Dimensional changes of commercial and novel polyvinyl siloxane impression materials following sodium hypochlorite disinfection (#64727)

First revision

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Dimensional changes of commercial and novel polyvinyl siloxane impression materials following sodium hypochlorite disinfection

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Background: Dental impressions are used to record anatomy of teeth and surrounding oral structures. Impression materials are soiled with saliva and blood leading to cross-contamination. Disinfection reduces cross infection but may have negative impact on dimensional stability of materials. **Objective:** Comparatively evaluate linear dimensional changes of synthesized Tetra-functional (dimethylsilyl) orthosilicate (TFDMOS) containing Polyvinylsiloxane (PVS) impressions following sodium hypochlorite disinfection. **Methods:** Percentage dimensional changes of three commercial PVS (Elite HD Monophase, Extrude and AquaSil Ultra Monophase) and five experimental PVS impression materials were measured. Exp-A (without TFDMOS), Exp-B (with TFDMOS), Exp-C (TFDMOS+ 2% Rhodasurf CET-2), Exp-D (TFDMOS+ 2.5% Rhodasurf CET-2) Exp-E (TFDMOS+ 3% Rhodasurf CET-2) were prepared. Samples were made using rectangular stainless-steel molds (40X10X3 mm^3) and linear dimensional changes were measured using a calibrated travelling microscope at 10x magnification after immersion in distilled water and 1 % Sodium Hypochlorite solution at 30 minutes and 24 hours. **Results:** Samples immersed in 1% NaOCl showed significant ($p < 0.05$) dimensional changes after 30 minutes of immersion. Exp-E showed significantly greater dimensional changes than their control (Exp-A and Exp-B). In distilled water, there were no significant difference among the tested materials. AquaSil exhibited highest expansion (0.06%) in both solutions. At 24 hours, among the commercial material, extrude had the greatest expansion followed by AquaSil and Elite in DW while AquaSil showed the greatest expansion followed by Extrude and Elite in NaOCl. **Conclusion:** Experimental PVS had linear dimensional changes within ISO 4823; 2015

recommended range. However, extended immersion can negatively affect the linear dimensions.

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Abstract

Background: Dental impressions are used to record anatomy of teeth and surrounding oral structures. Impression materials becomes contaminated with saliva and blood leading to health hazards. Disinfection reduces cross infection but may have negative impact on dimensional stability of materials.

Objective: Comparatively evaluate linear dimensional changes of synthesized Tetra-functional (dimethylsilyl) orthosilicate (TFDMOS) containing Polyvinylsiloxane (PVS) impressions following sodium hypochlorite disinfection.

Methods: Percentage dimensional changes of three commercial PVS (Elite HD Monophase, Extrude and AquaSil Ultra Monophase) and five experimental PVS impression materials were measured. Experimental material contained novel cross-linking agent (TFDMOS) and a non-ionic surfactant (Rhodasurf CET-2) that is Exp-A (without TFDMOS), Exp-B (with TFDMOS), Exp-C (TFDMOS+ 2% Rhodasurf CET-2), Exp-D (TFDMOS+ 2.5% Rhodasurf CET-2) Exp-E (TFDMOS+ 3% Rhodasurf CET-2). Samples were made using rectangular stainless-steel molds (40x10x3mm^3) and linear dimensional changes were measured using a calibrated travelling microscope at 10x magnification after immersion in distilled water (D.W) and 1 % Sodium Hypochlorite solution at two different time intervals i.e., 30 minutes and 24 hours.

Results: Samples immersed in 1% NaOCl showed significant ($p<0.05$) dimensional changes after 30 minutes of immersion. Exp-E showed significantly greater dimensional changes than their control (Exp-A and Exp-B). In distilled water, there were no significant difference among the tested materials. AquaSil exhibited highest expansion (0.06%) in both solutions. At 24 hours,

among the commercial material, Extrude had the greatest expansion followed by AquaSil and Elite in DW while AquaSil showed the greatest expansion followed by Extrude and Elite in NaOCl.

Conclusion: Experimental PVS had linear dimensional changes within ISO 4823; 2015 recommended range. However, extended immersion can negatively affect the linear dimensions.

