

Effect of ultraviolet disinfection on the wettability of polyvinyl siloxane impression material: An *in vitro* study

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Abstract

Objective: The objective of the present *in vitro* investigation was to ascertain the impact of ultraviolet (UV) disinfection for 10 min on the wettability of polyvinyl siloxane (PVS) impression material in comparison to the chemical disinfection method of 2% glutaraldehyde (GTA) for 10 min.

Materials and Methods: Thirty PVS impression specimens were prepared from custom-made stainless steel impression moulds and divided randomly into two groups. In Group A, chemical disinfection was accomplished using a 2% GTA solution for 10 min. In Group B, UV irradiation was administered for 10 min. The specimens in both groups were assessed for wettability both before and after the disinfection process designated for their respective group. A paired *t*-test and an independent *t*-test were employed to determine the intra-group effect and differences among each of the groups under investigation, respectively.

Results: The wettability evaluation of the PVS impression material before and after chemical disinfection indicated a statistically significant change in the wettability of the material ($P < 0.05$). Further, the contact angle before UV exposure exceeded that following UV exposure; however, this difference was statistically insignificant ($P > 0.05$). The wettability of PVS impression material following chemical disinfection with 2% GTA and UV disinfection demonstrated a statistically significant variation in the wettability of the material ($P < 0.05$). The contact angle following 2% GTA treatment was markedly greater than that observed after UV exposure.

Conclusion: The impression material preserved its wettability following UV light exposure, suggesting that UV disinfection is a more secure disinfection procedure compared to the 2% GTA solution.

Keywords: Contact angle, glutaraldehyde, impression, polyvinyl siloxane, ultraviolet disinfection, wettability

Introduction

Infection control is a vital concept in modern dentistry. Several authors advocate disinfection to sterilization when dealing with impression materials.^[1-3] Disinfection techniques are preferred because these materials are placed into and

removed from the oral cavity rather than placed into a sterile bodily cavity.^[2] Hydrophilicity is a key feature of impression materials. Wettability refers to a liquid's relative affinity for the surface of a solid. The wettability of a surface is typically assessed by evaluating the magnitude of the contact angle established between a drop of liquid and the

surface under consideration. Small contact angles suggest good wettability. One disadvantage of using elastomeric impression materials is that they have little surface energy, making it difficult to wet them with gypsum slurry. There is a dearth of studies evaluating the wettability of polyvinyl siloxane (PVS) impression materials by contrasting the chemical and physical disinfection methods, especially using ultraviolet (UV) irradiation.^[1,4,5]

Wettability, or the ability of a liquid to spread over a solid surface, might be tested using many methods, such as the Wilhelmy and sessile drop techniques.^[6] Both approaches assess increasing and receding contact angles. The advancing contact angle (θ_A) is the angle formed when a liquid advances over a solid surface. The contact angle between a solid and a liquid is determined by the context of the solid surface and the energy of the liquid surface, also known as surface tension ($\text{mN/m} = \text{dynes/cm}$). In particular, contact angle measurements might be utilized to determine the surface reactivity of a solid-liquid interface.^[5] The addition silicon impression material is the most precise and stable in dimension. They have evolved into one of the most widely used impression materials for indirect restorations, including crowns, fixed partial dentures, inlays, veneers, implant-supported restorations, and removable partial and complete dentures. The material is available in a range of viscosities to accommodate various impression processes. The accuracy of the impression following disinfection is of great interest.^[7]

The PVS impression materials are hydrophobic and may not adhere well to moist oral tissues or watery gypsum-based die materials. As a result, set gypsum casts and dies can contain pits and voids. Improved hydrophilic PVS impression materials have been introduced for enhanced impression making. Hydrophilic chemicals provide two primary functions: (a) to improve wetting and spreading on moistened oral tissues, and (b) to promote enhanced wettability by water-based dental stone slurries. Any alteration in the surface reactivity of the material used for the impression might impact the precision of

the impression, which is therapeutically relevant because impressions are frequently disinfected to reduce the propagation of diseases, which include tuberculosis, herpes simplex, HIV, and hepatitis B and C. A second pour utilizing an impression with lesser wettability could also demonstrate a substantial reduction in accuracy.^[6,8]

