller handpiece at a higher fluence versus the larger vacuum-assisted handpiece at a lower fluence. *Methods*: Five male patients with Fitzpatrick skin types I–IV were enrolled in the study. Three test spots on the right back were treated with the vacuum-assisted laser handpiece at a setting of 10–12 J/cm^2, and 61-ms pulse duration. Three test spots on the left back were treated with the sapphire-cooled handpiece with a setting of 30–34 J/cm^2 and a pulse duration of 14–16 ms. A punch biopsy was obtained from one treated area for each handpiece type. The biopsies were sectioned horizontally and examined for the degree of thermal damage to the hair follicle at the level of the isthmus and the bulb. Immediate treatment response, pain score, and total treatment time were recorded. *Results*: Biopsies from the skin treated with the sapphire-cooled handpiece and the vacuum-assisted handpiece showed the mean hair follicle diameter was 258.3 μm (SE [standard error] 41.7) and 225.1 μm (SE 17.1), respectively. The mean thermal damage diameter to hair diameter ratio was 0.91 (SE 0.10) and 0.72 (SE 0.12), respectively. The mean immediate treatment response, the mean pain severity, and the mean total treatment time were all lower for the vacuum-assisted handpiece. *Conclusion*: Treatment with the vacuum-assisted handpiece is faster and has a tendency to be more comfortable. Thermal damage to the hair follicle was greater with the sapphire-cooled handpiece.

Key Words: *diode laser, hair reduction, lasers and light sources, vacuum-assisted handpiece*

Introduction

Lasers and incoherent light sources reduce unwanted hair based on the theory of selective thermolysis (1–3). The 800-nm pulsed diode laser system is an effective hair reduction device (4–7). One handpiece consists of a 9 × 9 mm or 12 × 12 mm sapphire-cooled tip (ChillTip™). However, laser hair removal of large areas with this handpiece may be time-consuming due to the size of the treatment tip and coverage rate (1.6 cm^2/s).

An alternative handpiece (35 × 22 mm) that uses vacuum-assist technology has become available for the diode laser system. This vacuum suction 'pulls' the hair follicle closer to the surface, and theoretically requires less energy for target destruction. By stretching the epidermis, the suction allows for the laser energy to be distributed over a larger target area, thereby decreasing the epidermal melanin density and epidermal heating. This configuration theoretically allows for hair removal at a lower fluence and greater coverage rate (up to 5 cm^2/s).

Multiple studies have been published on the histological effects of laser hair removal using the sapphire-cooled handpiece of the 800-nm diode laser systems (8–10). The primary objective of this study was to compare the degree and extent of follicular thermal damage between (a) the sapphire-cooled handpiece at a higher fluence and a shorter pulse duration versus (b) the vacuum-assisted handpiece at a lower fluence and a longer pulse duration. The two respective

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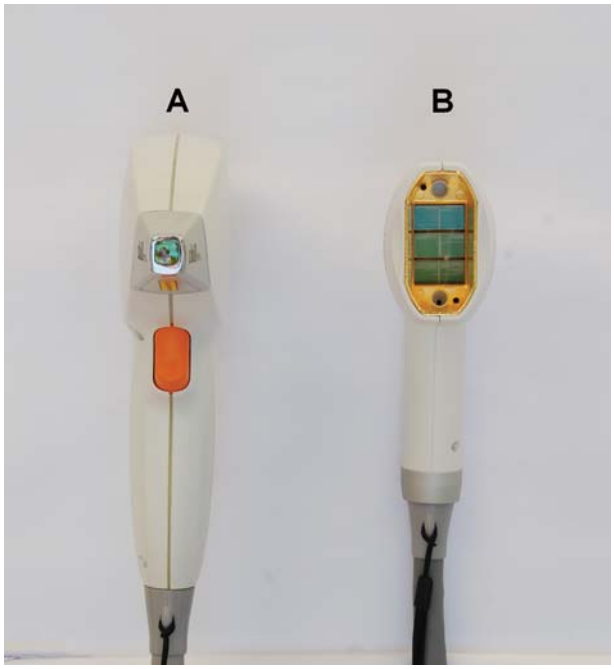

Figure 1. (A) Treatment window of the sapphire-chilled (ET) handpiece; (B) treatment window of the vacuum-assisted (HS) handpiece.

handpieces were applied (LightSheer® Duet™ ET and HS handpieces) and the extent and degree of thermal damage were assessed by biopsies of test spots. The secondary objective of this study was to compare the immediate treatment response, pain score, and total treatment time between the two handpieces.

