Effect of 0.5% glutaraldehyde disinfection on surface wettability of elastomeric impression materials

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Abstract Purpose: The purpose of this in-vitro study was to evaluate the effect of 0.5% glutaraldehyde spray disinfection on surface wettability of vinyl polysiloxane and polyether impression materials.

Methods and materials: Thirty-six specimens were prepared of vinyl polysiloxane-light (VPL), vinyl polysiloxane-regular (VPR) viscosity and polyether-monophase (PE) impression materials according to manufacturer’s recommendations. Specimens of each material were equally divided into control and experimental groups. All specimens were washed with water, dried and stored in closed containers. Specimens of experimental groups were sprayed with 0.5% glutaraldehyde disinfectant. The disinfectant was allowed to be in contact with the impression surface for 10 min. Contact angle was measured using a Contact Angle Goniometer at 0.5, 1 and 2 min after water drop contact with surfaces of impression materials. Five measurements at five different areas at each impression surface were recorded. A statistical analysis was done using Two-way repeated measures ANOVA and multiple comparison Tukey’s Post-hoc tests.

Results: All 0.5% glutaraldehyde-disinfected impression materials showed lower contact angle measurements than non-disinfected ones. Contact angle measurements of PE were much lower than those of VPL and VPR impression materials. However, there was a statistically significant difference of contact angle measurements between the three impression materials (p = 0.000). Contact angle measurements of all groups significantly decreased as the time was increased (p = 0.000).

Conclusion: Disinfection of the tested impression materials with 0.5% glutaraldehyde improved their wettability. Glutaraldehyde acted like a surface reducing agent (surfactant) that improved wetting potential of the impression materials.

1. Introduction

Dental impressions are often contaminated by microorganisms from saliva and blood. Washing impressions under...
tap water after removal from patient’s mouth does not eliminate all micro-organisms. Therefore, disinfection of dental impressions immediately after removal from the patient’s mouth is recommended by the American Dental Association (ADA) (ADA Council on Scientific Affairs and ADA Council on Dental Practice, 1996). It has become an essential procedure to prevent cross-infection between patients and dental staff in dental offices and laboratories. Two methods of disinfection of dental impression materials are commonly used; spray disinfection and immersion disinfection. The immersion method is more effective because disinfection of all surfaces of the impression material is guaranteed (Kaul et al., 2012). This could be due to longer time of exposure of the impression material to the disinfectant by immersion than by spraying. Nevertheless, spray disinfection remains most popular one.

Different disinfectants may be used including glutaraldehydes, sodium hypochlorite (NaOCl), iodophors, phenolic and alcohol compounds. Glutaraldehyde is preferred for disinfection. A successful disinfection may result from immersion in 2% glutaraldehyde for 5 min (Bustos et al., 2010). A complete disinfection and 100% reduction of micro-organisms without deteriorating surface details were reported as a result of immersion of impressions in 2% glutaraldehyde (Pal et al., 2014). Glutaraldehyde-based disinfectants were found effective in eliminating all microbial forms at surfaces of silicone impressions without changing its dimensional stability (Demajo et al., 2016).

Several investigators recommended to carefully monitor the time of immersion of different impression materials in disinfectants (Amin et al., 2009; Blalock et al., 2010; Shetty et al., 2013; Lad et al., 2015). Bustos et al. (2010) reported successful disinfection results when impressions were immersed for 5 and 10 min in disinfectants. No significant dimensional changes of polyether impressions were observed when disinfected by a 10-min immersion in 2% glutaraldehyde (Yilmaz et al., 2007). Sinobad et al. (2014) recommended immersion disinfection of polyether impressions in glutaraldehyde for 10 min. In 2012, Ahila and Subramaniam reported no significant dimensional changes in addition silicone after immersion and spray disinfection with 2.45% glutaraldehyde for 10, 30 and 60 min.

Effect of disinfection on dental impression materials is controversial. In 2008, Kotsiomer et al. did a PubMed search between 1980 and 2005 on the effect of chemical disinfection, by immersions or spraying, on the impression’s dimensional changes. They stated that there were variations in the laboratory studies due to variations of experimental design. However, they found an agreement on the statistically insignificant effect of disinfection on the dimensional stability of impression materials.

Disinfecting impressions may affect the wettability of the impression material. For evaluating wettability of the impression material, the contact angle of a liquid droplet on the solid surface of the impression material is measured. The contact angle is the angle formed between the surface of the wetted solid and a line tangent the curved surface of the drop. As the angle increases, the wettability decreases. Low values indicate a good wettability.

