Original Article

Effect of Two Different Disinfectant Agents on Wettability of Elastomeric Impression Materials

Alper Ozdogan [1], Mehmet Fatih Ozmen[2]

[1] Assistant Professor, Department of Prosthodontics, Faculty of Dentistry, University of Atatürk, Erzurum, Turkey

[2] Research Assistant, Department of Prosthodontics, Faculty of Dentistry, University of Atatürk, Erzurum, Turkey

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Abstract

Introduction: This study aims to evaluate surface wettability of additional silicone impression materials, which are immersed in different disinfecting agents with different time intervals. **Methods:** Ninety disk-shaped specimens to be eighteen specimens from each of five different impression materials (four vinyl polysiloxane and one vinyl polyether siloxane) were prepared. The specimens were divided into six groups according to the disinfecting agents (one of them containing ethanol and other one containing benzalkonium chloride) and periods. Then, the specimens were immersed in two disinfecting agents for 1 minute, 1 hour and 24 hours. Later, surface wettability was tested and recorded. Data were analyzed with analysis of variance (ANOVA). **Results:** There was no difference between impression materials and disinfectants in terms of the effect on the contact angle (p>0.05), and there was a significant difference between disinfection times (p=0.001). **Conclusions:** One-minute disinfection process increases wettability of specimens compared to long term disinfections.

Keywords: Additional Silicone, Contact Angle, Disinfection, Wettability.

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Introduction

The first and most important part of prosthetic restoration stages is to obtain negative model of jaws with an impression material. Impression materials used in restorative dentistry are traditionally divided into two groups of elastic and inelastic ones; elastic impression materials are divided into two groups as hydrocolloids and elastomers (1). Agar-agar and alginate impression materials are in group of hydrocolloids while polysulfide, polyether, condensation silicone, and vinyl polysiloxane (VPS) impression materials are in elastomeric group of impression materials (2). Compared to other impression materials, VPSs have advantages such as recording details, dimensional stability, polymerization contraction and no by-products released (3). However, despite their favorable properties, low wettability is considered a disadvantage in clinical use for VPS impression materials (4-6). Polymerization reaction between silane and vinyl groups produces a cross-linked silicon rubber in VPS impression material (7, 8). Siloxane bonds surrounded by aliphatic hydrocarbons in silicone rubber give material hydrophobicity property (9). Thus, low surface energy of silicone-based impression materials reduces their wettability (10). This situation prevents formation of a suitable and non-porous plaster model. Saliva and oral fluids contaminated dental impressions can cause cross-infection (11-13). Growth of microorganisms is observed in 77% of the impressions washed only under water (14). Therefore, impressions should be disinfected after removal from oral cavity and before pouring the plaster model (11, 12, 15). Disinfection goal is to remove microorganisms without causing any surface changes in the impression (16). Disinfection of impressions must be performed in clinics and laboratories. Disinfection process is performed by spraying or immersion methods. The immersion disinfection method ensures that all surfaces of dental impressions are exposed to disinfectant. Spraying and immersion disinfection methods using antimicrobial agents during mixing of plasters could affect several mechanical properties, including application time and dimensional stability in impressions and models (17). For disinfection of impressions, agents such as glutaraldehyde, iodophor, sodium hypochlorite, ethyl alcohol, isopropyl alcohol, benzalkonium chloride, and chlorhexidine are used (18). The term “wetting” can simply be named as a coating of a surface by a liquid (19). However, wetting may be defined physically as the contact angle formed between a liquid drop in thermal equilibrium and a horizontal surface (20). Depending on the surface type and liquid type, droplet can be of various shapes (21). Specifically, the "contact or wetting angle" is the angle formed at the interface between the droplet and the horizontal surface (21). In general, smaller contact angle indicates good wettability, and greater contact angle indicates poor wettability (7, 22). Hydrophilicity, which is the measure of the liquid's capability of dispersing onto a surface, can be quantitatively analyzed by using dynamic contact angle analysis (23, 24). This video-based drop shape analysis system can easily capture and measure contact angles, which change from initial contact, by analyzing a series of high-resolution sessile drop images (23, 24). To determine the hydrophilicity of impression materials, contact angle measurement between distilled water drop and flat surface of the material is a conventional method (25). This study aims to evaluate surface wettability of additional silicone impression materials, which are immersed in different disinfecting agents for different periods of time. The first hypothesis of the study is that wettability of specimens will vary according to impression materials, type of disinfectants and disinfection times, and the second hypothesis is that wettability of impression materials will decrease as the residence time in the disinfectant increases.

