Evaluation of some properties of elastomeric dental impression materials after disinfection

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Backgrounds and objectives: Dental impressions present a risk to spread infections among dental practitioners and should be disinfected to prevent the spread of these microorganisms. Different disinfectant materials and techniques can be used to eliminate this threat. The purpose of this study was to evaluate the effect of some disinfectant materials with two different techniques on surface detail and dimensional stability of elastomeric impression materials.

Materials and methods: Three dental impression materials were used in this study, Vinyl polysiloxane, Polyether and Vinyl polyether siloxane that were disinfected with sodium hypochlorite, Dettol and Cavex Impresafe by using two techniques, spraying and immersion methods for each.

Results: The results of this study showed a significant difference of the dimensions between immediate and 48 hours after disinfection $P<0.05$ with the maximum change (1.5%) appeared with vinyl polysiloxane material when immersed in sodium hypochlorite for 10 minutes and stored for 48 hours, but this change was acceptable by the ADA. Polyether showed the least dimensional change of 0.05% after 7 hours from disinfection with Cavex impresafe and the latter caused the least change on the impression materials.

Conclusion: Within the limitations of this in vitro study, it was concluded that dental impression materials can be disinfected without causing dimensional changes that affect the manufacture of dental prosthesis.

Keywords: Impression materials, disinfection, dimensional stability, spray, immersion.

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Introduction

Elastomeric impression materials were first used in dentistry in the 1950s.[1] Impression materials should reproduce hard and soft tissues in order to obtain biologically, mechanically, functionally and aesthetically acceptable restorations.[2] Vinyl polysiloxane (VPS) and polyether (PE) impression materials are commonly used to produce final impressions in restorative dentistry. VPS and PE exhibit excellent dimensional stability under different tests and storage conditions.[3]

The new vinyl polyether silicone (VPES) impression material, which is available in several viscosities and setting times, was introduced by the manufacturer as a combination of vinyl polysiloxane (VPS) and polyether (PE).

Dental professionals are widely exposed, either directly or indirectly, to a wide variety of microorganisms during their daily practice.[4] In order to combat this, the disinfection and sterilization of dental instruments and materials,

including impressions, are recommended by the American Dental Association (ADA) and the Centre for Disease Control to prevent the possible transmission of infectious diseases, such as hepatitis B, HIV, and tuberculosis.[5]

The precise fit of the dental prosthesis is the major factor impacting the success of the prosthodontic treatment, which in turn depends on the accurate recording of fine intraoral details. For various dental and maxillofacial rehabilitation procedures, the major requirement is to have an accurate negative replica of the respective site. Therefore, the aim of the present study was to determine the effect of chemical disinfection procedures on the dimensional stability and surface detail of elastomeric dental impression materials.

Materials and methods

The study consisted of total 180 specimens of three dental impression materials, VPS, PE, and VPES, 60 for each, disinfected with three disinfectants, sodium hypochlorite 5.25%, Dettol and Cavex impresafe by two techniques, spraying and immersion (Figure 1). These materials were mixed using auto mix machines with disposable tips to control the mixing speed. The samples were tested according to the ADA specification number 19 to test elastomeric impression materials.[6] By using stainless steel apparatus that contained a metal block carved with horizontal and vertical lines and a metal ring as a mould for the dental impression (Figure 2). The line used in this study was line B between line D1 and D2 which measured 25 mm in length and 20 microns in depth as shown in figure 3.

