Journal of Oral Science, Vol. 50, No. 4, 441-446, 2008

Original

The effect of immersion disinfection procedures on dimensional stability of two elastomeric impression materials

Dario Melilli, Antonio Rallo, Angelo Cassaro and Giuseppe Pizzo

Department of Oral Sciences, University of Palermo, Palermo, Italy

(Received 22 April and accepted 22 October 2008)

Abstract: The aim of this study was to determine the effect of immersion disinfection procedures on the dimensional stability of two elastomeric impression materials. Impressions of a stainless steel die were made with polyether (PE) and with addition-polymerized silicone rubber (PVS). The test specimens underwent disinfection treatment by immersion in two commercially available solutions containing quaternary ammonium compounds (Sterigum Powder, SP) and glutaraldehyde plus an amino derivative (MD520, MD), respectively. The impressions were measured at 4 different time points: before any disinfection treatment (T0); after the first disinfection (T1); 6 hours after the first disinfection (T2); after the second disinfection, carried out 6 hours after the first one (T3). Impressions which were not disinfected served as controls. When both impression materials were disinfected with SP, significant differences were detected among all measurements ($P < 0.0001$), with the exception of T2 vs T3 ($P > 0.05$). On the other hand, when MD was used, significant differences were found when T0 measurement was compared to T1, T2 and T3 measurements ($P = 0.0043$ for PE, and $P = 0.0014$ for PVS). The dimensional change of all material/disinfectant combinations was always ≤0.5%. Therefore, the effects of immersion disinfection on the dimension of elastomers in SP or MD are not clinically relevant. (J. Oral Sci. 50, 441-446, 2008)

Correspondence to Dr Giuseppe Pizzo, Dipartimento di Scienze Stomatologiche, Università di Palermo, Via del Vespro 129, 90127 Palermo, Italy
Tel: +39-091-6552231
Fax: +39-091-6552202
E-mail: giuseppepizzo@unipa.it

Keywords: impression materials, disinfectants, dimensional stability, disinfection, polyether, addition-polymerized silicone.

Introduction

Impression materials that have been exposed to infected saliva and blood provide a significant source for cross-contamination. Microorganisms from the oral cavity, in fact, can survive on the impression surface and can be transferred to the stone casts (1-5). Moreover, simply washing with water or rinsing in running water does not completely remove contaminating organisms from the impression (3,6,7). When considering methods and products for disinfecting impressions, two factors are important: the anti-bacterial efficacy of disinfecting procedures and the effect of these procedures on the dimensional stability of impression materials. Disinfection by immersion has been recognized as more effective and reliable than disinfection by spray (8-12). With the former method, in fact, the disinfectant solution comes into contact with all surfaces of the impression material and tray, and the risks of inhalation by the operator are minimized. Impression materials disinfected by immersion, however, may be subjected to dimensional changes which may have a direct effect on the prosthetic results achieved in dental practices.

The elastomeric impression materials are currently recommended to be disinfected by immersion (10), although there has been some concern over the effect of disinfection procedures on the dimensional stability (8,11,13,14). Several studies have been carried out to find an effective disinfection protocol that does not produce any clinically relevant changes in the elastomers, particularly the polyether ones (9,11,13,15-21). However, the findings from these studies have not always been univocal, because different exposure times and various combinations of

Table 1 Composition, spectrum of activity and direction for use of the disinfectants tested

	Composition	Effective spectrum	Directions for use
MD 520 (MD)	100 g contains: Glutaraldehyde 0.5 g; Alkyl-benzyl-dimethyl-ammonium chloride 0.25 g; Antifoaming agents; Complexing agents; Adjuvants	Bactericidal, fungicidal, virucidal (enveloped viruses, naked adenoviruses, HBV, HIV).	The impressions are dipped for 5 min, then rinsed thoroughly under running water and dried with blowing air.
Sterigum Powder (SP)	100 g contains: Alkyl-dimethyl-benzyl-ammonium chloride 0.10 g; Alkyl-dimethyl-etyl-ammonium chloride 0.15 g; Sodium perborate 0.5 g; Adjuvants	Virucidal (included HIV and HBV), bactericidal and fungicidal	The powder is diluted (2%) in a liter of water at 40°C, at the moment of the use. The impressions are dipped for 3 min.

disinfectant solutions and impression materials were used.

It must also be noted that in routine practice, gypsum casts may be made a few hours after the disinfection of impressions. Also, the impressions may undergo a further disinfection when they are received by the dental technician (22). It is yet unclarified, to the best of our knowledge, if these procedures adversely affect the dimensional stability of elastomers. The purpose of this study was to determine the effect of immersion disinfection procedures on the dimensional stability of two elastomeric impression materials, polyether and addition-polymerized silicone rubber.