Introduction

Dental impressions are used to accurately record and reproduce the shape, relationship of teeth and surrounding oral structures (Kumari & Nandeeshwar 2015). However, during impression making, the material becomes contaminated with saliva and often with blood which may pose health hazard to the dental team (Ud Din et al. 2018). Different methods of disinfection including spraying and immersion of impression material are commonly employed (Khan 2018). However, American Dental Association (ADA) recommends immersion technique because it allows direct contact of disinfectant solution with all surfaces of the impression (Samra & Bhide 2018). Disinfection through immersion reduces risk of cross infection, yet alteration in dimensions of impression materials and negative impact on quality of resulting cast has often been reported (Guiraldo et al. 2012; Martin et al. 2007). This might result in dimensional changes in dental prosthesis and ultimately affect the fit of final restoration (Asopa et al. 2020). Iwasaki et al. (2016) reported marked change in the dimension of alginate impressions due to water sorption after prolonged immersion in a disinfectant solution (Iwasaki et al. 2016). Similarly, Babiker et al. (2018) reported significant dimensional changes of gypsum cast obtained from irreversible hydrocolloids after disinfection by NaOCl immersion (Babiker et al. 2018).

The recommended products for disinfection of the impression materials are sodium hypochlorite, chlorhexidine, glutaraldehyde and iodine agents (Correia-Sousa et. al, 2013). Among numerous disinfectants available, sodium hypochlorite has been recommended by ADA and Environmental Protection Agency (EPA) for the disinfection of impressions due to its low cost and broad spectrum antimicrobial activity (Correia-Sousa et al. 2013; Khan and Mushtaq 2018). A study by Al-Enazi and Naik on the efficacy of 1 % sodium hypochlorite and 2 % glutaraldehyde disinfectant sprays on impression materials (alginate and addition silicone rubber-based impression material) established that 1 % sodium hypochlorite yielded better results (Al Enazi and Naik 2016).

Recently polyvinylsiloxane has gained popularity due to its ability to precisely record tissue details, excellent physical properties and easy manipulation, and is preferred for making final impression of fixed dental prosthesis (Azevedo et al. 2019). Nevertheless, these materials have lower tear strength and percentage elongation compared to polysulphide. Additionally, the hydrophobic nature of the material demands a dry field of operation to accurately record fine tissue details (Ud Din et al. 2018).

Different researchers have incorporated surfactant to the material composition to synthesize hydrophilic addition silicone, but limited literature is available on methods to improve tear strength of the material (Lee et al. 2004). Formerly, we have carried out synthesis of novel TFDMOS containing polyvinyl siloxane with a non-ionic surfactant (Rhodasurf CET-2) to improve the tear strength and hydrophilicity of conventional addition silicones. It was observed that experimental formulation had significantly higher tear strength compared to commercial material and that tear strength was directly proportional to the concentration of non-ionic surfactant (Din et al. 2018). Considering the variation in material properties corresponding to the composition of the material, the effect of non-ionic surfactant on dimensional stability of material especially after disinfection needed further exploration. It was hypothesized that the experimental formulations have higher water sorption due to presence of non-ionic surfactant, resulting in noticeable dimensional changes.

Extensive use of polyvinylsiloxane in dentistry and varieties of formulation available necessitated a comprehensive comparison of material particularly in terms of dimensional changes following long term disinfection. Therefore, the objective of this study was two-fold including formulation of experimental polyvinylsiloxane containing TFDMOS and evaluation of the influence of storage media that is distilled water and 1% sodium hypochlorite on the linear dimensional changes over the period of 24 hours, in commercial and synthesized PVS impression materials.

Materials & Methods

In this in-vitro experimental study, three commercially available medium bodied PVS materials, Aquasil (Ultra, Dentsply, USA), Elite HD Monophase (Zhermack, Italy) and Extrude (Kerr, USA) were selected. In addition, five experimental PVS materials were prepared as base and catalyst paste by weighing all components using four figure balance (Mettler, Toledo Ltd, Model AG204, UK) as already mentioned in published part of the study (Ud Din et al. 2018). The composition of experimental materials is illustrated in Table 1. To prevent premature polymerisation, equal amount of the prepared material was weighed with four figure balance and was packed into separate compartments of an auto-mixing cartridge and stored at 4°C. Exp-A served as a control for Exp-B, while Exp-B was used as a control for Exp-C, D and E. Rhodasurf CET-2 (non-ionic surfactant) was incorporated in the base paste of Exp-B at 2, 2.5 and 3% to formulate Exp C, D and E respectively.