The metal block was placed in a water bath with a temperature of 35 degrees centigrade for 15 minutes so the metal block temperature standardizes to intraoral temperature of a human.[7] Separating medium was placed on the edges of the metal block to facilitate removal and the impression material which was injected onto the metal block and placed back in the water bath. A glass slab was placed on top and a weight of 1 kilogram was placed on this assembly to mimic the pressure of the hand on the tray.[8]

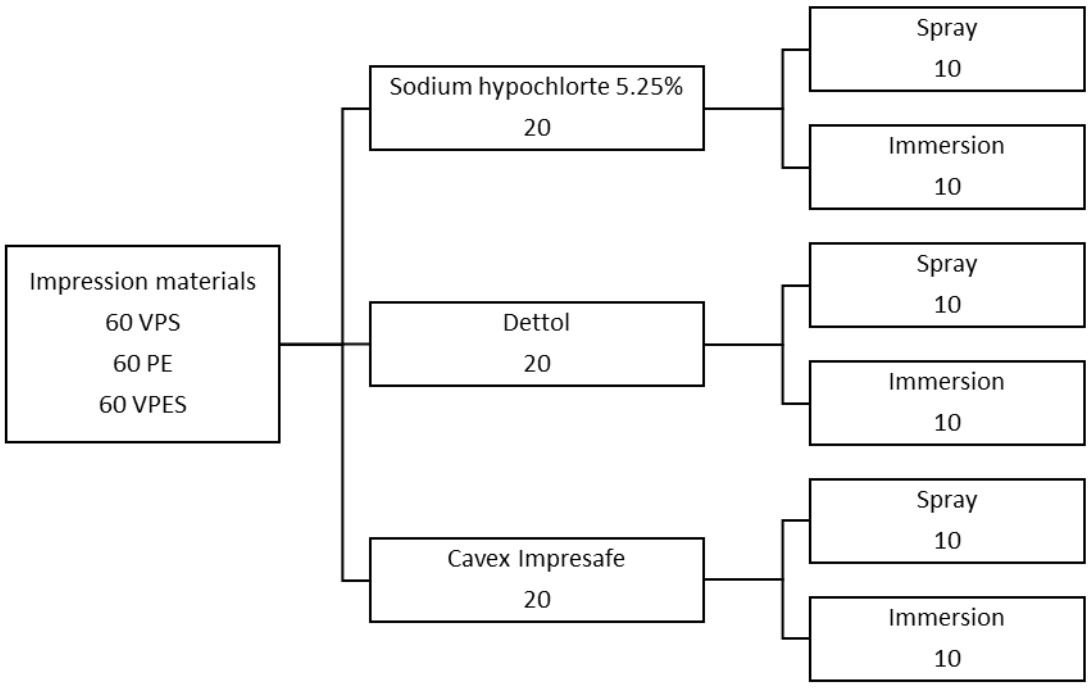

Figure 1: Study design.

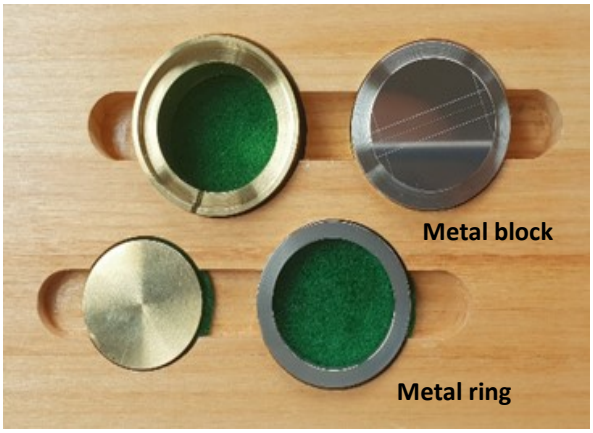

Figure 2: ADA specification number 19 apparatus used in the study.

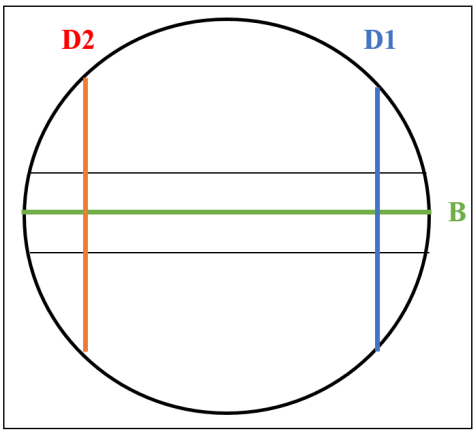

Figure 3: Diagram of the metal block used in this study.

