Original Article

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Effect of chemical disinfectant on the hydrophilicity of elastomeric impression material

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The aim of this study was to evaluate the effect of a chemical disinfectant on the hydrophilicity of elastomeric impression materials. Disc-shaped specimens (40 mm in diameter and 6 mm in thickness) of Silagum Light, Impregum™, Garant™, Duosoft™, and Identium® Light were prepared according to the manufacturers' recommendations. Six specimens of each impression material were allocated to control and experimental groups. Specimens in the experimental group were sprayed with 0.5% UMONIUM38® disinfectant and allowed a contact time of 10 minutes. Surface wettability was evaluated by measuring the contact angle using a goniometer with the sessile drop method, and the measurements were recorded using a video camera. The advancing contact angle of a distilled water droplet on the impression surface was measured at 0 s (T0), 30 s (T30), 60 s (T60), and 120 s (T120) after droplet placement. For each specimen, three sessile drops were applied to three different surface areas and recorded. The data were analyzed using mixed design ANOVA (repeated measure ANOVA and two-way ANOVA), followed by Bonferroni multiple comparison tests, with the level of statistical significance set at α = 0.05. When comparing the disinfectant group (0.5% UMONIUM38®) to the control group, no significant differences in contact angles were observed for all materials at T30, T60, and T120. However, at the initial time point (T0), the disinfectant significantly increased the contact angle of Identium® compared to its control. For SilagumLight and Impregum™, no significant differences were found between the experimental and control groups at T0. Overall, Identium® exhibited the lowest contact angles (highest hydrophilicity) in both control and disinfected groups across all time intervals compared to the other materials. Within the limitations of this study, it can be concluded that disinfection with 0.5% UMONIUM38® spray did not adversely affect the hydrophilicity of the tested VPS, PE, and VPES impression materials over time. The results demonstrate that this specific disinfectant is compatible with these elastomeric materials in terms of surface wettability, as the transient increase in contact angle observed for the VPES material was not clinically significant in the context of standard laboratory procedures. However, these findings are limited to the particular disinfectant tested; therefore, caution should be exercised when generalizing these results to other types of chemical disinfectants. Additionally, further investigation into dimensional stability and surface integrity is warranted to ensure overall clinical performance and long-term prosthetic success.

Keywords: chemical disinfectant, elastomeric impression materials, hydrophilicity, wettability

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Introduction

Accurate dental impressions are fundamental to the success of restorative and prosthetic dentistry, as they directly influence the fit, function, and longevity of definitive restorations. Elastomeric impression materials—particularly vinyl polysiloxane (VPS) and polyether (PE)—are widely used because of their excellent dimensional stability, elastic recovery, and ability to reproduce fine surface details [1]. More recently, vinyl polyether silicone (VPES)

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has been introduced as a hybrid elastomeric material designed to combine the favorable handling characteristics and hydrophilicity of PE with the dimensional stability and elastic properties of VPS [2–5].

Among the material properties that affect impression accuracy, hydrophilicity plays a critical role. Adequate hydrophilicity enhances the ability of impression materials to wet moist oral surfaces, displace saliva and blood, and flow into fine anatomical details. Increased wettability has been associated with reduced void formation and improved surface detail reproduction, particularly under clinically relevant wet conditions [2, 6–9]. While the hydrophilicity of unset impression materials is crucial for capturing details in a moist oral environment, the wettability of the set materials is equally vital for clinical success during laboratory procedures. The surface energy of the set impression directly influences its interaction with dental gypsum. A material with high hydrophilicity (low contact angle) facilitates the flow of stone into intricate areas of the impression and minimizes the entrapment of air bubbles at the interface. This ensures the production of a high-quality working model with superior surface detail reproduction and dimensional accuracy.

Despite their clinical advantages, dental impressions are inherently susceptible to microbial contamination because they come into direct contact with saliva, blood, and potentially pathogenic microorganisms, including bacteria, fungi, and viruses. To reduce the risk of cross-infection between dental clinics and laboratories, the Centers for Disease Control and Prevention (CDC) and the American Dental Association (ADA) recommend chemical disinfection of impressions before laboratory procedures [10]. A variety of chemical disinfectants—such as glutaraldehyde, sodium hypochlorite, chlorhexidine, and phenolic compounds—are commonly used owing to their broad-spectrum antimicrobial activity [11]. However, concerns remain regarding the potential adverse effects of these disinfectants on the surface and physical properties of elastomeric impression materials, particularly their hydrophilicity and wettability [12–15].