Although spray disinfection of dental impressions is more frequently used in clinics and laboratories than immersion method, most of the studies evaluated the effect of immersion disinfection on dimensional changes of impression materials. Only few studies were conducted on the effect of glutaraldehyde spray disinfection on surface wettability of impression materials (Blalock et al., 2010; Lad et al., 2015).

Therefore, the aim of this in-vitro study was to evaluate the effect of 0.5% glutaraldehyde spray disinfection on surface wettability of vinyl polysiloxane and polyether dental impression materials.

2. Material and methods

2.1. Specimen preparation

Thirty-six specimens were prepared of three impression materials according to manufacturer’s recommendations (12 specimens of each impression material). The impression materials were Vinylic Polysiloxane-Light viscosity, Vinylic Polysiloxane-Regular viscosity (VP MIX, HENRY SCHEIN INC., Melville, 11747, NY, USA) and Polyether-Monophase (3M ESPE Soft Monophase, 3M Deutschland GmbH Dental Products, Carl-Schurz Str.1, 41,453 Neuss, Germany). Stainless steel molds of 25 mm diameter and 5 mm thickness were used for preparation of specimens. Molds were placed on a glass slab. The vinyl polysiloxane impression material was automixed using a dispenser. Polyether impression material was mixed using an automatic mixing machine (Pentamix, 3M ESPE, Minneapolis, MN, USA). Materials were mixed at room temperature following manufacturer’s directions then poured into the molds. Immediately after pouring the impression material into the mold, another glass slab was placed on top of the mold to obtain a flat surface of the specimen. Materials were allowed to set for 10 min. All specimens were washed with distilled water for 1 min and carefully dried and stored in closed containers. Specimens of each impression material were equally divided into control and experimental groups. Specimens of the experimental group were immediately taken out of the closed containers to be ready for disinfection.

2.2. Disinfection procedure

Disinfection of specimens of the experimental group was carried out using 0.5% glutaraldehyde disinfectant spray (MD 520 Impression disinfectant, DURR DENTAL Products, Industrial Estate Kettering, Northants NN16 8PS, UK Ltd.). The disinfectant was allowed to be in contact with the impression surface for 10 min as recommended by the manufacturer. During the 10-min disinfection, specimens were stored in closed containers to avoid evaporation of disinfectant. Specimens were thoroughly washed with distilled water for 1 min, air dried, then stored again in closed containers. All specimens were coded for identification.

2.3. Contact angle measurement

Contact angle measurement of surfaces of all specimens was performed using a Contact Angle Goniometer (rame-hart instrument co., rame-hart Model 190 Contact Angle (CA) Goniometer with Dropimage CA Software v2.5, Succasunna, NJ 07876 USA) (Fig. 1) with contact angle range of 0–180° and accuracy of ±0.01° and resolution of 0.1°. Each specimen
was mounted on the adjustable mechanical stage of the Goniometer. Using an installed needle, a drop of distilled water was used as the wetting liquid of the surface of specimens at room temperature. An optic device equipped with a high digital video camera was used to monitor the dropped water. Images were monitored until the drop of distilled water contacted the surface of the specimen (Fig. 2). The contact angle was measured on surfaces of specimens at 0.5, 1 and 2 min after initial drop contact with the impression surface. These three measurement point times were selected to be longer than that selected in the study of Shetty et al. (2013) who evaluated wettability by measuring contact angles within 1 min after drop was placed on impression surface. Contact angle measurements were recorded using a Dropimage® Program. Five measurements at five different areas at each impression surface were recorded. The mean ± standard deviation was calculated.

2.4. Statistical analysis

The statistical analysis was performed using IBM Statistical Package for Social Sciences (IBM-SPSS ver. 20). Two-way repeated measures analysis of variance (ANOVA) test was used to compare contact angle measurements between the impression materials, the control and experimental groups and the different measurement point times. Multiple comparison Tukey’s Post-hoc test was also used to compare contact angle measurements between the control and experimental groups of each impression material at each measurement point time. Level of significance was <0.05.