The setting time recommended by the manufacturer was 3 minutes for the impression materials used in this study but the samples were taken out from the metal die 2 minutes more than the setting time as recommended by the ADA when testing silicone impression materials[6] then examined under a USB digital microscope connected to a computer.

A ranking system established by Owen,[7] was used in this study through observing the quality of the samples under the USB digital microscope by checking the reproduction of line B in the impression samples, according to this ranking system four scores are used for ranking:

Score 1: The whole line reproduced sharply and clearly between the marks.

Score 2: The line is clear over more than 50% of the length, or indistinct for less than 50%, or reproduced over the whole length but was not sharp.

Score 3: the line is clear over less than 50% of the length, or indistinct over more than 50%, or completely visible but blemished and rough.

Score 4: Blemished, pitted, or rough, and not reproduced over the whole length.

To obtain the clinical requirements of impression, all types were excluded except those ranking as score 1.

Disinfection. The sample was disinfected with two techniques, spraying and immersion. The spray was placed 15 cm away from the sample as recommended by spray manufacturers to standardize the spraying of the samples, then was sprayed with 10 puffs for 15 seconds[9] and left to be disinfected for 10 minutes for sodium hypochlorite 5.25% and Dettol groups[10] and left for 3 minutes for Cavex impresafe group as recommended by the manufacturer and then all sprayed samples were rinsed under distilled water for five seconds.

For the Immersion technique, the samples were immersed in plastic containers containing the disinfectants diluted as the manufacturer's instructions, and left for 10 minutes to be disinfected for sodium hypochlorite 5.25% and Dettol groups[10] and left for 3 minutes for Cavex impresafe group as recommended by the manufacturer and then all the immersed samples were rinsed under distilled water for five seconds.

Surface detail. After disinfection the samples were observed under the USB digital microscope checking line B immediately by three observers to determine the surface detail score, then every 10 samples for each material were stored together in a sealed plastic bag in room temperature. To assess the effect of the disinfectants on the surface detail of the impression materials the same procedure was repeated after 7 hours and 48 hours.

Dimensional stability. The samples were tested under the microscope by measuring line B between line D1 and Line D2 immediately after disinfection, 7 hours and 48 hours after disinfection. The measurement of the microscope was standardized by a calibration sheet provided with the microscope. Between each test 10 samples for each material were kept together

in a sealed plastic bag at room temperature. Dimensional stability was calculated according to this formula:

$$\Delta L = 100 \times [(L1 - L2)/L1],$$ [12]

where L1 is the length of line B as measured on the metal die, and L2 is the length of line B as measured on the sample.

Results

Surface detail test. The three impression materials were compared for surface detail reproduction before disinfection to assess the best impression material. According to the results of this study, the accurate impression material was PE with most of the samples having **score 1** (98%), while VPES showed 95% **score 1** and VPS showed 93% **Score 1** (Figure 4). The samples that scored 1 and 2 are shown in figures 5A and 5B respectively.

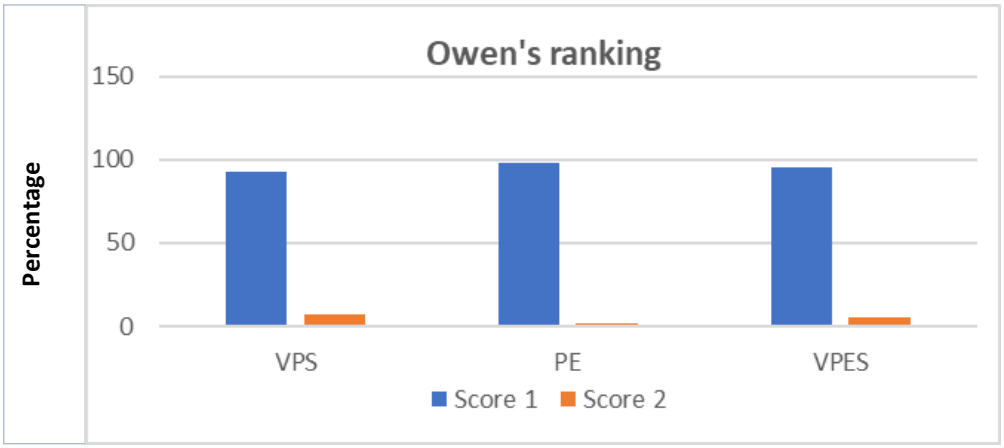

Figure 4: Owen ranking result for surface detail test before disinfection.