Chemical disinfection of impressions is typically performed using either immersion or spray techniques. Spray disinfection is often preferred in clinical practice because it allows adequate antimicrobial efficacy while minimizing the risk of dimensional distortion and surface degradation associated with prolonged immersion [10, 11]. At the Prosthodontic Clinic, Faculty of Dentistry, Mahidol University, a 0.5% Umonium 38® disinfectant (isopropyl-tridecyl-dimethyl-ammonium; Laboratoire Huckert's International) is routinely applied as a spray for a 10-minute contact period in accordance with the manufacturer's recommendations [16]. Although the effects of various disinfectants on elastomeric impression materials have been extensively investigated, limited evidence is available regarding the influence of Umonium 38® on the surface properties of these materials.

Contact angle measurement is the most commonly employed method for evaluating the wettability or hydrophilicity of dental impression materials [6–9,12–15]. Previous studies have reported that short-term disinfection may either increase or decrease material wettability, depending on the disinfectant type and material composition [12]. In contrast, polyether and addition silicone impression materials have been shown to tolerate long-term disinfection without significant changes in wettability [13]. However, data remain scarce regarding the effect of quaternary ammonium-based disinfectants, such as Umonium 38®, particularly on newer hybrid materials like VPES.

Therefore, the purpose of this study was to evaluate the effect of a 0.5% Umonium 38® disinfectant spray on the hydrophilicity of elastomeric impression materials, including VPS, PE, and VPES, by measuring advancing contact angles at four different time points following disinfection.

Materials and methods

Specimens preparation

Three types of elastomeric impression materials, Silagum Light (Vinyl polysiloxane silicone), Impregum™ Garant™L Duosoft ™(Polyether), and Identium® Light (Vinyl polyether silicone) used in this study are listed in Table 1.

Disc-shaped specimens (40 × 6 mm) of each impression material were fabricated using a polytetrafluoroethylene mold. Each material was mixed according to the manufacturer's instructions using an automatic cartridge mixing device with a spiral mixing tip. The mixed material was dispensed into the polytetrafluoroethylene mold, which was placed between two glass plates. After setting, each specimen was rinsed with distilled water for 1 minute and carefully air-dried. Specimens of each impression material were divided into control and experimental groups, with six specimens per group. For the control group, each specimen was kept in a closed container for 10 minutes, rinsed with distilled water for 1 minute, and carefully air-dried. The control specimens were then ready for contact angle measurement.

Disinfection procedure

Specimens in the experimental group were disinfected by spraying with 0.5% UMONIUM38® (Laboratoire Huckert's International). The disinfectant was maintained in contact with the impression surface for 10 min, in accordance with the manufacturer's recommendations. During the disinfection period, each specimen was stored in a closed container to prevent evaporation of the disinfectant. Subsequently, the specimens were rinsed with distilled water for 1 min to remove any residual disinfectant and carefully air-dried. The specimens were then ready for contact angle measurement.

Table 1 Elastomeric impression materials and disinfectant solutions used in this study.

Material	Manufacturer	Component	Working time/setting time (min at 23°C)
Impregum™ Garant™L Duosoft™	3M ESPE	Polyether (PE), Triglycerides	2.00/5.30
Silagum Light	DMG	Vinyl polysiloxane (VPS), Surfactants	2.00/5.45
Identium® Light	Kettenbach GmbH	Vinyl polysiloxane and polyether (VPES), Non-ionic surfactants	2.00/4.30
Umonium 38®	Laboratoire Huckert's International	Isopropyl alcohol, BenZalkonium chloride, Tridecyl ceteth alcohol, Quaternary ammonium compounds	

Contact angle measurement

Contact angle measurements of all impression material surfaces were performed using a contact angle goniometer (locally fabricated apparatus, Center of Nanotechnology Research Unit, Faculty of Science, Mahidol University, Thailand). Each specimen was positioned on the adjustable mechanical stage of the goniometer. A drop of distilled water, dispensed from an installed needle, was used as the wetting liquid and applied to the specimen surface at room temperature (25 °C). Each water droplet was immediately captured using a CCD camera (VCC-5775P, Sanyo Electric Co. Ltd., Tokyo, Japan). Images were monitored from the moment the distilled water droplet contacted the specimen surface. Advancing contact angles were measured at 0 s (T0), 30 s (T30), 60 s (T60), and 120 s (T120) after droplet deposition. Contact angle values were analyzed using image analysis software (Drop Analysis LB-ADSA and ImageJ software, version 1.47; National Institutes of Health, USA). For each specimen, three sessile drops were placed on three different areas, and all measurements were recorded for analysis.