Materials and Methods

Two commonly used elastomers were included in this investigation: a medium viscosity polyether (Impregum Penta Soft, 3M ESPE, St. Paul, MN, USA) (PE) and an addition-polymerized silicone rubber (Elite Mono Maxi, Zhermack, Badia Polesine, Italy) (PVS). Both impression materials underwent disinfection treatment by immersion in two commercially available solutions containing quaternary ammonium compounds (Sterigum Powder, Zhermack) (SP) and glutaraldehyde plus an amino derivative (MD 520, Dürr, Bietigheim Bissingen, Germany) (MD). The composition, effective spectrum and directions for use of these disinfectants are listed in Table 1. Impression materials and disinfectant products were used following the manufacturer's instructions, and all the tests were carried out at a temperature of 23°C and 60% humidity (23).

A standardized stainless steel die, recommended by the American Dental Association (ADA) specification no. 19 (23) and in accordance with the International Standard ISO 4823 (24), was used for impression making. The metal die was marked with 3 horizontal lines intersected by 2 vertical lines. Before recording each impression, the die was wiped with ethanol and allowed to dry at room temperature. All the impressions were made using prepackaged cartridges of PE and PVS and the Pentamix 2 electric mixing unit (3M ESPE). The impression material was placed on the metal die and compressed by a polyethylene sheet and a rigid, flat, glass plate. Sufficient force was applied to seat the plate firmly against the mold. This assembly was immediately transferred to a water bath at 32 ± 2°C. After the setting time was measured by a Cyclo-viscometer (Cyclo-visco-E, Brabender, Duisburg, Germany), the specimens were rinsed under running water and dried. Impressions were coded and six specimens of each material were randomly assigned to each of the disinfectants (test specimens). Six specimens of each impression material were not subjected to any disinfection and served as controls.

According to the ADA specification no. 19 (23) and the International Standard ISO 4823 (24), dimensional stability was assessed by measuring the d1-d2 distance (from the inner profile of Line d1 to the inner profile of Line d2) impressed on the specimens (Fig. 1). Measurements were taken by one investigator with a microscope (Olympus SZX9, Olympus, Tokyo, Japan) graduated at 8× magnification and provided with a digital micrometer (Mitutoyo, Hampshire, UK) to the nearest 0.001 mm.

The test specimens were measured at four different times: before disinfection treatment (T0); after the first disinfection, which was carried out immediately after removal of the impression (T1); 6 hours after the first disinfection (T2); after the second disinfection, which was carried out 6 hours after the first one (T3). The control specimens were measured immediately after removal of

the impressions (T0) and 6 hours later.

Each measurement was repeated four times and the mean of the 4 measurements was calculated. The percentage of change of the measurements at T1, T2 and T3 (S) from the metal die (K) and from the same specimen before disinfection (T0) (K) was calculated using the following formula:

$$\frac{(d1\text{-}d2\ S) - (d1\text{-}d2\ K)}{(d1\text{-}d2\ K)} \times 100$$

S = mean measurements of the specimens at T1, T2 or T3

K = mean measurements of the metal die or the specimen before disinfection (T0)

The data were analyzed for normality of distribution through the use of the Kolmogorov-Smirnov test. Since the data were normally distributed, an analysis of variance (ANOVA) was performed to determine differences in dimensional changes among the times tested (T0-T3). In the presence of significant differences, pairwise comparisons were made using the Student-Newman-Keuls (SNK) test. Dimensional changes of control specimens were compared by means of Student's *t*-test. The level of significance was set at $\alpha < 0.05$. Data analysis was performed using StatView 5.0.1 (SAS Institute, Cary, NC).

Results

The mean measurement (d1-d2) of the metal die was calculated to be 24.975 mm. Dimensional changes occurred in control specimens 6 hours after removal, but the differences between measurements were not significant ($P = 0.1224$ and $P = 0.0713$ for PVS and PE, respectively) (Table 2).

Table 3 shows the mean measurements of the PE and PVS specimens at the 4 experimental times. Both materials exhibited some dimensional changes, with significant differences after disinfection treatments. When both impression materials were disinfected with SP, significant differences were detected among all measurements ($P < 0.0001$), with the exception of T2 vs T3 ($P > 0.05$). On the other hand, when MD was used, significant differences were found when T0 measurement was compared to T1, T2 and T3 measurements ($P = 0.0043$ for PE, and $P = 0.0014$ for PVS). In spite of such significant differences, all measurements were within the ADA specification no. 19 (≤0.5% dimensional change) (23).