A total of eighty samples (n=10 for each material) were prepared by introducing the material from automixing syringe into the preformed stainless steel mold (40 x 10 x 2 mm^3) sandwiched between two metal plates lined by acetate paper. The assembly was placed under a hydraulic press (MESTRA MOD-030350, Talleres Mestraitua, Spain) Commercial material was allowed to polymerize for the time specified by the manufacturers, while experimental formulation were polymerized for 10 minutes (Ud Din et al. 2018; Din et al. 2018).

After polymerization, the material was removed from the mold and the specimens were divided into 2 test groups, each consisting of 5 samples from each material. Group 1 was immersed in 1% NaOCl and Group 2 in distilled water solution for 24 hours at 23 ± 1°C in an oven (Qualicool incubators, LTE Scientific Ltd). At predetermined time period, which ~~are~~ 10 and 30 min (replicate at-office disinfection), and 60 min and 24 hours (simulate the transportation time for the impression to reach the dental laboratory) each sample was removed from the respective liquid, blot dried. Linear dimensional changes were recorded using a calibrated travelling microscope (Chesterman, Sheffield, England) by measuring the distance between the fixed edge and free end of the sample (movable pin) at 10x magnification. Data was presented as mean and standard deviation using SPSS Version 22 (Armonk NY IBM Corp). Analysis of variance with post hoc Tukey's test was performed to statistically compare all PVS materials at different time points and p value of 0.05 was considered as significant.

Results

Figure 1 and 2 shows percentage linear dimensional changes of impression materials in DW and 1% NaOCl after 24 hours immersion. AquaSil exhibited highest expansion (0.06%) in both solutions while Exp-A exhibited least expansion (0.01%) in DW. For Group 1, a significant difference ($p \leq 0.05$) in dimensions was observed after 30 minutes of immersion. Inter-group analysis revealed statistically similar dimensional changes among all tested materials, except for Exp-E (Table II). The surfactant modified Exp-E showed significantly greater dimensional changes than their control groups (Exp A & Exp B). Among commercial materials, although no statistically significant changes in dimensions were observed, AquaSil showed the highest expansion followed by Extrude and Elite in 1% NaOCl solution.

For Group 2 immersed in distilled water, there were no significant difference among the commercial and experimental materials. Extrude had the highest expansion followed by AquaSil and Elite at 24 hours. Exp B showed slightly higher, but statistically similar expansion to Exp-A, while Exp-C, D and E exhibited higher expansion in each immersion solution compared to Exp-B (control) at each interval. Also, expansion of experimental materials was directly related to the concentration of the surfactant

Discussion

Impression making is an important aspect of prostheses fabrication. In the oral cavity, these material comes in contact with saliva and blood (Khan and Mushtaq 2018). This demands disinfection of materials to prevent cross-infection in dental clinics and hospital. However, it is important that the impressions remain dimensionally stable after disinfection.

The results of the present study revealed that immersion of addition silicones impression materials in distilled water (Group 2) had no significant impact on the dimensional stability of the material, where disinfection of impression with 1% NaOCl (Group 1) for 24 hours resulted in expansion of tested materials. However, the dimensional changes observed were not clinically relevant as the values are within the permitted range of ≤0.5% as recommended by ISO 4823; 2015 (ISO) and

ADA specification 19 (Association 2007). Thus, indicating high precision of the experimental material.

The limited amount of linear expansion could be attributed to the isotropic expansion of the samples as they adhere to the PTFE trough of travelling microscope. These findings were supported by Carvalhal et al (2011) who investigated the dimensional changes of polysulphide, polyether, addition and condensation silicone after immersion disinfection with 0.5% NaOCl and 2% glutaraldehyde. They observed insignificant changes in the linear dimensional of materials and recommended that all synthetic elastomers can be safely disinfected by immersion in 0.5% NaOCl and 2% glutaraldehyde (Carvalhal et al. 2011). In a similar study, Samra and Bhide (2018) observed clinically acceptable dimensional changes for alginate and PVS after disinfection with ultraviolet rays and immersion disinfection with sodium hypochlorite, changes in cross-arch space and inter-abutment distance on gypsum cast were noted for materials disinfected by glutaraldehyde immersion (Samra & Bhide 2018).