Materials and methods

This study was approved by the Institutional Review Board, Scripps Clinic, La Jolla, CA, USA. Five male patients, ranging from 35 to 54 years of age and with Fitzpatrick skin types I–IV, were enrolled. No patient had undergone previous laser hair removal and all had dark thick hair.

The 800-nm diode laser and higher fluence handpiece (LightSheer Duet ET handpiece; Lumenis, Santa Clara, CA, USA) was used for hair removal on the left back. The tip of this laser handpiece incorporates chilled sapphire contact cooling (5–7°C). The laser window size is 9 × 9 mm. The 800-nm diode laser and lower fluence handpiece (LightSheer Duet HS handpiece; Lumenis) was used for hair removal on the right back. The treatment window utilizes vacuum-assist technology (up to 18 inches Hg) to draw the skin into the handpiece. This configuration also uses a longer pulse duration compared to the sapphire-cooled handpiece. The treatment window size is 35 × 22 mm (about 10× the area of the smaller handpiece) (Figure 1).

Six test spot sites were mapped out on the right and left back to determine the optimal treatment parameters for each handpiece (Figures 2 and 3). The three test spots on the right back were treated with the larger vacuum-assisted handpiece using a setting of 10–12 J/cm^2, 61 ms, medium vacuum (12 inches Hg), and single pulse mode. There was no active cooling with the vacuum-assisted handpiece. The three test spots on the left back were treated with the smaller handpiece using a setting of 30–34 J/cm^2,

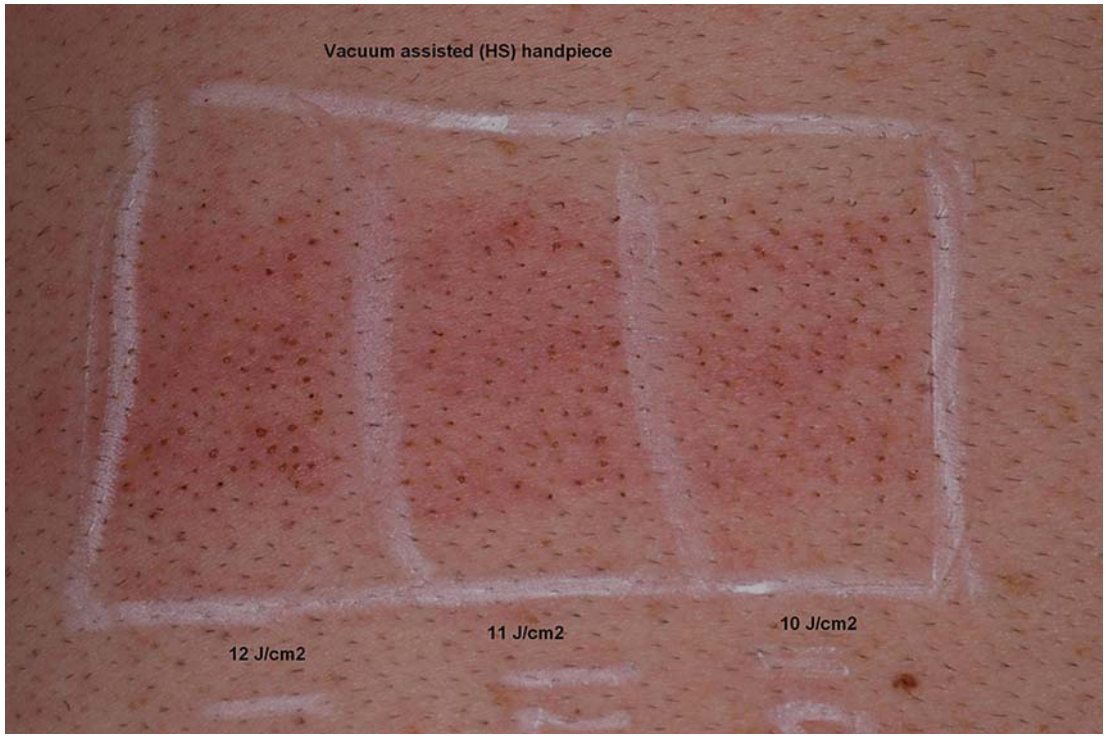

Figure 2. Test spots treated with the vacuum-assisted (HS) handpiece.