Data for dimensional changes of the test specimens compared to the metal die are shown in Table 4. The dimensional changes after the second disinfection (T3) ranged between 0.1% (PVS/MD) and -0.04% (PE/SP). In all instances, these changes were not clinically significant as they were lower than 0.5% (23). The dimensional

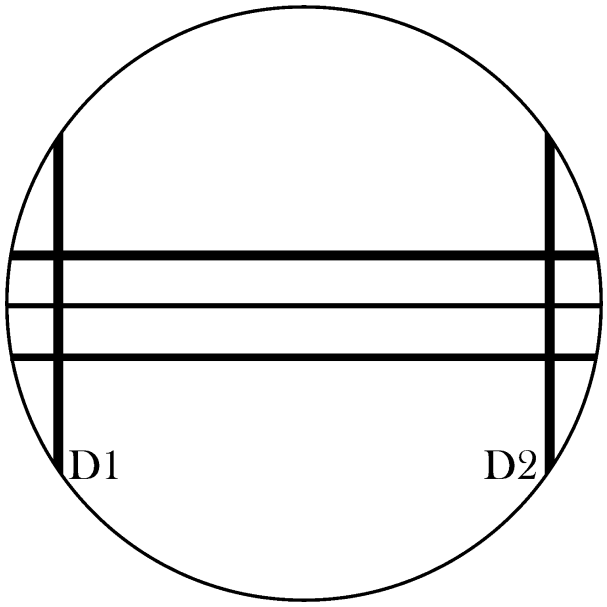

Fig. 1 Schematic illustration of the stainless steel test die showing the distance between the inner profile of Line d1 and the inner profile of Line d2 (d1-d2 distance). The width of vertical lines (d1 and d2) is 0.075 ± 0.008 mm, whereas the distance between the lines d1-d2 is 25 mm.

Table 2 Mean (SD) d1-d2 measurements (mm) and dimensional changes (%) of PE and PVS when used as controls

	Immediately after taking impressions (T0)	6 h after taking impressions
PE	24.994 (0.011)	24.987 (0.011) * *-0.03%*
PVS	24.983 (0.005)	24.981 (0.006) * *-0.01%*

PE: Polyether; PVS: addition silicone.
Measurements were carried out in triplicate. Italicized values indicate dimensional changes compared to T0. Shrinkage is represented by a negative number, expansion by a positive one
* Not significant ($P > 0.05$)

Table 3 Mean (SD) d1-d2 measurements (mm) and dimensional changes (%) of PE and PVS specimens disinfected in MD and SP disinfectant

Impression material/disinfectant	T0	T1	T2	T3
PE/SP	24.984 (0.004)	24.991 (0.004) *0.03%*	24.967 (0.007) * *- 0.07%*	24.963 (0.004) * *- 0.08%*
PE/MD	24.983 (0.005)	24.994 (0.008) *, ß *0.04%*	24.992 (0.003) *, ^ *0.04%*	24.996 (0.005) ß, ^ *0.05%*
PVS/SP	24.973 (0.004)	24.978 (0.003) *0.02%*	24.999 (0.005) * *0.10%*	24.997 (0.005) * *0.10%*
PVS/MD	24.968 (0.006)	25.001 (0.185) *, ß *0.13%*	24.985 (0.012) *, ^ *0.07%*	24.99 (0.004) ß, ^ *0.09%*

PE: Polyether; PVS: addition silicone. MD: MD 520; SP: Sterigum Powder
Measurements were carried out in triplicate. Italicized values indicate dimensional changes compared to T0.
Shrinkage is represented by a negative number, expansion by a positive one
*, ß, ^ : Not significant differences ($P > 0.05$)

Table 4 Mean dimensional changes (%) of test specimens compared to the metal die (d1-d2 = 24.975 mm)

Test specimens	T0	T1	T2	T3
PE/SP	0.04%	0.06%	-0.03%	-0.04%
PE/MD	0.03%	0.07%	0.07%	0.08%
PVS/SP	-0.01%	0.01%	0.1%	0.09%
PVS/MD	-0.02%	0.10%	0.04%	0.06%

PE: Polyether; PVS: addition silicone. MD: MD 520; SP: Sterigum Powder
Measurements were carried out in triplicate. Shrinkage is represented by a negative number, expansion by a positive one.

changes of the control specimens 6 hours after removal were also not statistically significant (data not shown; $P = 0.68$ and $P = 0.0867$ for PE and PVS, respectively).

Discussion

The risk of cross-infection from a patient to a dental technician is a topic of interest. In order to protect all the members of the dental team, a high standard of hygiene and disinfection of dental equipment, including dental impressions (14) is recommended. Through a questionnaire addressed to dental technicians, Jagger et al. (25) found that only 4% of the laboratories received disinfected impressions, whereas 56% of the laboratories did not know if impressions coming from the dental offices had been previously disinfected (22). Therefore, most of the laboratories (94%) usually disinfected the impressions they received (22).