Furthermore, Exp-E had significantly greater dimensional changes after immersion disinfection with NaOCl. This was in line with a number of studies that indicated hydrophilic silicones have greater tendency to absorb water and expand (Silva & Salvador 2004). Results also indicated that longer immersion periods can affect the materials. These findings were similar to those noted by Johnson (1996), who reported long term dimensional stability of PVS is unsatisfactory (Thouati et al. 1996). Similarly, Kumari and Nandeeshwar (2015) observed significant difference between non-disinfected and disinfected specimen of PVS and polyether after immersion of 16 hours in 0.525% sodium hypochlorite (Kumari & Nandeeshwar 2015). On contrary, Nassar et al found no statistically significant difference between dimensions of vinyl polyether silicone at time of fabrication and after storage for 1 and 2 weeks in 2.5 % buffered solution of glutaraldehyde and reported that dimensional changes within the material obeyed ANSI/ADA standards (Nassar et al. 2017).

The limitation of this study was that the accuracy of the impression material was determined by studying stability of the impression itself and that the setting expansion of the gypsum cast was not taken in account. However, the results confirmed the high precision of the experimental material, suggesting routine use of these materials for impression of fixed and removable partial dentures, complete dentures, precision attachments and implants. However, it is suggested to evaluate effect of other disinfectant system.

Conclusions

All three commercial and five experimental polyvinylsiloxane impressions exhibited linear expansion within the recommended range outlined by ANSI and ISO 4823; 2015 following 24hours of immersion, though extended immersion time amplified dimensional changes within all the groups. Therefore, following disinfection, the silicone impression materials must be poured within twenty-four hours.

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Table 1(on next page)

Composition of Experimental Polyvinyl siloxane impression materials

Table 1:Composition of Experimental Polyvinyl siloxane impression materials

Components	Base Paste(Wt %)				
	Exp-A	**Exp-B**	**Exp-C**	**Exp-D**	**Exp-E**
Vinyl-terminated dimethylpolysiloxane (Mw 62700)	39.90	39.90	37.95	37.46	36.98
Polymethylhydrosiloxane (Mw 2270)	1.10	0.77	0.74	0.73	0.72
Tetra-functional (dimethylsilyl) orthosilicate (Mw 329)	-	0.33	0.32	0.31	0.31
Components	**Catalyst Paste(Wt %)**				
	Exp-A	**Exp-B**	**Exp-C**	**Exp-D**	**Exp-E**
Vinyl-terminated dimethylpolysiloxane (Mw 62700)	40.72	40.72	39.51	39.51	39.51
Platinum (0.05 M)	0.06	0.06	1.27	1.27	1.27
Palladium (<1µm)	0.23	0.23	0.22	0.22	0.22
Rhodasurf CET-2	-	-	2.00	2.50	3.00

Table 2(on next page)

Comparison of linear dimensional changes of impression materials stored in 1% NaOCl disinfectant solution at 30 minutes

Table 2: Comparison of linear dimensional changes of impression materials stored in 1% NaOCl disinfectant solution at 30 minutes

Materails	**Mean**	**S.D**	**F (p-value)**	**Post –hoc Tukey test**	**p-value**
Aquasil	0.058	0.029	3.657 (0.005)	Exp E vs Aquasil	0.634
Extrude	0.046	0.027		Exp E vs Extrude	0.252
Elite	0.021	0.028		Exp E vs Elite	**0.012**
Exp A	0.010	0.023		Exp E vs Exp A	**0.003**
Exp B	0.031	0.028		Exp E vs Exp B	**0.047**
Exp C	0.041	0.023		Exp E vs Exp C	0.159
Exp D	0.032	0.029		Exp E vs Exp D	0.053
Exp E	0.040	0.023			

Figure 1

Mean linear dimensional changes with Standard Deviation of commercilal and experimental PVS impression materials over the period of 24 hours following immersion in Distal water

