applied sciences

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Evaluation of the Effectiveness of Overheated Dry-Saturated Steam Disinfection in the Control of the Dental Chair Contamination by Bioluminescence Analysis: A Pilot In Vitro Study

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Abstract: This study aimed to evaluate, through Adenosine triphosphate (ATP) bioluminescence analysis, the effectiveness of an overheated dry-saturated steam device (*Polti Sani System*) in decreasing the superficial microbial contamination on dental chairs' surfaces after 30 s steam disinfection (T1) in comparison to baseline (T0), i.e., at the end of an aerosol-generating procedure (AGDP), and to investigate any differences in the tested surfaces' contamination at T0 in relation to the surface's type. Three dental chair surfaces (scialytic lamp, control button panel, spit bowl), sized 10 × 10 cm each, were swabbed and analyzed before and after steam application. The procedure was repeated 20 times for a total of 60 before–after evaluations. Non-parametric tests were used to analyze Relative Light Unit (RLU) values and categorical data on the ATP molecules' amount detected on the tested surfaces. Statistically significant differences were found for both RLU and categorical data for all surfaces, and each type of surface evaluated at T0 and T1 ($p < 0.05$). Differences in RLU among the tested surfaces at T0 were not significant. By reducing the microbial contamination on the evaluated surfaces, the overheated dry-saturated steam system was an effective measure for the disinfection of the dental chair's surfaces after AGDPs, potentially reducing the risk of cross-infections.

Keywords: microbial contamination; aerosol-generating dental procedures; infection control; overheated dry-saturated steam disinfection; dental chair

Citation: Luppieri, V.; Giangreco, M.; Chermetz, M.; Ronfani, L.; Cadenaro, M. Evaluation of the Effectiveness of Overheated Dry-Saturated Steam Disinfection in the Control of the Dental Chair Contamination by Bioluminescence Analysis: A Pilot In Vitro Study. *Appl. Sci.* **2023**, *13*, 3685. https://doi.org/10.3390/app13063685

Academic Editors: Paola Gandini and Andrea Scribante

Received: 27 February 2023
Revised: 10 March 2023
Accepted: 11 March 2023
Published: 14 March 2023

1. Introduction

In this era, where the Corona Virus Disease-2019 (COVID-19) pandemic has become a significant global public health problem [1], and the rise of antibiotic resistance has resulted in an increase in untreatable infections [2,3], prevention of diseases has become pivotal and, in most cases, more cost-effective than cure [4].

The recent pandemic has further brought to light the high risk of cross-transmission of pathogens, including the Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2) responsible for COVID-19 [5], in dental practices for both patients and dental healthcare professionals (DHCPs) due to the working conditions in close and prolonged contact with patients and the performing of aerosol-generating dental procedures (AGDPs) [6–8]. In 2020, the New York Times stated that dentists are at the top of the ranking among healthcare professionals that are most at risk of cross-infections [9]. Airborne transmission from an infected individual in close contact with another is the main route of transmission for

respiratory pathogens [10]. However, the indirect transmission by first touching a contaminated surface and then touching the eyes, nose, and/or mouth, is no less significant [11], especially in relatively closed environments such as dental practices [12,13].

By definition, aerosols are composed of droplets with a size ≤ 5 µm in diameter, which can remain suspended in the air for hours, moved by air currents, until they deposit on surfaces [10]. The survival time of pathogens on the surfaces depends on several factors, including the microbial load, the material of the considered surface, and the ambient temperature and humidity [10,14]. For instance, during the recent pandemic, it has been demonstrated that SARS-CoV-2 can remain viable in respiratory droplets for up to 3 h [8,13], while on stainless steel and plastic surfaces, it can survive up to 72 h, with an average half-life of about 5.6 and 6.8 h, respectively [15,16]. The virus seems more stable on smooth surfaces and at a room temperature of 20–22 °C [17].