Materials and Methods

For this study 90 disk-shaped specimens 15 mm in diameter and 5 mm in height were prepared. Five different impression materials were used and 18 specimens were assigned to each one. Four of the used impression materials were selected to be of vinyl polysiloxane (VPS) formula, 1 of them was selected to be of vinyl polyether siloxane (VPES) formula and heavy body form. Molds with similar sized slots were used as specimens which allowed making at least ten specimens at the same time. The mold was placed on a clean and flat surface to ensure smoothness of the mold specimen surfaces. Then cartridge of the impression material was placed in silicone mixing device (Pentamix 2; 3M ESPE, Seefeld, Germany) and the device was operated. Homogeneously mixed impression materials were applied inwards of these slots. After the cavity structures were filled, a glass slab was placed in a way that it came on top of the impression materials and the same researcher applied equal force to each impression material specimen. Following hardening of the impression materials, specimens were carefully removed from the slots. The specimens obtained from each impression material were randomly divided into six groups with three specimens in each group according to disinfectant type and disinfection time. Two different alcohol-based impression disinfectants that are commonly used in our clinic were selected in this study. Disinfection was performed by immersion method, and time period of specimens immersed in disinfectant was determined to be 1 minute, 1 hour, and 24 hours. Table I provides information on impression materials and disinfectants used in this study. After disinfection process, specimen surfaces were washed under running water and dried thoroughly, and were subjected to surface wettability (contact angle) testing by same researcher in the Attention Thea Flex (Biolin Scientific AB, Vastra Frölunda, Sweden) device. A drop of distilled water was dropped on specimen surface while impressions were at the focal point of camera. It was in a range of 0-10 seconds, at 24 °C for each specimen. Dispersion of water was observed by a camera, and a 10-second video was recorded. The contact angle values for each specimen were obtained from right, left, and middle regions, and for one specimen, a total of 140 measurements were obtained in the range of 0-10 seconds separately for each angle. By taking the average of these measurements, mean contact angle value of each specimen in the 0-10 s range was obtained, and images were saved. The data were evaluated in ANOVA test according to 5x2x3 factorial arrangement to test the statistical differences among group means in the SPSS 20.0 statistics package software (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.). Duncan’s multiple range test was used to separate means, and differences were considered statistically significant at $P<0.05$.

Table I. The impression materials and disinfection agents used in the study

Product/batch number	Manufacturer	Type
elite HD+ maxi tray material/292501	Zhermack; Badia Polesine, Italy	VPS
hydrorise maxi heavy body/296610	Zhermack; Badia Polesine, Italy	VPS
Variotime heavy tray/K010178	Kulzer GmbH; Hanau, Germany	VPS
EXA'lence heavy body/1704121	GC Europe NV; Leuven, Belgium	VPES
V-Posil heavy soft fast/V804021	VOCO GmbH; Cuxhaven, Germany	VPS
Zeta 7 Spray/257322	Zhermack; Badia Polesine, Italy	Ethanol
Cavex Impresafe/16-12521	Cavex Holland BV; Haarlem, Netherlands	Benzalkonium chloride

Results

After analyzing results, it was observed that there was a statistically significant difference in interactions of impression material-disinfectant-disinfection time (P<0.05). There was a significant difference between the disinfection times (P=0.001), however there was no statistically significant difference between impression materials and disinfectants (P>0.05) (Table II). According to results of Duncan's multiple comparison test, a statistically significant difference was determined between disinfection time of 1 minute and disinfection times of 1 hour and 24 hours. Smaller contact angle values were achieved with disinfection for 1 minute.