The surface detail reproduction before and immediately after disinfection was the same and regarded as the control group. Following disinfection, the samples were reevaluated for surface detail check after 7 hours and 48 hours. The samples remained in the **score 1** ranking with all the disinfection materials and techniques.

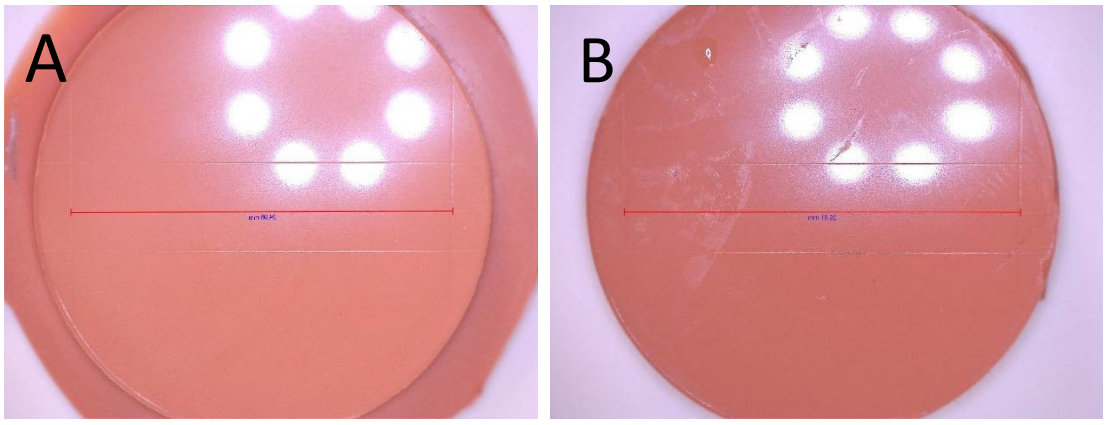

Figure 5: Owen ranking: (A) showing score 1, (B) showing score 2.

Dimensional stability test. The results showed that more changes occurred after 48 hours from disinfection with both the spray and the immersion techniques with a maximum of 1.5 % dimensional change which is acceptable by the ADA according to specification number 19. The mean percentage of dimensional change for VPS, PE, and VPES is shown in figures 6, 7 and 8 respectively.

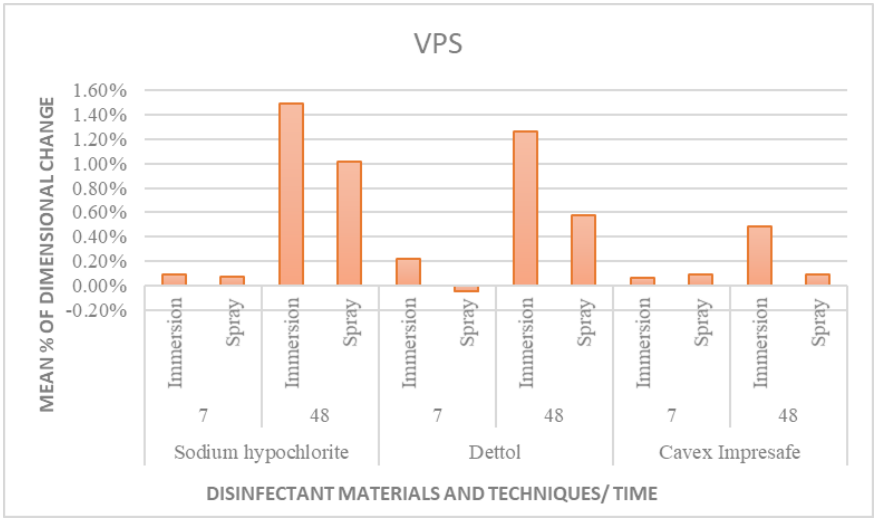

Figure 6: Mean values of dimensional changes for VPS material.