To reduce the risk of cross-infections in dental practices, DHCPs have to adopt protective measures and protocols, which have been further reinforced with new recommendations during the COVID-19 pandemic [8,18–20]. Assuming that proper hand washing is essential to prevent indirect contagion, accurate disinfection of work environments is equally important to reduce the risk of cross-infections, preventing the spread of pathogens, especially after performing AGDPs [12,18,19]. Among conventional disinfection methods, liquid chemical products such as sodium hypochlorite, hydrogen peroxide and ethanol are the most commonly used. The effectiveness of chemicals is closely related to the type of the product used and to its application procedure [21]; these products may also require long contact times to be effective (up to 5–15 min) and may release irritating or toxic disinfection-by-residues requiring an extra ventilation of the disinfected environments [21–23]. A non-toxic and environmentally friendly alternative to chemical disinfection is represented by overheated dry-saturated steam disinfection, which is part of the so-called "No-Touch" Disinfection (NTD) systems, also including ozone, air ionization and Ultraviolet (UV) radiation [21]. The literature describes overheated dry-saturated steam as effective in inactivating heat-sensitive bacteria, fungi and viruses, thus reducing the microbial contamination of the disinfected surfaces [22–28]. For instance, Tanner, 2009, states that 5-s steam disinfection was able to completely inactivate Escherichia coli, Enterococcus feacalis, methicillin-resistant Staphylococcus aureus (MRSA), Candida albicans and the endospores of Clostridium difficile on the treated surfaces [24] and, according to Song et al., 2012, already within 3 s of steam use, the 99.95% of E. coli, Pseudomonas aeruginosa and S. aureus present on surfaces, were killed [22]. Moreover, the in vitro study by Marchesi et al., 2021 stated that 99.99% of HCoV-OC43, a surrogate for SARS-CoV-2 [29] and of A/H1N1 virus, was inactivated by dry steam within 4 s of its use [23]. Overheated dry-saturated steam is currently used as an effective disinfection system in both healthcare and non-healthcare environments due to its easy and rapid use and high ability to inactivate pathogenic microorganisms, overcoming the disadvantages of chemicals [21–28,30–34]. In healthcare facilities, it is mainly used for surfaces and medical devices' disinfection, such as e.g., during the COVID-19 pandemic for filtering facepiece respirators' decontamination [21,22,31,32]. In non-health fields, its major applications include cleaning textile materials with no risk of damage and disinfection of surfaces in domestic, educational and food service settings [25,30,33]. The characteristics of the steam to be dispensed in terms of temperature, pressure, distance and time of application depend both on the features as well as on the type of the material and/or surface to be disinfected and on the chosen device that has to be used by following the manufactures' instructions. In general, the steam jet has to be vertically maintained above the surface to be disinfected without touching it and in continuous motion during its application. For instance, in real-life settings, using a 99 °C steam jet at a pressure of 83 to 138 kPa for 90 s is reported to be effective in the disinfection of carpets against human norovirus (HuNoV) [27].

To the best of our knowledge, to date, scant literature discusses studies evaluating the efficacy of overheated dry-saturated steam in the disinfection of surfaces in dental practice [21]. For this reason, the present study aimed to deepen the knowledge of using an

overheated dry-saturated steam system to disinfect dental chair surfaces after performing AGDPs through Adenosine triphosphate (ATP) bioluminescence analysis. ATP bioluminescence analysis is a rapid method used to evaluate the surfaces' cleanliness by measuring the cellular ATP amount. ATP levels on environmental surfaces provide a measure of the total organic matter present, including not only microorganisms, but also potential blood and saliva traces and tissue debris, which frequently contaminate the work surfaces. ATP bioluminescence analysis is based on an enzyme–substrate (luciferin–luciferase) chemical, which uses the ATP released by cells to generate a bioluminescent signal that is detected by a luminometer and expressed in Relative Light Unit (RLU). The RLU value provided by the luminometer is proportional to the ATP concentration on the tested surface. RLU reference values vary depending on the device used, but an ATP amount of 100 RLU/100 cm^3 is usually considered a threshold level [28,34,35].

This study aimed to decrease the superficial microbial contamination of the evaluated surfaces, reducing the risk of cross-infections for patients and DHCPs in dental practice. The primary hypothesis tested was that using the overheated dry-saturated steam disinfection system after performing AGDPs would reduce the superficial microbial contamination on the dental chair's surfaces. The secondary hypothesis tested was that after performing AGDPs, the microbial contamination on the dental chair's surfaces would not differ among the different surfaces.

2. Materials and Methods

2.1. Study Design and Ethics Approval

The present pilot in vitro before–after study was performed at the Dental Clinic of the Institute for Maternal and Child Health–IRCCS "Burlo Garofolo"–Trieste, Italy, between April and November 2022.