Disinfecting impression materials can reduce cross-contamination, although it may affect their wettability.^[9] Some chemical treatments often employed to disinfect impressions which can produce considerable dimensional alterations.^[10] Because the dimensional precision of the impression plays a significant role in determining the success or failure of the restoration or prosthesis made from it, UV has become recognized as an efficient technique for inactivating microorganisms in recent decades, as opposed to other disinfection techniques such as spraying and immersion.^[7] Consequently, the objective of this *in vitro* investigation was to ascertain the impact of UV disinfection for 10 min on the wettability of PVS impression material in comparison to the chemical disinfection method of 2% glutaraldehyde (GTA) for 10 min.

Materials and Methods

The objective of the current investigation was to assess the wettability of PVS impression material that was subjected to two distinct disinfection methods. The sample size was calculated using the formula $n = 2 \text{SD}^2 [Z_{\alpha} + Z_{\beta}]^2 / \delta^2$; where, $Z_{\alpha} = 1.96$, $Z_{\beta} = 0.84$, $\text{SD} = 4.73$, $\delta = 5$. The standard deviation values were determined from the preceding investigation.^[11] The calculation indicated that the minimum estimated sample size was 14.03. Therefore, in this investigation, we have selected $n = 15$ for each group, resulting in an overall sample size of 30.

Fabrication of specimens for wettability

The measurement and handling of light-body PVS impression material were conducted in accordance with the manufacturer's guidelines. A stainless steel impression mold was constructed with an inner

diameter of 29.97 mm, an outer diameter of 38 mm, and a height of 3 mm. PVS impression material (Zhermack Elite HD + Light body) was injected into the mold and later pressed against two glass slabs to create a planar surface. Only specimens devoid of flaws were considered. Subsequently, specimens were cleansed with running water for 30 seconds and then dried using filtered compressed air.

Grouping the specimens for testing

Thirty specimens were prepared and divided randomly into two groups: Group A and Group B. In Group A, chemical disinfection was accomplished by submerging the specimen in a 2% GTA solution for 10 min. In Group B, UV disinfection using a corona oven was administered for 10 min (voltage 220V, frequency 50 Hz, input power 220W, Model No. COVN002). The specimens in both groups were subsequently assessed for wettability both before and after the disinfection process designated for their respective group.

Testing the specimens for wettability

Specimens were evaluated for wettability before disinfection and 30 min post-disinfection for each group. This was intended to replicate the clinical scenario, as recommended by the ADA. Each specimen was positioned on the platform of a telescopic goniometer. Three drops of 0.05 mL of a saturated calcium sulfate solution in double-distilled water were subsequently applied to the test surface. The drops were permitted to rest for thirty seconds to attain equilibrium, and the contact angles of each of the three drops were accurately recorded using the goniometer. The mean of these drops was computed for each specimen. The acquired data were organized into a table and subsequently utilized for additional analytical examination. With an accuracy of 0.1° , the resultant variable was the contact angle expressed in degrees.

Statistical analysis

The data were compiled in Microsoft Excel and subsequently analyzed using IBM Statistical

Package for the Social Sciences Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA) which was employed to conduct a statistical analysis of the test results. A paired *t*-test and an independent *t*-test were employed to determine the intra-group effect and differences among each of the groups under investigation, respectively.

Results

The evaluation of the wettability of PVS impression material before and after chemical disinfection with 2% GTA for 10 min was conducted using the paired sample *t*-test. The results revealed a statistically significant change in the wettability of PVS impression material pre- and post-chemical disinfection with 2% GTA ($P < 0.05$), 95% CI (-7.6, -3.5) [Table 1].

The assessment of the wettability of PVS impression material before and after 10 min of UV disinfection was conducted using the paired sample *t*-test. The contact angle before UV exposure exceeded that following UV exposure, however, this difference was statistically insignificant ($P > 0.05$), 95% CI (-0.26, 4.91) [Table 2].