Statistical analysis

Statistical analysis was performed using SPSS Statistics software (IBM SPSS, version 27; IBM Corp.). The data were analyzed using mixed design ANOVA (repeated measure ANOVA and two-way ANOVA), followed by Bonferroni multiple comparison tests, with the level of statistical significance set at $\alpha = 0.05$.

Results

The mean contact angle values and standard deviations for the control and experimental groups of the three impression materials at four measurement time points are presented in Fig. 1. Representative images of distilled water droplets on the surfaces of each impression material at the different measurement times are shown in Figs. 2–4. The different elastomeric impression materials exhibited distinct contact angle values and wettability characteristics, with variations observed over time during water droplet contact.

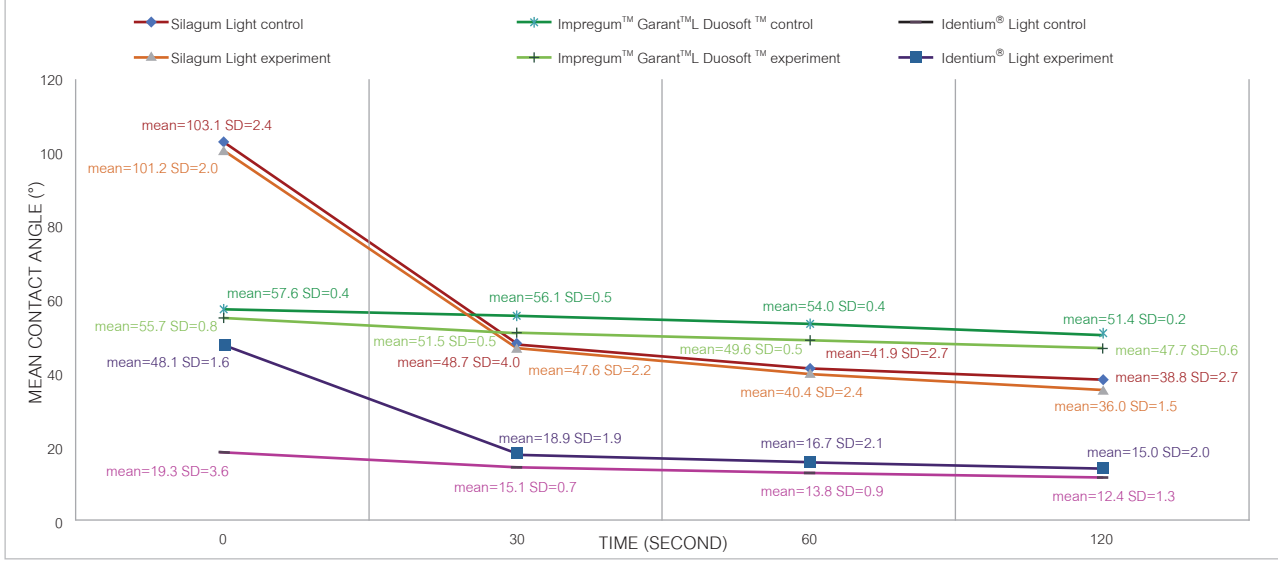


Figure 1 Mean contact angle values of the control and experimental groups for the three impression materials at four different measurement times.