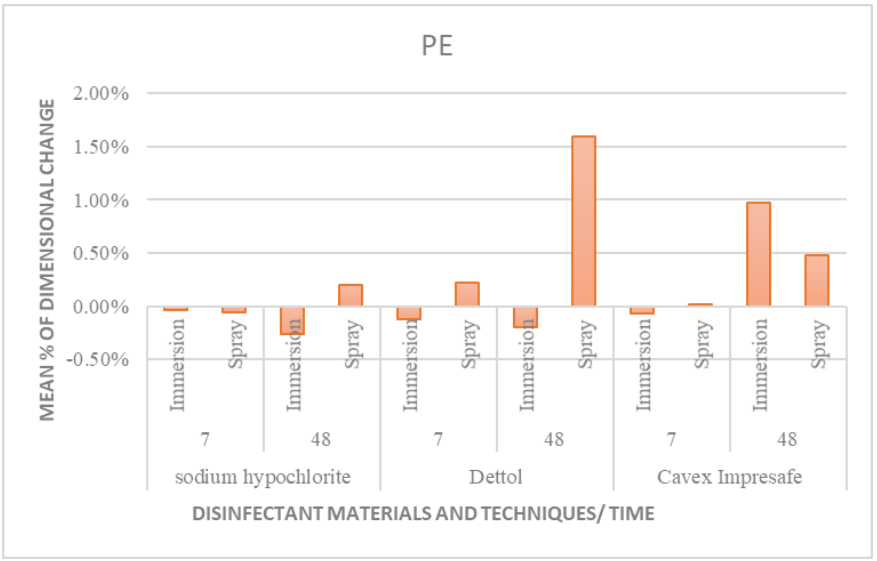

Figure 7: Mean values of dimensional changes for PE material.

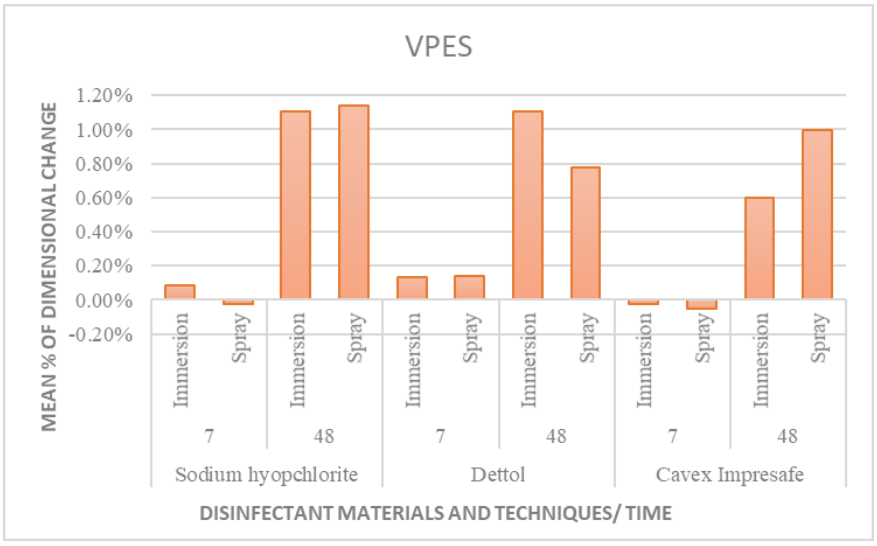

Figure 8: Mean values of dimensional changes for VPES material.

The statistical analysis was done by using one sample t-test to compare the dimensional changes between the immediate time after disinfection with 7 hours and 48 hours after disinfection with both the spray and the immersion techniques for the same material.