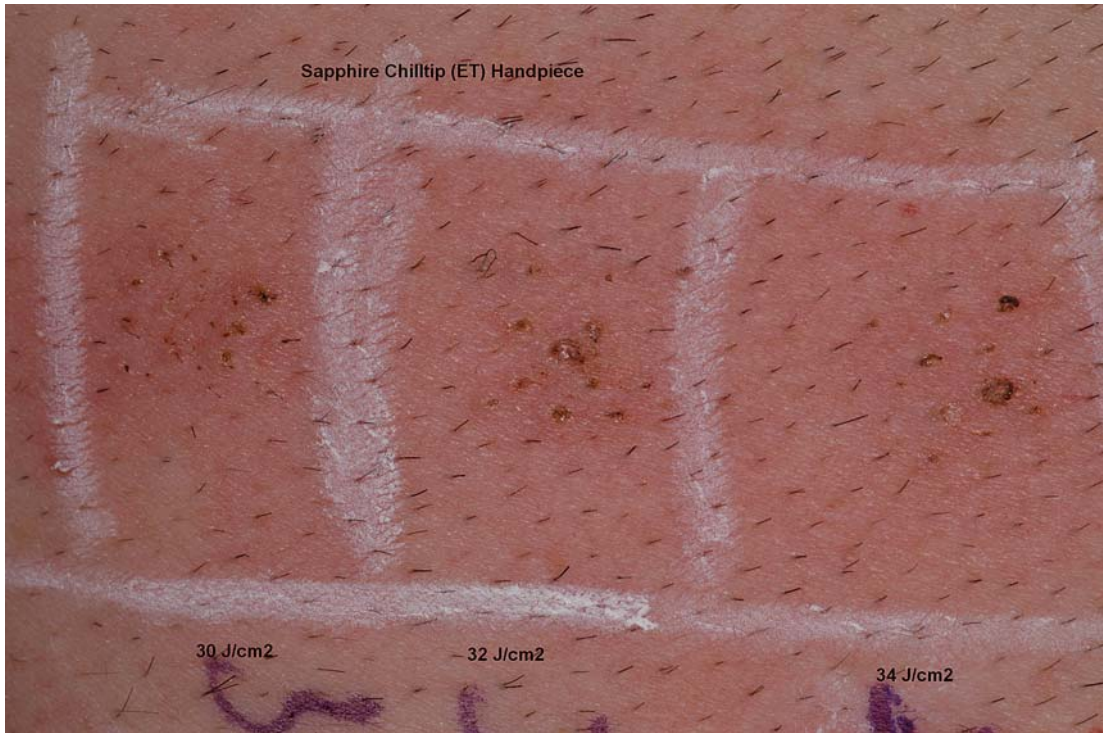

Figure 3. Test spots treated with the sapphire-chilled (ET) handpiece.

14–16 ms, and single pulses. The smaller handpiece settings were those values typically used in clinical practice for their respective hair and skin types. Perifollicular edema (PFE) and pain severity from each test spot were recorded (Tables I–III).

Optimal treatment parameters for the test spots were determined to be settings where patients developed the greatest PFE and the least epidermal side effects. Subsequently, a 6-mm punch biopsy was performed on the test spot treated with a setting of 12 J/cm^2, 61 ms, and medium vacuum on the right back. Similarly, a 6-mm punch biopsy was performed on the test spot treated with a setting of 30 J/cm^2 and 15 ms on the left back. A local injection of 1.0 ml of 2% lidocaine with epinephrine 1:100 000 was administered prior to biopsy. Each biopsy specimen was horizontally sectioned to maximize the number of follicles seen on the subsequent slide review and was stained with hematoxylin-eosin. A slide reticule was used to measure the hair follicle diameter (μm) and the thermal damage diameter (μm) at the isthmus and the bulb. The hair follicle diameter (FD) was measured from one end of the fibrous root sheath to the other. The thermal damage diameter (TDD) was determined microscopically from the vacuolar heat alterations to the hair follicle from one end to the other in cross section. The ratio of the mean thermal damage diameter to hair follicle diameter (R) was calculated.