The wettability of PVS impression material following chemical disinfection with 2% GTA and UV disinfection demonstrated a statistically significant variation in the wettability of PVS impression material. The contact angle following 2% GTA treatment was markedly greater than that observed after UV exposure ($P < 0.05$), 95% CI (2.31, 8.06) [Table 3].

Discussion

The ADA and the Center for Disease Control strongly advocate for the disinfection of all impressions to mitigate the potential transfer of infectious diseases. The diverse dental materials used for impressions may necessitate varying disinfection techniques. Chemical disinfection of impression material can be accomplished either by immersion or spraying with various disinfectants at designated concentrations for a set duration.^[12]

Table 1: Comparison of the wettability of polyvinyl siloxane impression material before and after chemical disinfection using 2% glutaraldehyde

Contact angle - 2% glutaraldehyde	N	Mean	Standard deviation	95% confidence interval of the difference		P-value
				Lower	Upper	
Contact angle before 2% glutaraldehyde	15	60.76	2.05	-7.6	-3.5	0.000**
Contact angle after 2% glutaraldehyde	15	66.40	3.74			

**P<0.01 - highly significant. UV: Ultraviolet

Table 2: Comparison of the wettability of polyvinyl siloxane impression material before and after UV disinfection

Contact angle - UV exposure	N	Mean	Standard deviation	95% confidence interval of the difference		P-value
				Lower	Upper	
Contact angle before UV exposure	15	63.54	2.97	-0.26	4.91	0.075
Contact angle after UV exposure	15	61.21	4.28			

P>0.05 - insignificant. UV: Ultraviolet

Table 3: Comparison of the effect of UV disinfection with chemical disinfection on the wettability of polyvinyl siloxane impression material by measuring the contact angle

Wettability	N	Mean	Standard deviation	95% confidence interval of the difference		P-value
				Lower	Upper	
Contact angle after 2% glutaraldehyde	15	66.400	3.740	2.31	8.06	0.001**
Contact angle after UV exposure	15	61.210	4.280			

**P<0.01 - highly significant. UV: Ultraviolet

Immersion ensures contact with all surfaces for an extended duration and, hence, accomplishes an improved method of disinfection.^[13]

Another effective form of disinfection that inactivates germs is UV irradiation. This is a contemporary technology wherein the item to be disinfected is situated within a UV disinfection chamber and subjected to UV radiation from multiple angles for a predetermined duration, adjustable between 1 and 60 min. UV light influences cellular DNA and exhibits a significant antibacterial response. The factors affecting effectiveness include exposure duration, radiation intensity, and microbe accessibility. Various investigators have undertaken studies to compare different combinations of disinfection procedures, examining their effects on bacterial count, dimensional accuracy, stability, and surface

qualities.^[14] The majority of investigations indicated that materials exposed to different sterilization methods experience dimensional alterations in microns, potentially impacting the precision of prosthodontic impressions.^[15]

Nimonkar *et al.*^[16] assessed the impact of chemical disinfectants and UV disinfection on the dimensional stability of PVS impressions. They observed significant dimensional alterations in specimens disinfected with 2% GTA and 1% sodium hypochlorite, in contrast to those treated with a UV disinfectant unit. Asopa *et al.*^[15] observed that the dimensional alterations in the impression material following disinfection with 2% GTA were significantly greater than those resulting from autoclaving. To avoid contamination and cross-contamination of these impressions, they must be immediately cleaned after being taken out

of the mouth and clearly labeled. While rinsing impressions with running water is a prevalent method to remove saliva and blood, it might not adequately eradicate pathogenic bacteria. Consequently, dental personnel must be acquainted with standardized protocols for disinfecting dental impressions and casts. Several techniques have been documented for impression disinfection, such as chemical disinfection, autoclaving, microwave treatment, and UV radiation, each possessing distinct merits, drawbacks, and impacts on impression materials and casts.^[17,18]

Various chemical disinfectants, including GTA and sodium hypochlorite, are employed to disinfect impressions. GTA, a volatile colorless solution, serves as a disinfectant in both liquid and gaseous forms. GTA, frequently utilized for the sterilization of medical and dental instruments, additionally functions as a preservative in industrial settings. It exhibits strong efficacy against microorganisms, spores, fungi, and parasites, demonstrating enhanced effectiveness at lower concentrations of organic material. Correct application of these disinfectants necessitates appropriate protective gear in a well-ventilated setting under the oversight of a qualified professional.^[19]