As a result of the two-factor treatment means for the disinfectants; Cavex Impresafe showed statistically significant difference (P<0.01), but Zeta 7 Spray did not show statistically significant difference in interactions of impression materials - disinfection times (P>0.05). As a result of two-factor treatment means for the disinfection times; disinfection of 1 minute showed statistically significant difference (P<0.05), the other disinfection times did not show statistically significant differences (P>0.05) in interactions of impression materials - disinfectants. The lowest contact angle value was seen in the EXA'lence specimen immersed in Zeta 7 Spray for 1 minute (100.66±11.66), while the highest contact angle value was seen in the V-Posil specimen immersed in Cavex Impresafe for 24 hours (120.57±0.89). The least squares means, standard deviations, and in-group comparisons of each materials were presented in Table III, and the contact angle images were demonstrated in Figure 1 and 2. The plots of interactions of groups are presented in Figure 3 and 4.

Table II. Variance analysis table and Interactions of contact angle values of the groups

Variance components	df	Mean Square	F	Sig.
Impression Materials	4	17.633	.740	.568
Disinfectants	1	63.706	2.675	.107
Disinfection Times	2	201.565	8.463	.001
Impression Materials* Disinfectants	4	35.741	1.501	.213
Impression Materials* Disinfection Times	8	42.243	1.774	.100
Disinfectants* Disinfection Times	2	162.935	6.841	.002

Impression Materials* Disinfectants* Disinfection Times	8	56.761	2.383	.027
Error	60	23.816		
Corrected Total	89			

Table III. Least Squares Means and Standard deviations for Disinfectants, Impression Materials and Disinfection Times.

Disinfectants	Impression Materials	1Minute Disinfection	1Hour Disinfection	24Hours Disinfection	Total
		Mean±Std Dev.	Mean±Std Dev.	Mean±Std Dev.	Mean±Std Dev.
Zeta 7 Spray	elite HD	104.84±5.23	112.06±4.47	109.90±2.36	108.93±4.85
	hydrorise	102.25±4.36^{*A}	113.58±3.67^{B}	113.69±4.42^{B}	109.84±6.74
	EXA'lence	100.66±11.66	108.77±3.70	115.29±5.09	108.24±9.11
	Variotime	112.30±1.72	112.49±1.78	113.59±6.13	112.79±3.36
	V-Posil	103.91±6.89^{*A}	113.55±2.17^{B}	115.67±3.80^{B}	111.04±6.79
	Total	104.79±7.06^{**A}	112.09±3.34^{B}	113.63±4.38^{B}	110.17±6.38
Cavex Impresafe	elite HD	116.45±0.59^{*b}	107.98±8.08	106.74±2.68^{*a}	110.39±6.26
	hydrorise	113.76±1.57^{ab}	114.39±8.30	111.90±4.10^{ab}	113.35±4.82
	EXA'lence	114.99±6.56^{b}	110.23±1.28	115.79±6.54^{bc}	113.67±5.35
	Variotime	105.49±3.81^{a,A}	109.15±2.51^{B}	120.57±0.89^{c,B}	111.73±7.19
	V-Posil	108.33±6.45^{ab}	110.53±0.81	111.49±3.83^{ab}	110.11±4.02
	Total	111.80±5.77	110.46±5.04	113.30±5.89	111.85±5.58
Total	elite HD	110.65±7.18	110.02±6.26	108.32±2.85	109.67±5.48
	hydrorise	108.01±6.95	113.99±5.76	112.80±3.94	111.60±5.97
	EXA'lence	107.83±11.46	109.51±2.60	115.54±5.25	110.96±7.77
	Variotime	108.90±4.58	110.82±2.67	117.08±5.48	112.27±5.48
	V-Posil	106.12±6.45	112.05±2.21	113.58±4.11	110.58±5.44
Total		108.30±7.27^{**a}	111.28±4.29^{b}	113.47±5.11^{b}	111.01±6.02

*Means in column/row with different superscripts are significantly different at P<0.05 or P<0.01; *:P<0.05,**:P<0.01. While uppercase letters indicate the differences in the same row, lower case letters indicate the differences in the same column.*