Each patient was subsequently treated with the larger vacuum-assisted handpiece with the optimal setting of 12 J/cm^2, 61 ms, medium vacuum, single pulse mode to the entire right back. The smaller handpiece with the optimal setting of 30 J/cm^2, 15 ms, and single pulsing was used to treat the entire left back. The pain score and total treatment time were recorded for each side after completing the treatment.

Table I. Edema/erythema severity and pain scale.

0	None
1	Minimal
2	Moderate
3	Marked
4	Severe

Results

There was significant immediate PFE in areas treated by both the sapphire-cooled and vacuum-assisted handpieces (Figures 2 and 3). The degree

Table II. ET handpiece (Sapphire ChillTip™, 9 × 9 mm): test spots, perifollicular edema/erythema, and pain scores.

	Test spot 1 30 J/cm^2		Test spot 2 32 J/cm^2		Test spot 3 34 J/cm^2	
Patient	Edema/ erythema	Pain	Edema/ erythema	Pain	Edema/ erythema	Pain
1	1	3	1	3	1	3
2	2	2	2	2	2	2
3	2	2	3	2	3	2
4	0	1	0	1	0	1
5	2	2	2	2	2	2

of PFE was greater in the areas treated with the sapphire tip.

Histologically, the post-treatment epidermis was normal with the exception of mild vacuolar changes in the epidermal-dermal junction at some higher fluence sites. The mean hair follicle diameter was 258.3 μm (SE [standard error] 41.7) from the right back (treated with the vacuum-assisted handpiece). The mean ratio of thermal damage diameter to hair follicle diameter was 0.91 (SE 0.10). The mean hair follicle diameter was 225.1 μm (SE 17.1) from the left back (treated with the ET handpiece). The mean ratio of thermal damage diameter to hair follicle diameter was 0.72 (SE 0.12). The *p*-value for differences in the mean ratio of thermal damage diameter and hair shaft diameter between the two handpieces was 0.375 (Wilcoxon ranked test) (Table IV). Although the calculated ratio of the thermal damage diameter to hair follicle diameter was not statistically different between the two handpieces, the observed characteristic of the thermal damage diameter was dissimilar (Figures 4 and 5). There was a tendency toward more pronounced thermal damage from the specimens of the smaller handpiece. That is, the severity of the coagulation was greater in the small handpiece/high fluence specimens.

The mean immediate treatment response for the right back was 1.6 (SE 0.24, mild PFE and erythema) and the left back was 3 (SE 0.32, marked PFE and erythema). The mean pain score for the right back was 2.2 (SE 0.37, moderate pain) and the left back was 3.2 (SE 0.58, marked pain), with a *p*-value of 0.125. The mean total treatment time for the right back was 10.4 minutes (SE 0.51) and the left back was 21 minutes (SE 0.63), with a *p*-value 0.0625 (Table IV).

Discussion

Laser hair removal can be painful and time-consuming using the sapphire-cooled handpiece due to the high fluence requirement and small tip size. The larger vacuum-assisted handpiece reduces treatment time and showed a tendency towards less pain.

Table III. HS handpiece (vacuum-assisted, 22 × 35 mm): test spots, perifollicular edema/erythema, and pain scores.

	Test spot 1 10 J/cm^2		Test spot 2 11 J/cm^2		Test spot 3 12 J/cm^2	
	Edema/ erythema	Pain	Edema/ erythema	Pain	Edema/ erythema	Pain
1	2	1	2	1	2	1
2	0	0	1	1	2	2
3	2	1	2	1	2	1
4	1	2	1	2	2	1
5	2	1	2	1	2	1

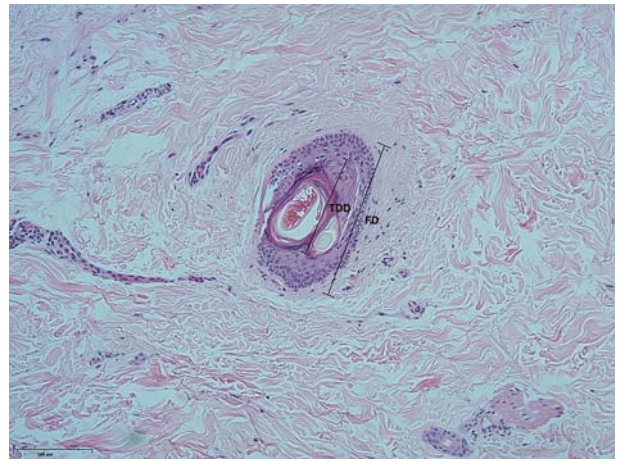

Figure 4. Hair follicle treated with the vacuum-assisted (HS) handpiece. (FD = follicle diameter; TDD = thermal damage diameter.) H&E, 10×.