3. Results

For all impression materials, contact angle measurements at E group is lower than those at C group at all times (Table 1). This indicates improved wettability of 0.5% glutaraldehyde-disinfected surfaces of impression materials (Figs. 3–5). However, there was a statistically significant difference of contact angle measurements between C and E groups only for VPL (p < 0.05). PVR and PE showed insignificant difference in measurements of contact angle between C and E groups (p = 0.227 and p = 0.051 respectively). As the contact times were prolonged, a statistically significant decrease of contact angle measurements was evident at each group of each impression material (p < 0.05). The highest values were recorded at 0.5 min and lowest ones were recorded at 2 min. Contact angle measurements of PE were much lower than those of VPL and VPR impression materials. However, there was a statistically significant difference of contact angle measurements between the three impression materials (p < 0.05).

Results of the multiple comparison Tukey’s Post-hoc test generally showed that contact angle measurements at E are lower than those at C group (Table 2). However, statistically significant differences existed when comparing contact angle
measurements at C and E groups of VPL at all three measurement point times (p = 0.000), of VPR only at 2 min (p = 0.003) and of PE at 0.5 min and 2 min measurement point times (p = 0.032 and 0.045 respectively).

4. Discussion

In the present study, contact angle measurements of all surfaces of impression materials whether disinfected or not, were reduced as measuring time was prolonged. This means that as time went on, there was an improved wetting potential of impression materials. Therefore, the best wettability of impression materials was reported at 2 min.

A statistically significant difference in contact angle measurements existed when different groups of impression materials were compared at all measurement times. This indicated different wetting potentials of different materials. Polyether showed lower contact angle measurements than did vinyl polysiloxane, and therefore, polyether exhibited better wettability than did vinyl polysiloxane impression materials. This may be related to the hydrophilic nature of the polyether impression material (Zgura et al., 2010). Our findings are

| Material | Group | Time (min) | Mean | Std. Error | 95% Confidence interval | p-value |
|----------|-------|------------|------|------------|-------------------------|---------|
|          |       |            | Lower bound | Upper bound | Between times | Between groups | Between materials |
| PVL C    | 0.5   | 75.697     | 0.361 | 74.984     | 76.409       | 0.000*   | 0.000*   | 0.000*   |
| E        | 0.5   | 70.007     | 0.361 | 69.294     | 70.719       | 0.000*   |         |         |
| E        | 0.5   | 58.530     | 0.307 | 57.925     | 59.135       |         |         |         |
| E        | 0.5   | 49.123     | 0.300 | 48.532     | 49.715       |         |         |         |
| PVR C    | 0.5   | 77.010     | 0.361 | 76.297     | 77.723       | 0.000*   | 0.227   |         |
| E        | 0.5   | 76.470     | 0.361 | 75.757     | 77.138       | 0.000*   |         |         |
| E        | 0.5   | 62.883     | 0.307 | 62.278     | 63.488       |         |         |         |
| E        | 0.5   | 52.897     | 0.300 | 52.305     | 53.488       |         |         |         |
| PE C     | 0.5   | 57.430     | 0.361 | 56.717     | 58.143       | 0.000*   | 0.051   |         |
| E        | 0.5   | 56.703     | 0.361 | 55.991     | 57.416       | 0.000*   |         |         |
| E        | 0.5   | 54.157     | 0.307 | 53.552     | 54.762       |         |         |         |
| E        | 0.5   | 50.943     | 0.300 | 50.352     | 51.535       |         |         |         |

C: Control group.
E: Experimental group.
* Significant (<0.05).

Fig. 3 Mean contact angle measurements of control and experimental groups of VPL impression material at three different times.
supported by Zgura et al. (2010) who also reported significantly lower contact angles of polyether impression materials than those of vinyl polysiloxane impression materials.

In the present study, all 0.5% glutaraldehyde-disinfected impressions material specimens had lower contact angles than non-disinfected specimens at 0.5, 1 and 2 min measurement point times. Accordingly, wettability of vinyl polysiloxane and polyether impressions was improved by a 10-min spray disinfection. This is supported by the recent study of Lad et al. (2015) who concluded that a 10-min spray disinfection of silicone and polyether impressions using 2% glutaraldehyde did not compromise their wettability. In this study, only a statistically significant decrease of contact angle measurements of group E of PVL existed when compared to group C at all measurement times. It may be again due to the hydrophobic behavior of the material or the consistency and flowing ability of the material. When C and E of VPR were compared, a statistically significant difference existed only at 2 min measurement point time. This may be also related to the hydrophobic behavior of the regular-consistency material that was in prolonged contact (2 min) with the drop of liquid.