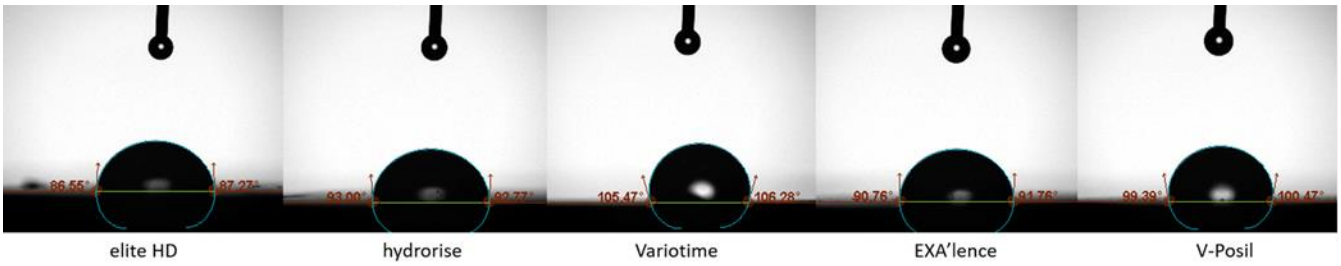

Fig. 1. The CA images of impression materials that have been left in Zeta 7 Spray for 1 minute.

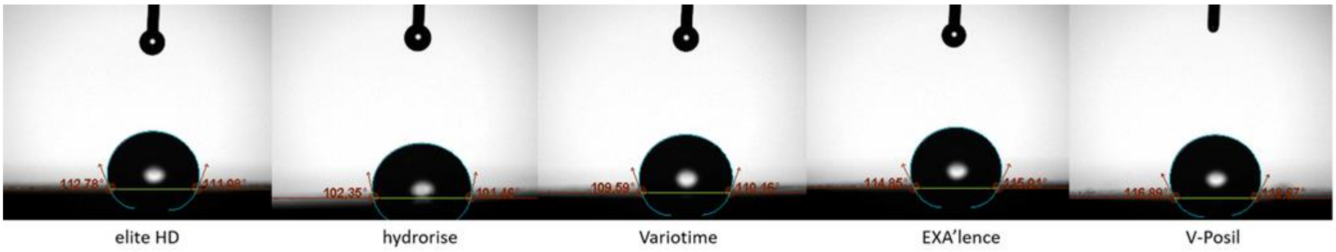

Fig. 2. The CA images of impression materials that have been left in Cavex Impresafe for 1 minute.