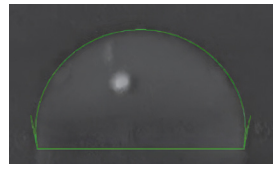
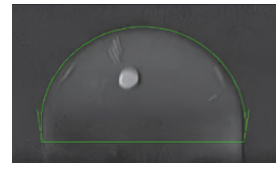
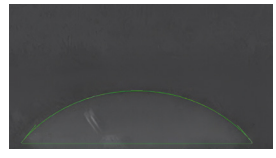
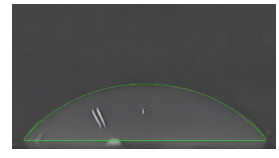
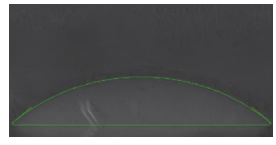
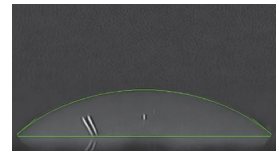
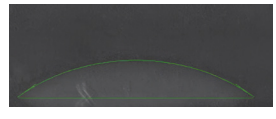
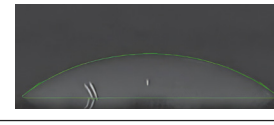
Material / Time (s)	Silagum Light (Control)	Silagum Light (Experiment)
0		
30		
60		
120		

Figure 2 The image of water drops on the surface of Silagum Light (VPS) impression material at four different measurement times.

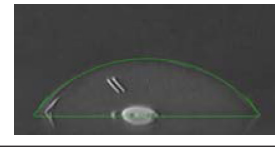
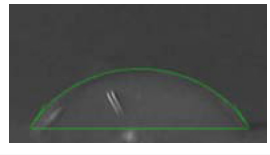
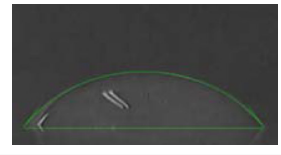
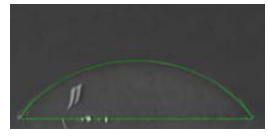
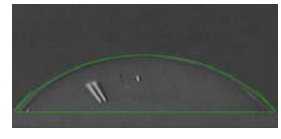
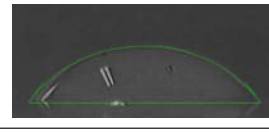
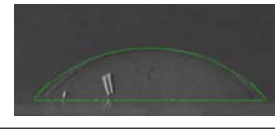
Material / Time (s)	Impregum™ Garant™ L Duosoft ™ (Control)	Impregum™ Garant™ L Duosoft ™ (Experiment)
0		
30		
60		
120		

Figure 3 The image of water drops on the surface of Impregum™ Garant™ L Duosoft™ (PE) impression material at four different measurement times

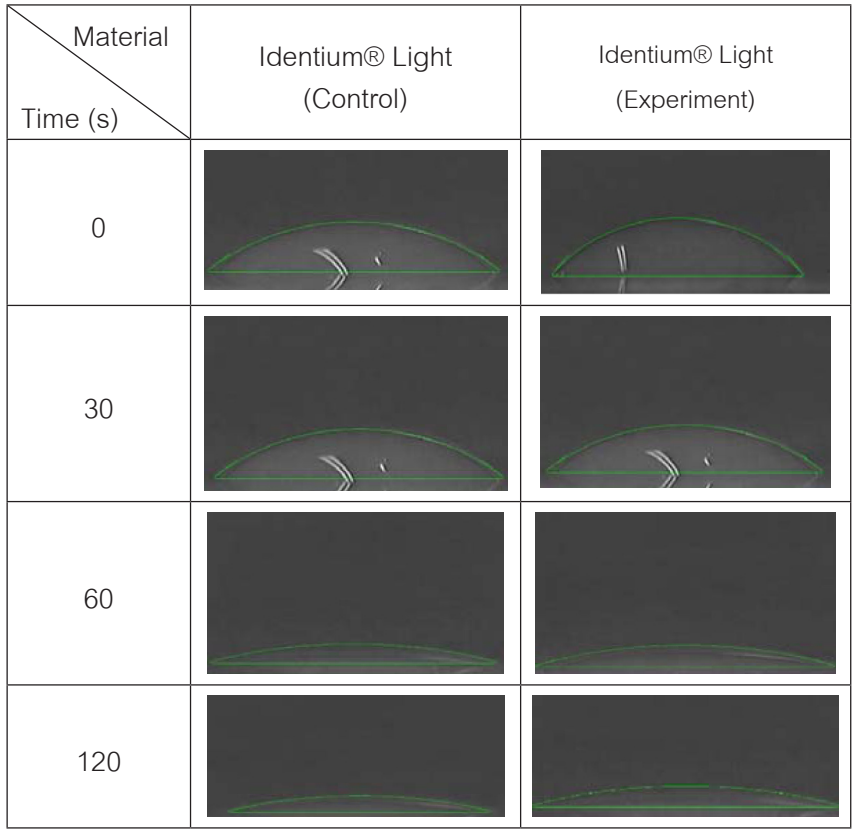


Figure 4 The image of water drops on the surface of Identium® Light (VPES) impression material at four different measurement times.