Disinfection may be affected by the hydrophilicity nature of the impression material as well as the time of its exposure to a disinfectant. Spray disinfection is preferred for hydrophilic impression materials like hydrocolloids. (Rad et al., 2010; Kaul et al., 2012) However, results of this study encourage using spray disinfection of vinyl polysiloxane and polyether impression materials using a glutaraldehyde spray disinfectant.

Adequate wetting potential of surfaces of dental impression materials should be considered for reproduction of surface details of the dental surface and accuracy of the dental die cast. In fact, application a topical surface wetting agent (surfactant) was recommended to increase wettability of the impression materials (Kotian et al., 2011). Inadequate wettability of impressions results in inaccurate gypsum casts and dies with lots of voids on their surfaces that may be located in critical areas.

The disinfectant used in this study (MD 520) is a highly effective, formaldehyde-free solution for simultaneous disinfection. According to manufacturers, 100 g MD 520 contain glutardialdehyde 0.5 g, alkyl benzyl-dimethyl-ammonium chloride 0.25 g, special antifoaming agents and complexing agents. The MD 520 was applied undiluted as recommended.

**Fig. 4** Mean contact angle measurements of control and experimental groups of VPR impression material at three different times.

**Fig. 5** Mean contact angle measurements of control and experimental groups of PE impression material at three different times.
by the manufacturers. According to findings of this study, the glutaraldehyde disinfectant acted like a surface reducing agent (surfactant) that improved wetting potential of the impression materials. Therefore, 0.5% glutaraldehyde disinfectant can be safely used to disinfect vinyl polysiloxane and polyether impression materials with the advantage of improving their surface wettability that is necessary for reproduction of surface details for fabrication of well-fitted restorations.

Implications of findings; improvements of wettability of disinfected surfaces of the impression materials were observed as measurement point time was increased. Therefore, 0.5% glutaraldehyde disinfection of impression materials can be safely done with no adverse effect on their wetting potential. However, as was suggested by Jaggar et al. (2007), it may be better to recommend the use of a particular disinfectant for each impression material to ensure optimum dimensional stability.

5. Conclusion

Within the limitations of the study, the results showed statistically significant differences in wettability between all tested impression materials. Improvements of wettability of 0.5% glutaraldehyde-disinfected surfaces of the impression materials were observed as measurement point time was increased. Therefore, 0.5% Glutaraldehyde disinfectant is recommended to disinfect the tested impression materials. However, further investigations are needed to include other impression materials for glutaraldehyde disinfection.

Ethical statement

This research does not require ethical approval. I followed the Helsinki declaration.

Conflict of interest

There is no conflict of interest.

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### Table 2

Multiple comparison Tukey’s Post-hoc test to compare the contact angle measurements between the control and experimental groups of each impression material at each measurement time point.

| Material | Time (min) | Group | Number of measurements | Mean   | Std. deviation | p-value |
|---------|-----------|-------|------------------------|--------|---------------|---------|
| PVL     | 0.5       | C     | 30                     | 75.70  | 1.910         | 0.000*  |
|         |           | E     | 30                     | 70.01  | 3.204         |         |
|         | 1         | C     | 30                     | 61.90  | 1.018         | 0.000*  |
|         |           | E     | 30                     | 58.53  | 2.246         |         |
|         | 2         | C     | 30                     | 51.47  | 0.915         | 0.000*  |
|         |           | E     | 30                     | 49.12  | 1.859         |         |
| PVR     | 0.5       | C     | 30                     | 77.01  | 1.724         | 0.243   |
|         |           | E     | 30                     | 76.47  | 1.821         |         |
|         | 1         | C     | 30                     | 62.15  | 1.678         | 0.113   |
|         |           | E     | 30                     | 62.88  | 1.859         |         |
|         | 2         | C     | 30                     | 51.48  | 1.850         | 0.003*  |
|         |           | E     | 30                     | 52.90  | 1.621         |         |
| PE      | 0.5       | C     | 30                     | 57.43  | 1.704         | 0.032*  |
|         |           | E     | 30                     | 56.70  | 0.611         |         |
|         | 1         | C     | 30                     | 54.80  | 2.060         | 0.104   |
|         |           | E     | 30                     | 54.16  | 0.564         |         |
|         | 2         | C     | 30                     | 51.86  | 2.337         | 0.045*  |
|         |           | E     | 30                     | 50.94  | 0.603         |         |

C: Control group.
E: Experimental group.
* Significant (<0.05).
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