The Institutional Review Board (IRB) of the Institute for Maternal and Child Health–IRCCS "Burlo Garofolo"–Trieste approved the study under the univocal code protocol GEN/INT 0001310 on 7 July 2021. Being an in vitro study not involving human subjects, informed consent was not required.

2.2. Study Objectives

The primary aim of the study was to evaluate, through Adenosine triphosphate (ATP) bioluminescence analysis, whether the use of an overheated dry-saturated steam system was effective in reducing the superficial microbial contamination on selected surfaces of the dental chair after the disinfection procedure (T1), in comparison to the baseline (T0), i.e., at the end of an aerosol-generating dental procedure, before performing any routine cleaning and disinfecting procedures. The secondary aim was to evaluate, through ATP bioluminescence analysis, any differences in the superficial microbial contamination of the examined dental chair's surfaces at T0 in relation to the surface type.

2.3. Dental Chair' Surfaces

The following three surfaces of the dental chair were included in the study: the center of the scialytic lamp, the control button panel, and the center of the spit bowl. The surfaces to be analyzed had to be dry and visibly clean of any traces of dirt and/or blood stains. All surfaces under study were allowed to dry for a few minutes after performing the aerosol-generating dental procedure and after the steam disinfection before performing the analysis. Any visible water that remained on the surface after a few minutes, particularly with respect to the spit bowl, was gently dried with a paper tissue. Any surfaces with visibly detected stains were excluded from the study and disinfected using chemical agents according to the disinfection protocol followed by the Institute for Maternal and Child Health–IRCCS "Burlo Garofolo"–Trieste, Italy.

2.4. Sample Size Calculation

The sample size was calculated on the study's primary outcome (variation of the superficial microbial contamination of the dental chair's surfaces between T0 and T1) by hypothesizing mean microbial contamination on each dental chair's surface of 250 RLU (standard deviation 240) before and 50 RLU (standard deviation 45) after the disinfection (effect size = 0.9), setting alpha at 0.05 and beta at 0.2. The minimum expected sample size required was 13 evaluations for each surface (G*Power, Wilcoxon signed-rank test–matched pairs). This number applied to each surface included in the study has brought to a minimum of 39 tests before–after evaluations to complete the study.

2.5. Operative Protocol

The superficial microbial contamination of each dental chair's surface included in the study was evaluated by ATP bioluminescence analysis at the end of an AGDP (professional oral hygiene session using an ultrasonic scaling device) before performing any cleaning procedures (T0) and after the disinfection procedure with an overheated dry-saturated steam system (T1).

In order to avoid any bias in the analysis and ensure that the surfaces under study were clean before starting the AGDP, all surfaces of the dental chair were disinfected by using chemical agents following the Institute's disinfection protocol, and they were tested using the ATP bioluminescence analysis before seating the patient.

2.5.1. Samples Collection

In order to detect the presence of ATP molecules on the surfaces under study, a swab provided by the test manufacturer (3M ESPE) compatible with the luminometer used for ATP bioluminescence analyses was swabbed over the selected surfaces horizontally from one side to the other and vertically from top to bottom, slightly pressing and rotating it to ensure the complete contact with the surface as specified by the manufacturer's sampling guide [36]. For each surface under study, a flat area of about 10 × 10 cm, as measured with a caliper, was swabbed.

2.5.2. Overheated Dry-Saturated Steam Disinfection System

The professional steam disinfection device *Polti Sani System*–Professional Division–Polti S.p.A., Como, IT, was used to disinfect the surfaces under study according to the operative protocol recommended by the manufacturer [37]. The dry-saturated steam was delivered at a temperature of 180 °C, at a pressure of max 6 Bar, and at a speed of 10 cm/s for 30 s for each area to be disinfected, keeping the steam jet perpendicularly to the surface at a distance of 0.5 cm. The steam ejection was not interrupted for more than 5 s when passing from one surface to another. The *Polti hpMED* detergent, whose use is optional [37], was not used since the present study aimed to evaluate the effectiveness of the overheated dry-saturated steam alone in the disinfection of the dental chair's surfaces.