For Silagum Light (Fig. 1), the mean contact angles of both the control and experimental groups at T0 were the highest recorded values (103.1 ± 2.4° and 101.2 ± 2.0°, respectively). At T30, the mean contact angles of the control and experimental groups decreased markedly to 48.7 ± 4.0° and 47.6 ± 2.2°, respectively. A further slight reduction was observed at T60 (41.9 ± 2.7° and 40.4 ± 2.4°) and T120 (38.8 ± 2.7° and 36.0 ± 1.5°). The experimental group exhibited a trend similar to that of the control group throughout the measurement period (Fig. 1). Contact angle values greater than 100° at T0 indicate a hydrophobic surface characteristic for both groups. At T30, T60, and T120, contact angle values decreased to below 100°, indicating a transition to hydrophilic behavior in both the control and experimental groups.

For Impregum™ Garant™ L Duosoft™ (Fig. 1), the mean contact angle values of the control group were 57.6 ± 0.4° at T0, 56.1 ± 0.5° at T30, 54.0 ± 0.4° at T60, and 51.4 ± 0.2° at T120. The corresponding values for the experimental group were 55.7 ± 0.8°, 51.5 ± 0.9°, 49.6 ± 0.5°, and 47.7 ± 0.6°, respectively. All contact angle values for Impregum™ Garant™ L Duosoft™ were below 100°, indicating a hydrophilic surface characteristic. The experimental group consistently exhibited slightly lower contact angle values than the control group throughout the measurement period (Fig. 1).

For Identium® Light (Fig. 1), the mean contact angle values of the control group were 19.3 ± 3.6° at T0, 15.1 ± 0.7° at T30, 13.8 ± 0.9° at T60, and 12.4 ± 1.3° at T120. The corresponding values for the experimental group were 48.1 ± 1.6° at T0, 18.9 ± 1.9° at T30, 16.7 ± 2.1° at T60, and 15.0 ± 2.0° at T120. The contact angle of the experimental group at T0 was significantly greater than that of the control group. At T30, T60, and T120, the contact angle values of the experimental group remained slightly higher than those of the control group; however, these differences were not considered clinically significant. The use of 0.5% UMONIUM38® disinfectant influenced the hydrophilicity of Identium® Light only at T0.

Discussion

Contact angle measurements have been widely used to evaluate the hydrophilicity of elastomeric impression materials [5–9]. The sessile drop method employed in the present study is a well-established technique for measuring contact angles and assessing the hydrophilic properties of impression materials. Contact angle measurements using water on set impression materials reflect the ability of gypsum slurry to flow over the impression surface [3,6–8], with lower contact angle values indicating greater hydrophilicity [3,6–8]. In the present study, contact angle measurements for both the control and experimental groups

Table 2 Means and standard deviations of contact angle of three types of impression materials at four different times.

Material	Group	Mean contact angle (°) ± SD				*p*-value	
		T_0	T_{30}	T_{60}	T_{120}	Between times	Between materials
Silagum Light (VPS)	control	103.1 ± 2.4	48.7 ± 4.0	41.9 ± 2.7	38.8 ± 2.7	<0.001	<0.001
	experiment	101.2 ± 2.0	47.6 ± 2.2	40.4 ± 2.4	36.0 ± 1.5	<0.001	<0.001
p-value (Between groups)		0.124	0.375	0.179	0.006		
Impregum™ Garant™ L Duosoft™ (PE)	control	57.6 ± 0.4	56.1 ± 0.5	54.0 ± 0.4	51.4 ± 0.2	T_0& T_{30} (p>0.05)	<0.001
	experiment	55.7 ± 0.8	51.5 ± 0.9	49.6 ± 0.5	47.7 ± 0.6	<0.001	<0.001
p-value (Between groups)		0.128	<0.001	<0.001	<0.001		
Identium® light (VPES)	control	19.3 ± 3.6	15.1 ± 0.7	13.8 ± 0.9	12.4 ± 1.3	<0.001	<0.001
	experiment	48.1 ± 1.6	18.9 ± 1.9	16.7 ± 2.1	15.0 ± 2.0	<0.001	<0.001
p-value (Between groups)		<0.001	0.003	0.008	0.007		