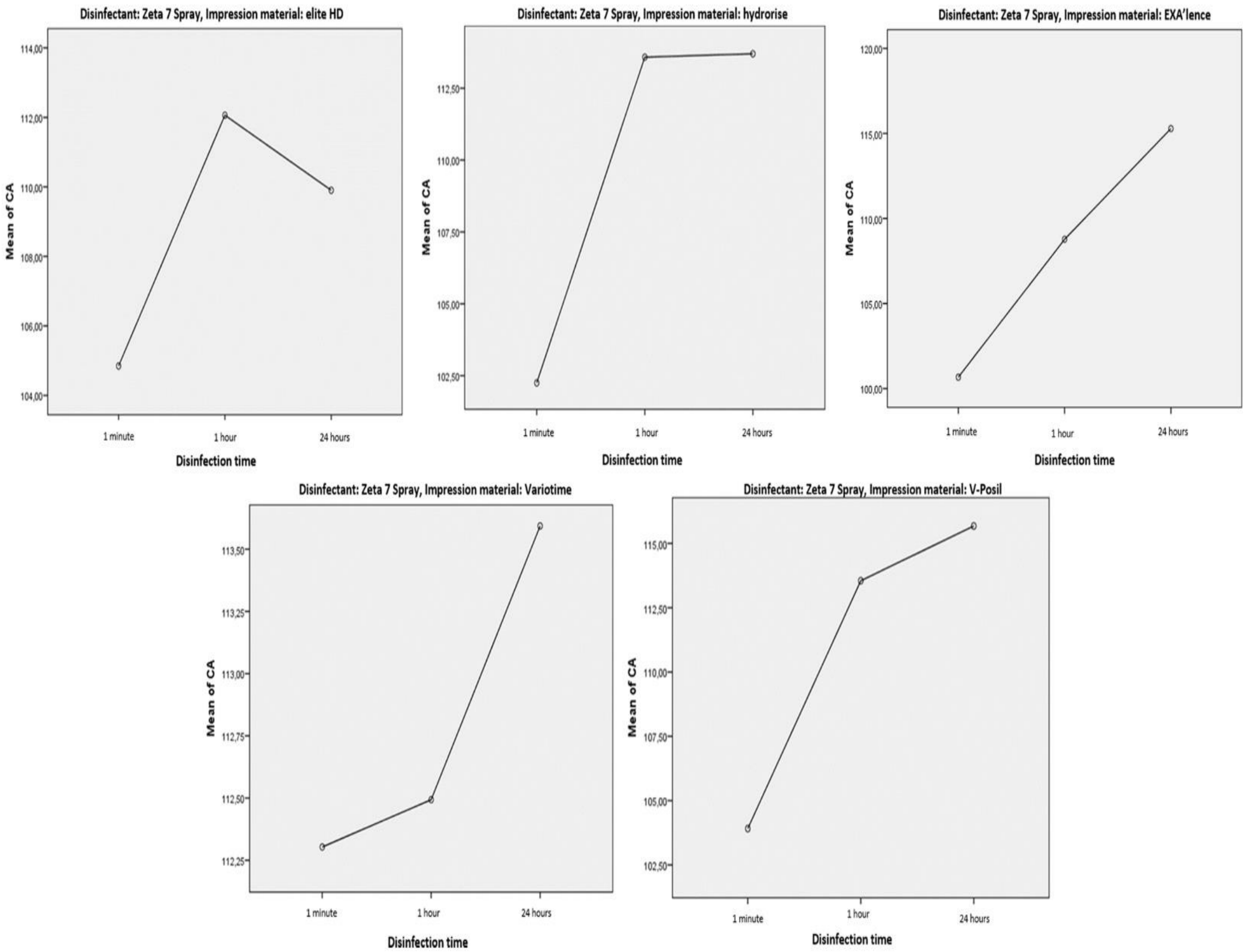

Fig. 3. Plots showing contact angle changes depending on time of impression materials immersed in Zeta 7 Spray.