The VPS material showed significant changes after 48 hours from disinfection with all disinfectant materials and techniques but spraying with Cavex impresafe had the least effect between the other disinfectant materials and techniques.

PE showed good dimensional stability after disinfection except for disinfection with Dettol by spraying method after 48 hours from disinfection which was statistically significant and was similar to VPES material with dimensional stability except that VPES showed dimensional changes with sodium hypochlorite after 48 hours by immersion technique. In tables 1, 2 and 3 are the detailed statistics for each sample, VPS, PE, and VPES respectively.

Table 1: ΔL values (% dimensional changes) mean ± SEM, and t-test for mean difference (n = 10 per group).

		Time (hours)	Mean ± SEM	t-test	P-value
VPS	Immersion with sodium hypochlorite	7	0.0009 ± 0.0003	3.5036	0.008
		48	0.0149 ± 0.0025	5.9701	0.000
	Immersion with Dettol	7	0.0022 ± 0.0006	3.6966	0.006
		48	0.0126 ± 0.0003	4.9578	0.001
	Immersion in Cavex Impresafe	7	0.0006 ± 0.0008	0.8008	0.446
		48	0.0048 ± 0.0042	1.1342	0.289
	Spray with Sodium hypochlorite	7	0.0008 ± 0.0005	1.5079	0.170
		48	0.0102 ± 0.0025	4.1288	0.003
	Spray with Dettol	7	-0.0006 ± 0.0007	-0.7529	0.473
		48	0.0058 ± 0.0050	1.1637	0.278
	Spray with Cavex Impresafe	7	0.0009 ± 0.0003	3.5036	0.008
		48	0.0009 ± 0.0003	3.5036	0.008

Table 2: ΔL values (% dimensional changes) mean ± SEM, and t-test for mean difference (n = 10 per group).

		Time (hours)	Mean ± SEM	t-test	P-value
PE	Immersion with sodium hypochlorite	7	-0.0004 ± 0.0011	-0.3844	0.710
		48	-0.0029 ± 0.0095	-0.3027	0.769
	Immersion with Dettol	7	-0.0012 ± 0.0009	-1.2824	0.231
		48	-0.0020 ± 0.0016	-1.2183	0.254
	Immersion in Cavex Impresafe	7	-0.0007 ± 0.0010	-0.7610	0.466
		48	0.0097 ± 0.0070	1.3940	0.196
	Spray with Sodium hypochlorite	7	-0.0006 ± 0.0009	-0.6210	0.551
		48	0.0022 ± 0.0088	0.2532	0.806
	Spray with Dettol	7	0.0023 ± 0.0014	1.5704	0.150
		48	0.0159 ± 0.0065	2.4406	0.037
	Spray with Cavex Impresafe	7	0.0001 ± 0.0016	0.0833	0.935
		48	0.0048 ± 0.0078	0.6133	0.554

Table 3: ΔL values (% dimensional changes) mean ± SEM, and t-test for mean difference (n = 10 per group).

		Time (hours)	Mean ± SEM	t-test	P-value
VPES	Immersion with sodium hypochlorite	7	0.0009 ± 0.0009	1.1276	0.292
		48	0.0123 ± 0.0049	2.5028	0.036
	Immersion with Dettol	7	0.0015 ± 0.0012	1.2158	0.258
		48	0.0122 ± 0.0068	1.7947	0.110
	Immersion in Cavex Impresafe	7	-0.0005 ± 0.0018	-0.2619	0.800
		48	0.0045 ± 0.0085	0.5289	0.611
	Spray with Sodium hypochlorite	7	-0.0003 ± 0.0013	-0.2216	0.830
		48	0.0127 ± 0.0057	2.2396	0.055
	Spray with Dettol	7	0.0016 ± 0.0015	1.0363	0.330
		48	0.0086 ± 0.0060	1.4450	0.186
	Spray with Cavex Impresafe	7	-0.0008 ± 0.0014	-0.5568	0.592
		48	0.0096 ± 0.0063	1.5079	0.170

Discussion

Dimensional stability of the impression materials used in dentistry presents a significant reason for the accuracy of dental devices. A dental impression is the first stage of the complicated consequence of dental device manufacture. Each phase donates to the overall error of the future work and can lead to poor quality and diminished accuracy. An error made in the initial stages of production cannot be corrected in the further process but becomes the source of the new errors. That is why the information of impression materials properties is imperious for a dental practice so that a practitioner can choose suitable mass that corresponds to the present situation.