demonstrated that the hybrid material (Identium® Light) exhibited the lowest contact angle values, whereas the modified VPS material (Silagum Light) and the polyether material (Impregum™ Garant™ L Duosoft™) showed moderate contact angle values. The initial contact angles at T0 for both the control and experimental groups of the VPS material (Silagum Light) were the highest among the tested materials. However, after T30, the contact angle values of the VPS material in both groups decreased to levels lower than those of the polyether material.

Norling *et al.* [17] reported that the contact angle of unmodified silicone was 97.2°. Following the addition of an appropriate type and concentration of surfactant, the contact angle was reduced to 38°. In the present study, Silagum Light, a surfactant-modified silicone impression material, exhibited the highest contact angle values at T0; however, from T30 to T120, its contact angle values were lower than those of Impregum™ Garant™ L Duosoft™. Previous studies have reported that the contact angle of surfactant-modified VPS materials is lower than that of polyether once the material has set [9, 20, 22, 23], whereas polyether materials exhibit greater hydrophilicity in the unset stage [9, 20, 22, 23]. The limitations of unmodified VPS materials are primarily associated with their hydrophobic nature, as they lack polarized functional groups [9, 12, 18]. To address this, non-ionic surfactants are now incorporated into VPS formulations. These surfactant-modified VPS materials demonstrate reduced contact angles and increased wettability and hydrophilicity due to the release of surfactant components from the impression surface and their interaction with the water droplet, which lowers the surface tension of the liquid [3, 9, 19–21]. The higher contact angle values observed for Silagum Light at the initial measurement time (T0) may be attributed to delayed surfactant leaching, with surfactant activity becoming more pronounced over time. This observation is consistent with the findings of Kanehira *et al.* [3] and Kugel *et al.* [22], who reported that hydrophilic VPS materials provide a continuous supply of surfactant that diffuses to the surface, resulting in a stepwise reduction in contact angle. This shift can be attributed to the advanced formulation of modern VPS, which incorporates highly effective non-ionic surfactants that continuously migrate to the surface once the material has set. Consequently, in the laboratory phase where the material is already set, surfactant-modified VPS may offer better compatibility with gypsum products than traditional Polyether, challenging the long-held assumption that Polyether is universally more hydrophilic across all stages.

VPES is a novel hybrid impression material composed of a chemically engineered combination of polyether polymers and vinyl groups from addition silicone [5]. Its chemical structure consists of large polyether molecules forming the backbone, to which smaller VPS molecules are grafted. VPES impression materials incorporate polyether functional groups as well as added surfactants. Menees *et al.* [23] reported that Identium contains two surfactants: Tenside I (a surface-tension-reducing surfactant) and Tenside II (a wetting-conditioner surfactant). The low contact angle values observed for Identium may therefore be attributed to the combined effects of these surfactants and the grafted polyether groups. Consequently, VPES materials exhibit lower contact angles and improved wettability with water compared with VPS and polyether impression materials [5, 18, 23, 24], demonstrating remarkable hydrophilicity. Heuttig *et al.* [24] reported that VPES exhibited the highest hydrophilicity, with a mean contact angle of 16.8°.

Previous studies have reported that chemical disinfectants may either increase or decrease the hydrophilicity of dental impressions. It has been suggested that surface characteristics and chemical composition can be altered during the disinfection process [12]. Pratten *et al.* [12] investigated several disinfectant solutions, including alkaline glutaraldehyde, acidic glutaraldehyde, chlorine dioxide, iodophors, and sodium hypochlorite, and found that certain disinfectants significantly influenced the wettability of impression materials. Importantly, disinfectant solutions did not exert the same effects across all types of impression materials. Milward *et al.* reported that different disinfectant solutions produced varying effects on the wettability of VPS impression materials, with some disinfectants causing a decrease in wettability, as indicated by increased contact angle values [25], while others resulted in improved wettability. Lad et al. evaluated the effects of short-term disinfection (10 min) using 2% glutaraldehyde and 4% sodium hypochlorite and reported improved wettability of both VPS and polyether impression materials following disinfection [26]. In contrast, Blalock *et al.* examined the effect of spraying a chlorine-based disinfectant and found that the contact angle of surfactant-modified VPS impression materials increased with longer disinfection times [14].