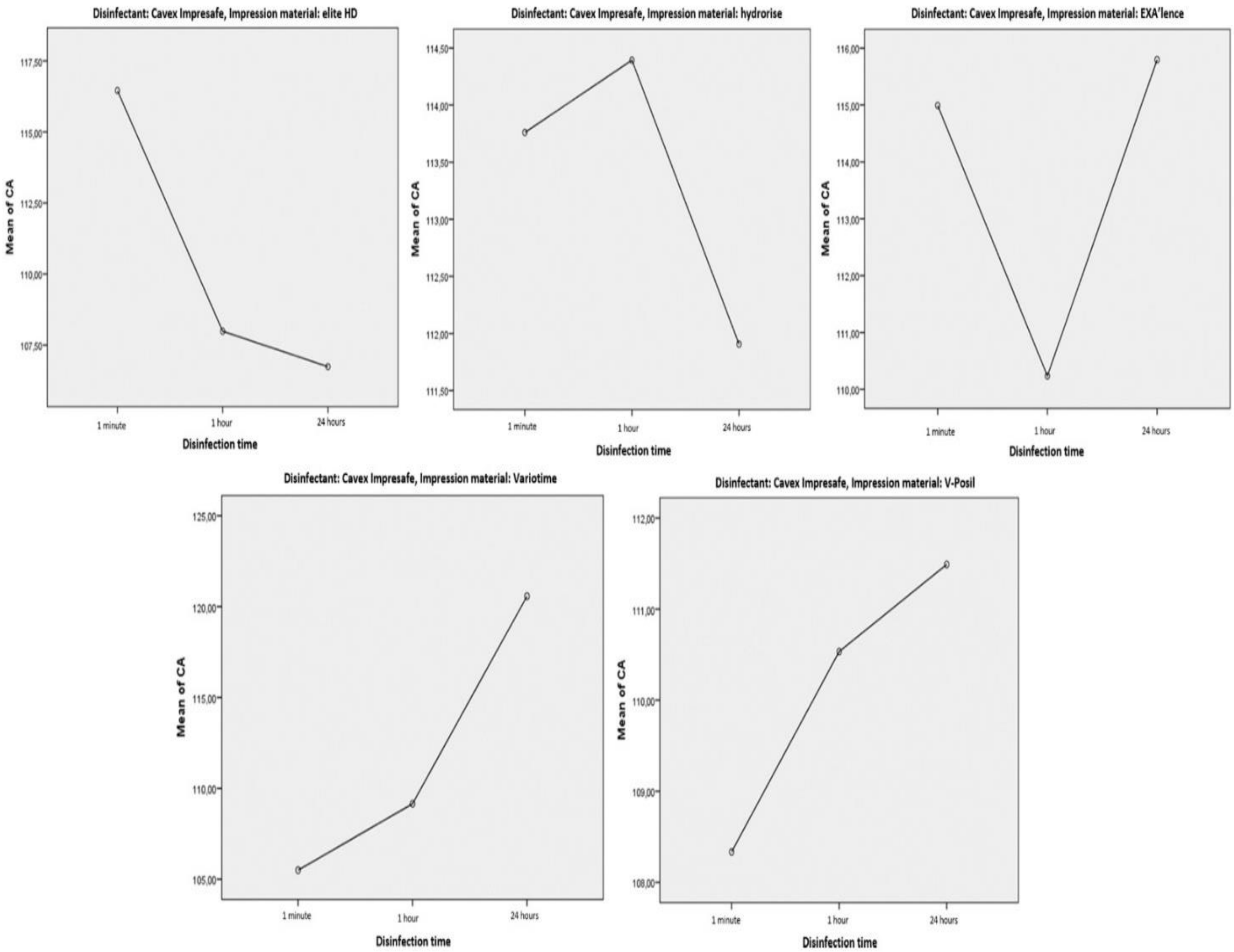

Fig. 4. Plots showing contact angle changes depending on time of impression materials immersed in Cavex Impresafe.

Discussion:

In this study, wettability of additional silicone impression materials, which stayed in different disinfectants for different periods of time, was evaluated. As a result of the study, since there was no difference in wettability of specimens depending on the impression material, the disinfectant type and the disinfection time, our first hypothesis that we had initially established was rejected. However, our second hypothesis was accepted since wettability of specimens decreased with increasing residence time in the disinfectant. Additional types of impression materials (VPS) are the most commonly used silicone impression materials in both fixed partial and implant-retained restorations. Since their ability to save details and their dimensional stabilities are very good, they are used in wide range of treatments. Vinyl polyether silicone (VPES) has a different composition than other elastomeric impression materials because it combines vinyl polysiloxane (VPS) and polyether (PE). Therefore, in the present study, together with four different VPS impression materials, 1 VPES impression material was used. The manufacturers can produce impression materials in different ways according to mixing techniques, hardening times, and contents. Silicone impression materials may be in form of cartridges which are mixed manually, or which are mixed automatically by guns and machines. Since previous studies have demonstrated that surface properties of an impression material can be influenced by disinfection processes as well as the mixing method used (26, 27), the impression materials used in this study were selected as heavy body type auto mixed materials.