2.5.3. Adenosine Triphosphate (ATP) Bioluminescence Analyses

A luminometer (3M Clean-Trace Luminometer) was used for the ATP bioluminescence analysis according to the operative protocol specified by the manufacturer [36]. After swabbing each surface under study, the swab was placed into the tube of the luminometer, and the ATP test was activated by pressing down the tube's blue handle; the tube was shaken from side to side for at least 5 s to ensure the mixing of reagents and then inserted into the luminometer's chamber for real-time reading of the result. The ATP amount of each tested surface, which gives a measure of its microbial contamination [34], was shown on the luminometer screen expressed both quantitatively in RLU (cut-off = 150 RLU) and qualitatively as "approved" or "not approved" [36].

Whenever the disinfected surfaces showed high values of microbial contamination, the disinfection procedure with the overheated dry-saturated steam disinfection system and the ATP bioluminescence analysis was repeated. After obtaining the approved status from

the luminometer, the surfaces under study and all the other surfaces of the dental chair were disinfected according to the routine protocols followed by the Institute for Maternal and Child Health–IRCCS "Burlo Garofolo"–Trieste, Italy.

2.6. Statistical Analysis

Statistical analysis was performed using SAS software, v. 9.4 (SAS Institute, Cary, NC, USA). A descriptive statistical analysis of the superficial microbial contamination of all surfaces and each type of surface under study was performed in terms of the median and interquartile range (25–75%) at T0 and T1. The Wilcoxon signed-rank test was used to evaluate the difference between the RLU values at T0 and T1 for all surfaces and for each type of surface under study. Differences between the disinfection at T0 and T1, expressed by the luminometer as categorical data "approved" or "not approved" for all surfaces and each type of surface under study, were analyzed by the McNemar test. To evaluate the differences in the superficial microbial contamination among the three surfaces under study, at T0 and T1 separately, the Kruskal Wallis test and the Chi-Square tests were performed. The appropriate test was chosen based on the type of disinfection data, continuous or categorical, respectively. The level of significance (p) was set to <0.05.

Data registered before seating the patient and starting the dental procedure ensured that the surfaces under study were cleaned but were not included in the analyses, since the study aimed to evaluate the effectiveness of the overheated dry-saturated steam system alone in the disinfection of the dental chair surfaces.

3. Results

Twenty detections on three dental chair areas (scialytic lamp, control button panel, spit bowl) were recorded for a total of 60 before–after evaluations.

Table 1 shows the distributions of RLU continuous values of superficial contamination at T0 and T1 and the distribution of their paired difference for all the evaluated surfaces. The paired distribution between categorical disinfection data at T0 and T1 is reported in Table 2. All surfaces were significantly cleaned after the use of the overheated dry-saturated steam.

Table 1. Distributions of the Relative Light Unit (RLU) values for all tested surfaces. A cut-off of 150 RLU was set to consider a surface clean.

Time	N	Min	25th Percentile	Median	75th Percentile	Max	Wilcoxon Signed-Rank *p-Value*
T0	60	15	96	255	751.5	32,097	
T1	60	4	15	28	63	645	
Paired difference *	60	−32,015	−670	−208	−60.5	32.5	<0.0001

* Paired difference = T1 RLU value-T0 RLU value for the same detection.

Table 2. Paired distribution between categorical disinfection data at T0 and T1 for all tested surfaces; ($p < 0.05$).

	T1		McNemar *p-Value*
T0	*"Not Approved"* (n = 4)	*"Approved"* (n = 56)	
"Not approved" (n = 40)	4 (100.0)	36 (64.3)	<0.0001
"Approved" (n = 20)	0 (0.0)	20 (35.7)	

In Table 2, four surfaces resulted as "not approved" at T1. In particular, the RLU mean values of these surfaces were 3.118 at T0 and 550, respectively, at T1. The disinfection procedure was thus repeated and the surfaces were tested again, showing low RLU values (mean values = 69).

Table 3 contains data regarding descriptive analysis of the superficial contamination at T0 and T1 and their paired difference for each evaluated surface.

Table 3. Distributions of the RLU values for each evaluated surface; ($p < 0.05$). A cut-off of 150 RLU was set to consider a surface clean.