The disinfectant used in the present study, UMONIUM38®, is an effective antimicrobial agent [16]. According to the manufacturer, it contains isopropyl alcohol, benzalkonium chloride, tridecyl ceteth alcohol, and quaternary ammonium compounds. The mechanism of action of this disinfectant includes a reduction in surface tension, allowing it to function in a manner similar to a surfactant, thereby improving the wettability of impression materials, particularly VPS impression materials [14]. In addition, AlZain [15] reported that this disinfectant acts as a surface-tension-reducing agent, enhancing the wetting potential of impression materials.

The disinfectant contains isopropyl alcohol, which may play a crucial role in surface interaction. It is hypothesized that alcohol can temporarily interfere with or mask the active wetting conditioners, specifically the grafted polyether groups and surfactants (Tenside I and II), on the surface of the VPES material. This interference briefly disrupts the surface energy, leading to the observed higher contact angle immediately after disinfection. However, as the isopropyl alcohol rapidly evaporates from the surface, these wetting conditioners and non-ionic surfactants within the material's matrix can re-establish their presence at the interface. This recovery mechanism explains why the contact angle of Identium® returned to a level comparable to the control group by T30, demonstrating that the inhibitory effect of the disinfectant is merely transient and does not permanently alter the material's intrinsic hydrophilicity.

In the present study, no statistically significant differences were observed between the control and experimental groups for VPS (Silagum Light) at T0, T30, and T60. Although a statistically significant difference was detected at T120 (p = 0.006), the absolute intergroup difference was only 1.4°, which is unlikely to be clinically relevant. For the polyether material (Impregum™ Garant™ L Duosoft™), the experimental group demonstrated contact angle values 3–4° lower than those of the control group at all time points; however, these differences were not clinically significant. For the VPES material (Identium® Light), disinfection resulted in a 28° increase in contact angle at T0 (48.1° vs. 19.3°). Nevertheless, both values remained within the hydrophilic range (< 90°), and the effect was transient, as the contact angle decreased to

approximately 18.9° by T30. At subsequent time points (T30–T120), intergroup differences were minimal (2–3°) and not clinically meaningful. From a prosthodontic perspective, contact angles below 90° are considered hydrophilic, while values in the range of 40–50° are generally regarded as favorable for optimal gypsum flow and surface detail reproduction [3, 23]. Accordingly, the observed differences are unlikely to compromise cast accuracy. Furthermore, for materials such as Silagum Light that exhibit initial hydrophobicity (>100° at T0), a short delay in model pouring (30–60 seconds) may allow surfactant activation and improve wettability.

Conversely, for Identium®, although disinfection temporarily increases the contact angle at the immediate moment of contact (T0), the material's "self-healing" hydrophilic nature ensures that if the clinician waits just 30 seconds before pouring the stone, the disinfection effect becomes clinically negligible. Therefore, the use of 0.5% UMONIUM38® does not necessitate modification of the standard laboratory workflow, provided that the model is not poured immediately within the first few seconds of liquid contact. This ensures that the high-quality, void-free working models required for precise prosthetic fit are consistently achieved.

Conclusion

Within the limitations of this study, it can be concluded that disinfection with 0.5% UMONIUM38® spray did not adversely affect the hydrophilicity of the tested VPS, PE, and VPES impression materials over time. The results demonstrate that this specific disinfectant is compatible with these elastomeric materials in terms of surface wettability, as the transient increase in contact angle observed for the VPES material was not clinically significant in the context of standard laboratory procedures. However, these findings are limited to the particular disinfectant tested; therefore, caution should be exercised when generalizing these results to other types of chemical disinfectants. Additionally, further investigation into dimensional stability and surface integrity is warranted to ensure overall clinical performance and long-term prosthetic success.

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