This study showed that although dimensional changes occurred after disinfection, these changes were in the acceptable limit according to ADA specification number 19. However, this standard method produces an impression sample that allows only a 2D measurement that goals at assessing the dimensional change the material may experience.

In other words, it does not mimic clinical situations, which include the use of impression trays, adhesive, and dental stone for making impressions and casts. Thus, the 3D constancy of the measurement of the materials in a further study is advocated.

Other research models are available that more closely mimic the clinical situation; however, they also introduce a number of additional issues, contributing to changeability and making comparisons more difficult.[13,14]

This study compared three different dental impression materials with three different disinfectants by using two disinfectant techniques, spray and immersion. VPS, PE and VPES were the dental impression materials and were disinfected by sodium hypochlorite, Dettol and Cavex impresafe to check for dimensional stability. VPES was presented by the manufacturer as a mixture of VPS and PE. The manufacturer reports that it has 5% to 20% polyether compound, which is seemingly responsible for enhancing the hydrophilicity of the impression material. The remainder of the material, the VPS component, consists of a mixture of vinyldimethylpolysiloxane (10%-50%), methylhydrogen dimethylpolysiloxane (3% -10%) and silicon dioxide (30%-65%). This combination is supposed by the manufacturer to provide excellent elastic recovery and good tear strength. Because

of this unique composition of VPS and PE, it is reasonable to debate VPES behavior using the established knowledge on these two categories of impression materials.

According to this study, polyether material showed the least dimensional change after disinfection, this result may be due to that the samples were stored in sealed plastic bags that preserved the moister from evaporation as polyether is the most hydrophilic material compared to the other materials.[15]

VPS showed the most dimensional change of 1.5% after 48 hours from disinfection by immersion in sodium hypochlorite with significant statistical differnce but this change was acceptable by the ADA according to specification number 19.[6]

Cavex impresafe disinfectant material had the least effect on the dimensional stability of the impression materials this may be due to the short contact time of only three minutes as instructed by the manufacturer.[16]

There was no significant difference between spray or immersion technique to disinfect the impression materials both showed slight dimensional stability similar to each other. According to statistical analysis, both techniques were sufficient to maintain the dimensional integrity of the impression materials. The minimal dimensional changes in this study are constant with what other studies have reported.[5,14]

Longer storage periods were not examined in this study, though Clancy et al reported that the dimensional stability of the VPS and PE materials established was not affected by storage for up to 4 weeks.[17] However, since VPES showed the least contraction at zero time, and since dimensional stability information for longer storage periods have not been reported, it is preferable to pour such impressions immediately after disinfection or, if needed, within a few days.

Though this study does not conclusively determine the reason that VPES had less dimensional change than VPS, nor it explains how the disinfectant resulted in continued stability over time, there are a number of possible clarifications. The PE portion of VPES may be responsible for initial imbibition hardened by the contraction of the VPS component and possibly the loss of unstable components from the PE portion.[18] However, as the exact components of VPES are exclusive, a number of other explanations are also equally reasonable, filler materials may have different absorbance and release of water properties, a chemical collaboration of VPS and/or PE with the filler may result in novel assets, or surfactant combination in the impression materials could have a possible effect.

Conclusion

Within the limitations of this in vitro study all VPS, PE, and VPES performed within the limits specified by ADA specification No. 19, and these materials were stable over a storage time of 48 hours, PE underwent less dimensional change than VPES and the latter showed less dimensional change than VPS.

Cavex impresafe had the least effect on the dimensional stability compared with the other disinfectants. Different techniques of disinfection did not significantly differ from each other, their effects on the impression materials were similar. Spraying with Cavex impresafe for disinfecting the impression materials had the least influence on their accuracy.