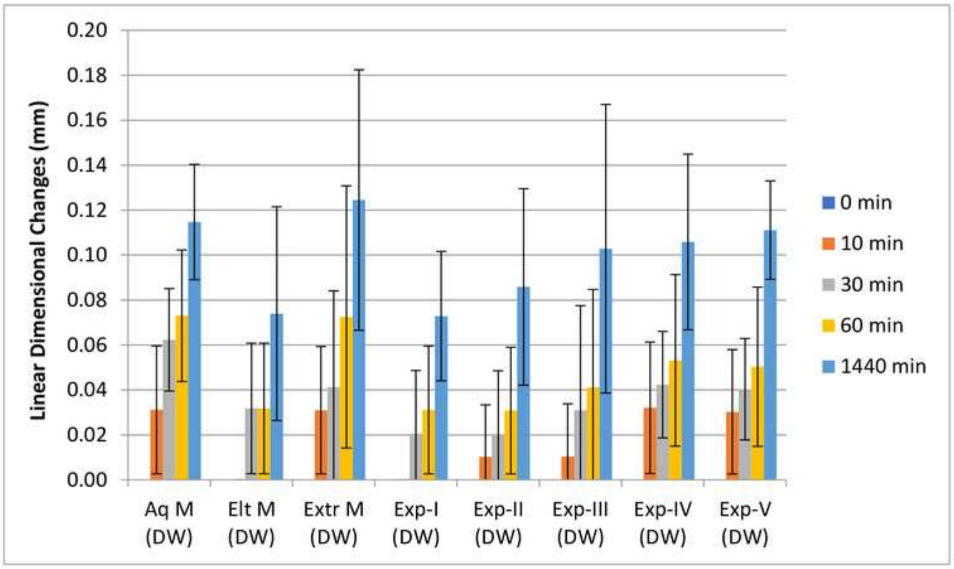

Fig 1: mean linear dimensional changes with Standard Deviation of commercilal and experimental PVS impression materials over the period of 24 hours following immersion in Distal water

Figure 2

Mean linear dimensional changes with Standard Deviation of commercilal and experimental PVS impression materials over the period of 24 hours following immersion in 1% NaOCl

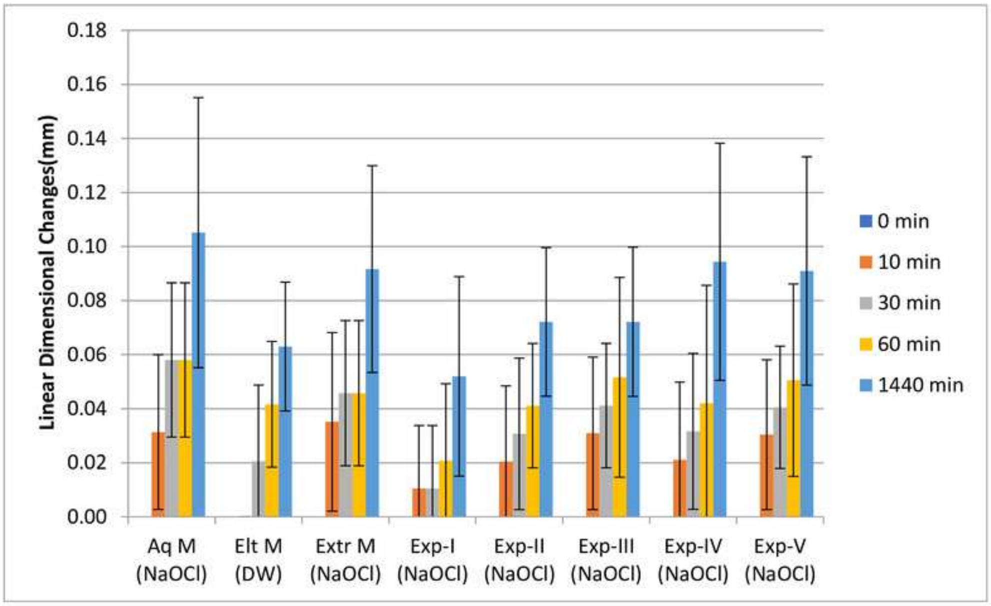

Fig 2: mean linear dimensional changes with Standard Deviation of commercilal and experimental PVS impression materials over the period of 24 hours following immersion in 1% NaOCl