Surface	Time	N	Min	25th Percentile	Median	75th Percentile	Max	Wilcoxon Signed-Rank *p-Value*
Scialytic lamp	T0	20	15	70	175	441.5	4846	
	T1	20	4	9	20	28	645	
	Paired difference *	20	−4201	−428	−157	−43.5	1	<0.0001
Control panel	T0	20	42.5	126.5	201.5	596	32,097	
	T1	20	7	17	26.5	69	94.5	
	Paired difference *	20	−32,015	−580	−180	−68	32.5	<0.0001
Spit bowl	T0	20	36	175	417.5	1070	3739	
	T1	20	7	23	48	90.5	410	
	Paired difference *	20	−3663	−891.5	−368.5	−93	13	<0.0001

* Paired difference = T1 RLU value-T0 RLU value for the same detection.

Table 4 presents categorical disinfection data at T0 and T1, stratified for each surface. Each surface shows statistically significant results after cleaning with the overheated dry-saturated steam.

Table 4. Paired distribution between categorical disinfection data at T0 and T1 for each evaluated surface; ($p < 0.05$).

Surface		T1		McNemar *p-value*
Scialytic lamp	**T0**	*"Not approved"* (n = 1)	*"Approved"* (n = 19)	
	"Not approved" (n = 11)	1 (100.0)	10 (52.6)	0.002
	"Approved" (n = 9)	0 (0.0)	9 (47.4)	
		T1		**McNemar *p-value***
Control panel	**T0**	*"Not approved"* (n = 3)	*"Approved"* (n = 17)	
	"Not approved" (n = 15)	3 (100.0)	12 (70.6)	0.001
	"Approved" (n = 5)	0 (0.0)	5 (29.4)	
		T1		**McNemar *p-value***
Spit bowl	**T0**	*"Not approved"* (n = 0)	*"Approved"* (n = 20)	
	"Not approved" (n = 14)	0 (0.0)	14 (70.0)	0.001
	"Approved" (n = 6)	0 (0.0)	6 (30.0)	

Differences in the superficial contamination among the surfaces under study at T0 and T1, separately, are reported in Table 5.

Table 6 shows associations between the surface type and categorical disinfection results. No difference in the degree of disinfection among the surfaces at T0 and T1 emerged.

Table 5. Distributions of the RLU values for each evaluated surface at T0 and T1; ($p < 0.05$). A cut-off of 150 RLU was set to consider a surface clean.

Time	Surface	N	Min	25th Percentile	Median	75th Percentile	Max	Kruskall Wallis *p-Value*
T0	*Scialytic lamp*	20	15	70	175	441.5	4846	0.15
	Control panel	20	42.5	126.5	201.5	596	32,097	
	Spit bowl	20	36	175	417.5	1070	3739	
T1	*Scialytic lamp*	20	4	9	20	28	645	0.6
	Control panel	20	7	17	26.5	69	94.5	
	Spit bowl	20	7	23	48	90.5	410	

Table 6. Associations between the surface type and categorical disinfection results; ($p < 0.05$).

Surface	T0		Chi-square *p-value*
	"Not approved" (n = 40)	*"Approved"* (n = 20)	
Scialytic lamp	11 (27.5)	9 (45.0)	0.38
Control panel	14 (35.0)	6 (30.0)	
Spit bowl	15 (37.5)	5 (25.0)	
Surface	**T1**		**Chi-square *p-value***
	"Not approved" (n = 4)	*"Approved"* (n = 56)	
Scialytic lamp	1 (25.0)	19 (33.9)	0.31
Control panel	0 (0.0)	20 (35.7)	
Spit bowl	3 (75.0)	17 (30.4)	

4. Discussion

Due to the working conditions in close contact with the patient and the performing of aerosol-generating dental procedures [6–8], dentists are reported to be among the healthcare professionals with a high risk of contagion and have been considered particularly exposed during the COVID-19 pandemic [8,9]. Adopting proper disinfection protocols in dental work environments is fundamental to reduce the risk of cross-infections for patients and dental healthcare professionals [8,12,18–20].

Among the physical so-called "No-Touch" Disinfection (NTD) systems, the overheated dry-saturated steam is reported to be effective in inactivating heat-sensitive bacteria, fungi and viruses, including the HCoV-OC43 virus, a surrogate for SARS-CoV-2 [21–29].