Conflicts of interest

The authors reported no conflict of interest.

References

1. Vitti RP, Correr-Sobrinho L, Sinhoreti MAC. Dimensional accuracy of stone casts made by a monophase impression technique using different elastomeric impression materials. Braz J Oral Sci 2011; 10(3):175–9.
2. Wadhwa SS, Mehta R, Duggal N, Vasudeva K. The effect of pouring time on the dimensional accuracy of casts made from different irreversible hydrocolloid impression materials. Contemp Clin Dent 2013; 4(3):313–8.
3. Nassar U, Flores-Mir C, Heo G, Torrealba Y. The effect of prolonged storage and disinfection on the dimensional stability of 5 vinyl polyether silicone impression materials. J Adv Prosthodont 2017; 9(3):182–7.

4. Sebastiani FR, Dym H, Kirpalani T. Infection control in the dental office. Dent Clin 2017; 61 (2):435–57.
5. Walker MP, Rondeau M, Petrie C, Tasca A, Williams K. Surface quality and long-term dimensional stability of current elastomeric impression materials after disinfection. J Prosthodont 2007; 16(5):343–51.
6. Revised American Dental Association Specification No. 19 for Non-Aqueous, Elastomeric Dental Impression Materials. J Am Dent Assoc 1977; 94(4):733–41.
7. Nassar U, Chow AK. Surface detail reproduction and effect of disinfectant and long-term storage on the dimensional stability of a novel vinyl polyether silicone impression material. J Prosthodont 2015; 24(6):494–8.
8. Chopra S, Gupta NK, Tandan A, Dwivedi R, Gupta S, Agarwal G. Comparative evaluation of pressure generated on a simulated maxillary oral analog by impression materials in custom trays of different spacer designs: An in vitro study. Contemp Clin Dent 2016; 7(1):55–60.
9. Badrian H, Davoudi A, Molazem M, Zare MH. The effect of spraying different disinfectants on condensational silicone impressions; an in vitro study. J Indian Prosthodont Soc 2015; 15(3):263–7.
10. Kalantari MH, Malekzadeh A, Emami A. The effect of disinfection with sodium hypochlorite 0.5% on dimensional stability of condensation silicone impression materials of Speedex and Irasil. J Dent 2014; 15(3):98–103.
11. Estrela C, Estrela CRA, Barbin EL, Spanó JCE, Marchesan MA, Pécora JD. Mechanism of action of sodium hypochlorite. Braz Dent J 2002; 13 (2):113–7.
12. Kim K-M, Lee J-S, Kim K-N, Shin S-W. Dimensional changes of dental impression materials by thermal changes. J Biomed Mater Res 2001; 58(3):217–20.
13. Nassar U, Oko A, Adeeb S, El-Rich M, Flores-Mir C. An in vitro study on the dimensional stability of a vinyl polyether silicone impression material over a prolonged storage period. J Prosthet Dent 2013; 109(3):172–8.
14. Stober T, Johnson GH, Schmitter M. Accuracy of the newly formulated vinyl siloxanether elastomeric impression material. J Prosthet Dent 2010; 103(4):228–39.
15. Corso M, Abanomy A, Di Canzio J, Zurakowski D, Morgano SM. The effect of temperature changes on the dimensional stability of polyvinyl siloxane and polyether impression materials. J Prosthet Dent 1998; 79(6):626–31.
16. Dreesen K, Kellens A, Wevers M, Thilakarathne PJ, Willems G. The influence of mixing methods and disinfectant on the physical properties of alginate impression materials. Eur J Orthod 2013; 35(3):381–7.
17. Clancy JMS, Scandrett FR, Ettinger RL. Long-term dimensional stability of three current elastomers. J Oral Rehabil 1983; 10(4):325–33.
18. Kanehira M, Finger WJ, Endo T. Volatilization of components from and water absorption of polyether impressions. J Dent 2006;3 4(2):134–8.