Physical disinfection of dental impressions can be achieved through UV and microwave methods. The efficacy of UV disinfection is contingent upon several elements, such as duration, intensity, humidity, and microorganism permeability. Due to the presence of numerous sites conducive to microbial proliferation in dental prostheses, UV light must be administered from various angles. When exposed to UV light, *Candida albicans* colonies decreased significantly as opposed to low-intensity direct current discharge. The utilization of higher wattage UV light tubes has been shown to markedly decrease colony counts in a reduced timeframe. The optimal antibacterial efficacy through UV disinfection is achieved at 24 watts (3750 $\mu\text{W}/\text{cm}^2$), with increased wattages leading to a more rapid decline in *Candida albicans* colony counts, eventually resulting in complete eradication.^[18,20]

Samra *et al.*^[21] suggested that the UV method is an advantageous option for disinfecting impressions while maintaining their dimensional stability. The effects of UV light on sodium hypochlorite (1% or 5.25%) and 2% GTA have been compared in the literature.^[4,16,21] A similar study examined UV light with quaternary ammonium compounds, phenoxyethanol, alcohol, and ozone.^[20] Similarly, an additional investigation evaluated the efficacy of UV light in comparison to 0.2% peracetic acid, glucosamine natural polymer, and ozonated water.^[22] Consequently, UV light is a physical technique supported by substantial proof in the literature.^[23-25] Furthermore, some investigations examined varied durations for disinfection in the UV light chamber. A prior study allocated 3 min for alginate and addition silicone,^[21] while another investigation designated 10 min for addition silicone.^[7] Yet another investigation assigned 10 min for zinc oxide eugenol, polyether, and alginate.^[22] In addition, two other investigations evaluated 20 min for addition silicone and polyether,^[4,16] and another study utilized 40 min for addition and condensation silicones.^[20]

The prior studies indicate studies that the disinfection efficacy of UV light was assessed for durations of 15, 30, 60, 90, 120, and 180 s for addition silicone,^[26] 3 min for alginate and addition silicone,^[27] 20 min for alginate,^[18] 40 min for addition and condensation silicones,^[24] and 3, 6, 10, and 15 min for alginate, polyether, and addition silicone.^[23] Aeran *et al.*^[23] determined that a 10-min exposure was adequate for disinfection of alginate and addition silicone, whereas a 3-min treatment sufficed for complete disinfection of polyether. Considering the variability in observed UV light disinfection durations, additional research is necessary to standardize exposure times based on the dental impression materials employed.

In clinical practice, ensuring optimum wettability of impressions is essential, as inadequate wettability heightens the likelihood of voids and incomplete stone flow while pouring; thus jeopardizing the precision and fit of the cast. Our findings demonstrate a statistically significant reduction

in contact angle following the UV treatment employed. This finding of the study corroborates similar prior studies^[28,29] that suggest a decrease in wettability of PVS impression material as a result of disinfection with 2% GTA solution. This was further verified by our study findings, in which the comparison of the wettability of PVS impression material before and after chemical disinfection using 2% GTA demonstrated a considerable increase in contact angle after GTA disinfection. Henceforth, UV light could be an appropriate method to disinfect PVS impression material, giving an added benefit of leaving no chemical residues and significantly increasing wettability.

Conclusion

The 2% GTA solution diminished wettability, as evidenced by a notable rise in the contact angle scores of the impression material. In contrast, UV disinfection enhanced wettability while decreasing contact angle values, although not significantly. Consequently, under the constraints of this *in vitro* study, it can be determined that UV disinfection did not negatively impact the wettability of PVS impression material. Moreover, the impression material preserved its wettability following UV light exposure, suggesting that UV disinfection is a more secure disinfection procedure compared to the 2% GTA solution. In clinical practice, UV disinfection can thus be indicated as a dependable technique for controlling infections with PVS impression materials.

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