However, the literature to date is lacking in studies evaluating the efficacy of overheated dry-saturated steam in the disinfection of surfaces in dental offices [21]. Given the limited available data, the present pilot in vitro study aimed to deepen the knowledge on the use of an overheated dry-saturated steam disinfection procedure in the dental practice and, in particular, its efficacy in reducing the superficial contamination of selected dental surfaces of the dental chair after performing aerosol-generating dental procedures. The rationale of this study was that the overheated dry-saturated steam might decrease the superficial microbial contamination of the evaluated surfaces thanks to its bactericidal, virucidal and fungicidal activity [22–28], consequently reducing the risk of cross-infections for both patients and professionals. In order to evaluate the cleanliness of the surfaces under study, an ATP bioluminescence analysis was used. This easy-to-use and handy tool is helpful in evaluating the effectiveness of disinfection procedures by providing an immediate result of the ATP amount present on the tested surfaces. The main limitation of this method, however, is linked to the fact that it measures the total organic contamination

on the surface and not the microbial count alone. Anyway, current literature points to a positive correlation between ATP levels and Total Viable Count (TVC) values, which estimate the microorganisms present on the evaluated surface, defining it as a suitable method for measuring the microbial count [34,35].

The choice to analyze the scialytic lamp, the control button panel and the spit bowl of the dental chair was dictated by the fact that these are easily accessible surfaces, resistant to heat, and representative of the surfaces that are most exposed to contamination during AGDPs. The scialytic lamp is one of the most exposed surfaces to aerosol, the control button panel is one of the surfaces most touched by the operator, and the spit bowl is the most exposed to the patient's saliva.

Data on the contamination of the evaluated surfaces showed a significant decrease of ATP on all the tested surfaces at T1 in comparison to T0, both in terms of RLU values (T1 median value = 28 versus T0 median value = 255; cut-off = 150) and of categorical data (56 "approved" evaluations at T1 out of the 60 performed). With respect to the four "not approved" evaluations at T1, the high cellular ATP amount detected on these surfaces by the luminometer (RLU mean value = 550, which is more than three times the cut-off) after the steam application, might be related to the incomplete removal of residual water or saliva on the tested surfaces. The fact that these surfaces were found to be clean after 30 additional seconds of steam disinfection (RLU mean value = 69) suggests that 60 s steam disinfection may be required in the case of high contamination. In addition, it should be considered that in this study, the *Polti hpMED* detergent [37] was not used in order to evaluate the efficacy of the steam alone. It may be hypothesized that using the detergent in combination with the steam might help remove the residual contaminants on the surface, improving the disinfecting power of this procedure.

Significant findings were also observed when stratifying the data by type of surface. Median RLU values calculated for the scialytic lamp, the control button panel and the spit bowl decreased, in fact, from 175, 201.5 and 417.5, respectively, at T0 to 20, 26.5 and 48, respectively, at T1. In relation to the categorical data at T1, of the 20 evaluations performed for each surface, 19 evaluations of the scialytic lamp' surface, 17 of the control button panel surface and 20 of the spit bowl surface out were "approved," showing that the use of the overheated dry-saturated steam disinfection after the performing of AGDPs was effective in reducing the contamination on the evaluated surfaces. The primary hypothesis tested was thus accepted. On the other hand, considering the different surfaces evaluated at T0, the spit bowl showed the highest RLU value (417.5), while the scialytic lamp showed the lowest (175). However, differences in terms of superficial contamination among the evaluated surfaces were not statistically significant, which demonstrates that all surfaces of the dental chair were equally contaminated after performing AGDPs.

Based on this study's findings, overheated dry-saturated steam effectively reduced the superficial contamination of selected surfaces of the dental chair. Decreasing the microbial contamination on frequently touched surfaces means reducing the risk of indirect infections for patients and DHCPs and, consequently, the care burden.

Overheated dry-saturated steam has several advantages: it is an easy-to-use and rapid method able to inactivate heat-sensitive pathogens in a few seconds at the temperature of 180°C without leaving any residues and without the need to ventilate the environment after its use, unlike chemical disinfectants; it does not require the use of individual protective devices for users; and the risk of burns is very low since the temperature of the steam jet considerably decreases at a few centimeters distance from the emission nozzle. In addition, since it requires water with no additional chemicals, it can be used on textiles with no damage risk, and the risk of slippery surfaces is negligible. Lastly, an NTD system does not depend on the operator because it relies on a steam-generation device to ensure a standardized disinfection procedure [21,27,28,30,37].