While a restoration is being performed, a multi-leg system comes into play and passes through many stages both in clinical and laboratory environment. While the impression phase constitutes first stage of the clinical environment of a restoration, until the last moment it will be inserted in the mouth, the restoration is continuously transferred between laboratory and clinic. This situation leads to a circulation allowing cross-infection. In order to prevent cross-infection, it is necessary to pay attention to several disinfection procedures starting from the impression stage. Disinfecting agent type and residence time of impression in disinfectant are of great importance in terms of preservation of physical properties of impression material. At the same time, the effect of disinfection on wettability of impression materials is another critical issue because wettability is known to directly affect size and number of air bubbles that may occur in plaster model poured from the impression (28). Many studies have been investigating wettability of impression materials and effects of different disinfection and surface treatments on contact angle of impression materials. As a result of disinfecting the impression materials with low viscosity in 2% glutaraldehyde disinfectant for 30 minutes by the immersion method, Lepe et al (26) indicated a slight decrease in wettability of impression materials. Blalock et al (15) used a hypochlorite-based disinfectant in their study. They determined that wettability of both heavy and wash types of VPS impression materials decreased with increasing exposure times to the disinfectant. Kang et al (29) preferred quaternary ammonium-based and chlorine-based disinfectants for disinfecting VPS materials in their study and stated that the chlorine-based disinfectant was more advantageous in terms of wettability. Milward and Waters (30) evaluated effect of disinfection procedures on wettability of VPS impression materials and reported that short-term disinfection by immersion significantly reduced wettability. In their study, Kotha et al (31) evaluated five different VPS materials in terms of chemical disinfection, autoclave sterilization, and microwave sterilization, and stated that all three methods did not cause any significant difference in the wettability of the impression materials. Al Zain (32) investigated the wettability of VPS and polyether specimens, disinfected with 0.5% glutaraldehyde spray. In this study, impression materials disinfected with 0.5% glutaraldehyde were observed to have lower contact angles at 0.5, 1 and 2-minute measurement points than not disinfected specimens, and therefore 0.5% glutaraldehyde was recommended to use for disinfecting the tested impression materials. Lad et al (33) concluded that disinfecting silicone and polyether impressions with 2% glutaraldehyde by a 10-minute spray did not cause a significant change in wettability. In this study, it was shown that disinfection process performed with two different disinfectants and for different periods of time led to changes in contact angles of VPS and VPES impression materials, and depending on the increase in the disinfection time, an increase in contact angles, thus a decrease in the wettability of the impression materials occurred. This situation supports the data in the literature. We think that the statistical differences between both disinfectants are due to differences in ethanol and benzalkonium contained in the active ingredients of disinfectants. We interpret that disinfection time affects differences significantly, as it causes deterioration in the surface of the material as the duration of disinfection increases, or due to the decrease in wettability due to adverse effects of surfactants on the surface of additional silicones. Especially the fact that the 1-minute disinfection time shows lowest contact angle values and the statistical differences with the following times support this view. At the same time, it shows that disinfection time in all interactions between groups causes statistical differences, and that disinfection process to be applied for impression materials should be limited to 1 minute in order not to negatively affect wettability. Menees et al (9) compared wettability of seven different elastomeric impression materials during polymerization by measuring their contact angles with saliva and water drops. VPS and hybrid materials modified with new surfactants showed a decrease in contact angle in measurement with water. In their study, Karaaslan et al (34) compared dimensional changes and wettability of three impression materials, to be VPES, VPS, and PE, with each other. Although best properties of VPS and PE impression materials were combined and a new hybrid impression material called VPES was introduced, the wettability of VPES was not higher than that of VPS. In our study, no significant difference was found between the wettability of the used VPS and VPES impression materials, and this result supports the results of Karaaslan et al (34). The lack of difference between impression materials may be due to the fact that all impression materials are additional type silicone and their surface wettability is similar to each other. However, the VPES impression material immersed in Zeta 7 Spray showed the lowest contact angle values even though there was no statistical difference. We believe that this is due to the hybrid formula depending on the polyether in the material.

One of the limitations of this study is that while the effect of the disinfection process on wettability of the impression materials is evaluated in the study, the effect on roughness of the specimens is not included in the study. Another limitation that could be discussed is that while VPS and VPES type impression materials are examined, polyether impression materials are not included in this study as a separate group. In future studies, application time of disinfectants can be changed, and roughness and microbiological tests can be used to support data on the effects of disinfectants on impression materials.

Conclusions

Within the limitations of this study, following conclusions were reached:

1. The disinfection process did not lead to a significant difference between contact angles of four different VPS and 1 VPES impression materials.

2. The effects of disinfecting agents of two different chemical formulas on wettability of impression materials did not display a difference.

3. The effect of disinfection time on wettability of impression material is important. The 1-minute disinfection process has the lowest contact angle values for all groups and displays a statistically significant difference compared to disinfection process for 1 hour and 24 hours.

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Conflict of interest

Authors declare that they have no conflict of interest.

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Corresponding Author
Alper Ozdogan
Assistant Professor, Department of Prosthodontics, Faculty of Dentistry, University of Atatürk, Erzurum, Turkey
Tell: +9044223609442/1684
Email: alprozdgn@gmail.com