In theory, for the *same* spot size, a lower fluence/longer pulse duration configuration should result in lower peak temperatures at the follicle. Although we did not specifically measure hair reduction outcomes, preliminary studies suggest similar hair reduction between the two handpieces. These studies have been carried out to 3 months after the final treatment in a multiple session protocol with several treatments conducted at intervals of 4–8 weeks (11).

Mathematical models have attributed the similar efficacies to a combination of the newer handpiece's gold coating, larger beam size, and vacuum suction (11). The gold coating reduces laser light loss due to reflections from the skin surface. The wider beam increases the total number of photons emitted per pulse (even at a lower fluence) and makes the central irradiated area more susceptible to deeper photon absorption. The vacuum suction changes the skin geometry from a flat to a bulged surface. This bulged surface allows hair follicles to be subjected to laser

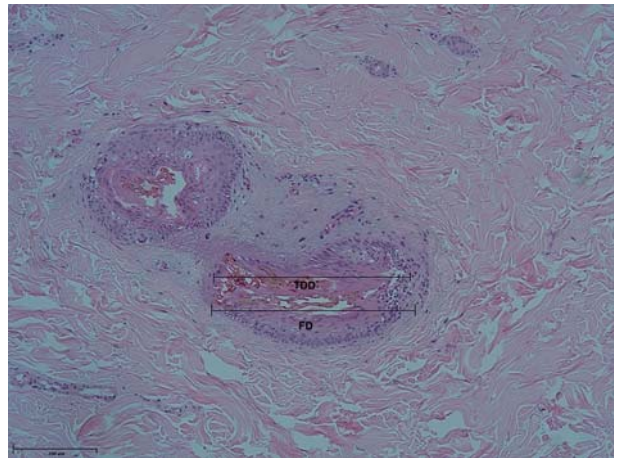

Figure 5. Hair follicle treated with the sapphire-chilled (ET) handpiece. (FD = follicle diameter; TDD = thermal damage diameter.) H&E, 10×.

Table IV. Results.

Results noted	Vacuum-assisted HS handpiece, 22 × 35 mm	Sapphire ChillTip™ ET handpiece, 9 × 9 mm	Wilcoxon *p*-value
Mean follicle diameter	225.1 μm (SE 17.1)	258.3 μm (SE 41.7)	
Mean ratio of thermal damage diameter to follicle diameter	0.72 (SE 0.12)	0.91 (SE 0.10)	0.375
Immediate treatment response	1.6 (SE 0.24, mild PFE/erythema)	3 (SE 0.32, marked PFE/erythema)	
Pain	2.2 (SE 0.37, moderate pain)	3.2 (SE 0.58, marked pain)	0.125
Mean treatment time	10.4 min (SE 0.51)	21 min (SE 0.63)	0.0625

PFE = perifollicular edema.

irradiation from more directions. Despite the above-referenced arguments supporting the larger spot size and lower fluence configuration, our results suggest that a larger surface fluence and shorter pulse duration, even applied over a small area (9 × 9 mm tip), results in more complete microscopic coagulation of the similar areas of the respective follicles. Whether these differences in thermal damage are clinically significant will be determined from larger scale long-term studies of laser hair reduction.

One deficiency in this study was the lack of an arm where we would have investigated the histological effects of the 9 × 9 mm handpiece with a pulse width and fluence (i.e. 61 ms and 12 J/cm^2) that matched those of the 35 × 22 mm handpiece. Such a parameter set would be predicted to cause very little thermal damage.[12] Nonetheless, the histologic data presented suggests that the larger spot and vacuum work to compensate for the lower surface fluence in the 'high-speed handpiece' group. We are presently investigating the beam transmission differences between the two spot designs. These studies should support our microscopic results of thermal damage for the two groups.

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Conflict of interest: Dr Ross is a consultant for Lumenis.

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