On the other hand, the main limitation of overheated dry-saturated steam is the presence of visible traces of dirt and/or blood stains on the surfaces that must first be cleaned with chemicals. Caution should also be taken when disinfecting electrical equipment; the

steam jet must not be directed toward live electronic devices or onto toxic substances and explosive liquids or powders [23,37].

Although this is a pilot study, it represents a significant scientific contribution to disinfection protocols and measures that have to be adopted by DHCPs in order to reduce the risk of cross-infections in dental practices. The literature on this topic is still limited and the present study's findings enrich the current knowledge, primarily based on studies evaluating the efficacy of steam disinfection on selected pathogens grown in in vitro culture media [22–28]. The study was performed in a real dental setting and therefore provides relevant findings with a practical application in the dental practice's daily disinfection routine. These findings are even more important in a pediatric dental setting, such as the one in which the study was performed, where children frequently have respiratory symptoms that increase the risk of cross-infections. In addition, being a health-safe non-toxic disinfection system, it reduces the risk of allergies or adverse reactions to chemicals, which is not negligible among children who are prone to explore and first touch the chair surfaces and then their eyes, nose and/or mouth.

Considering the obtained preliminary findings, the study design was adequate to achieve its purpose; anyway, as this was a pilot study, further research is needed to evaluate the overheated dry-saturated steam system's efficacy in the disinfection of other surfaces and/or devices in dental offices. In addition, since the ATP bioluminescence analysis does not provide information on the type of microorganisms e.g., bacteria, viruses and fungi present on the evaluated surface, microbiological studies on contaminated surfaces are necessarily required to deepen the knowledge on this topic. Nevertheless, by giving an immediate result of the ATP cellular amount of the evaluated surface, it is a very useful screening tool to monitor the hygienic quality of surfaces, especially in the healthcare setting. It may allow immediate intervention if surfaces are not adequately disinfected and also, by giving an immediate visible result of the efficacy of cleaning procedures, it may help increase professionals' awareness of the importance of proper disinfection especially in light of the COVID-19 pandemic [34,35]. Lastly, comparing the efficacy of overheated dry-saturated steam versus conventional chemical disinfection measures in the disinfection of surfaces in dental offices might help draw specific conclusions and define new disinfection protocols in dental practice.

5. Conclusions

Based on the obtained findings and within the limits of this preliminary study, a 30 s disinfection with dry-saturated steam at the temperature of 180 °C and a pressure of max 6 bar effectively decreased the microbial contamination on dental chair surfaces after the performing of aerosol-generating dental procedures. Dry-saturated steam disinfection can therefore be used daily in dental practices as a rapid and easy-to-use disinfection system. Moreover, being a non-toxic disinfection system, its use may be proposed as an environmentally friendly alternative to conventional chemical disinfectants when surfaces with no visible traces of dirt and/or blood stains need to be cleaned.

Author Contributions: Conceptualization, V.L. and M.C. (Milena Cadenaro); methodology, V.L., M.G., L.R. and M.C. (Milena Cadenaro); investigation, V.L. and M.C. (Maddalena Chermetz); resources, V.L., M.G. and M.C. (Milena Cadenaro); data curation, V.L., M.G. and M.C. (Maddalena Chermetz); writing—original draft preparation, V.L. and M.G.; writing—review and editing, V.L., M.G. and M.C. (Milena Cadenaro); visualization, V.L., M.G., M.C. (Maddalena Chermetz), L.R. and M.C. (Milena Cadenaro); supervision, M.C. (Milena Cadenaro). All authors have read and agreed to the published version of the manuscript.

Funding: Polti S.p.A. Company supported this work through the contribution given to the Institute for Maternal and Child Health IRCCS Burlo Garofolo, Trieste, Italy.

Institutional Review Board Statement: The study was approved by the ethical committee of the Institute for Maternal and Child Health–IRCCS "Burlo Garofolo" under the univocal code Prot. GEN/INT 0001310, 7 July 2021.

Informed Consent Statement: Not applicable (the study did not involve humans).

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: This work was carried out by the health professionals at the Dental Clinic of the Institute for Maternal and Child Health IRCCS Burlo Garofolo-Trieste, Italy.

Conflicts of Interest: The authors declare no conflict of interest.

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