This study evaluated and compared the dimensional changes of 2 elastomers as a result of impression disinfection by immersion. Impressions were subjected to 3 different procedures, all of them commonly employed in dental practice: 1) Immediate disinfection when the impression is taken (T1 specimens); 2) Immediate disinfection followed by a 6 hour wait (T2 specimens), to assess the effect of a delayed pouring; 3) A second disinfection carried out 6 hours after the first one (T3 specimens), to assess the effect of two disinfections. The latter would simulate the disinfection performed by the dental technician when he receives an impression previously disinfected by the dental office personnel. For comparative purposes, dimensional changes were also assessed when the impressions did not undergo any disinfection (control specimens) (Table 2), with measurements taken immediately and again 6 hours later. This condition simulated impressions sent to a dental laboratory and poured without disinfection.

The results (Table 3) showed that PE impression material disinfected by SP expanded slightly (0.03%) after the first disinfection (T0 vs. T1), whereas 6 hours later (T0 vs. T2) a contraction of the material occurred (-0.07%). In both instances, the differences in dimensional stability were statistically significant ($P < 0.05$). The second disinfection (T3) did not cause any significant change compared to that found in T2. The PE impression material disinfected by MD expanded significantly only after the first disinfection (0.04%), whereas it was stable 6 hours later and after the second disinfection ($P > 0.05$). These findings suggest that the first disinfection by immersion, both in SP or MD,

induced a significant expansion of PE material. It should be noted, however, that both disinfectant products were used according to the manufacturers' instructions. Hydrophilic materials as PE, in fact, may be prone to water absorption and an immersion longer than the recommended time may result in a clinically significant dimensional change (13,15,17,21,26).

PVS, similar to PE, expanded slightly after the first disinfection (T1), when using both SP (0.02%) and MD (0.13%). It also continued to expand after 6 hours (T2) when it had been disinfected with SP (0.1%), whereas no change occurred after the second disinfection (T3) (0.1%). All these differences were statistically significant, with the exception of the dimensional change found after the second disinfection (T2 vs. T3) ($P > 0.05$). When MD was used, PVS suffered a contraction (0.07%) at T2, whereas it remained stable after the second disinfection (T3) (0.09%). All dimensional changes were statistically significant when compared to T0 values.

The present findings indicated that, without disinfection, the tested impression materials were quite accurate and suffered dimensional changes (Table 2) well below the value of the ADA specification standard of ≤0.5% (23). When disinfected by immersion, the impression materials exhibited minimal dimensional changes when compared both to the specimens before immersion (Table 3) and to the metal die (Table 4). It must be noted that similar dimensional changes, probably due to the chemical structure of the material and/or disinfectant, have been previously reported (6,19,21,27,28).

The specimens of PE/SP combination (Table 3) after the second disinfection (T3) and measurements of PE controls (Table 2) had a similar trend: both of them shrank (-0.08% and -0.03%, respectively). The other combinations (PE/MD, PVS/SP, PVS/MD), however, showed an expansion of materials as a result of the disinfection treatments. It is not easy to explain why an elastomer sometimes expanded and sometimes shrank. It may be due to the chemical nature of the disinfectant and its reaction with the impression material. The importance of the disinfectant solution chemistry was supported by previous investigations reporting that chlorhexidine and glutaraldehyde caused the least dimensional distortion (11,15,17,18,20).

The principal finding of our study is that immediate disinfection by immersion, independent of the disinfectant used, always induces an expansion of both PVS and PE. In the six hours following the disinfection, the behavior of the impression material was not univocal: PE immersed in MD remained stable, whereas PVS, after immersion in SP, continued to expand. On the other hand, when PE and PVS were immersed in SP and MD, respectively, a material shrinkage was found. Moreover, for all the combinations of impression material/disinfectant, the second disinfection did not induce any significant dimensional change. This is probably due to the chemical stabilization of the material that occurs in the first hours after impression taking.

Although the tested material did not behave univocally after 2 disinfections by immersion, and in spite of significant statistical differences between T3 and T0, dimensional changes at T3 could be considered irrelevant because they are well below the value of the ADA specification standard (23). Such findings agree with those reported by previous investigations which evaluated different combinations of impression materials and disinfectant products (15-18,21,27,29). A number of authors reported greater dimensional changes, but it must be noted that they used longer immersion times or different protocols (13,26).

Within the parameters of the present investigation, our findings suggested that PE and PVS impression materials show linear dimensional changes as a result of immersion disinfection in MD or SP. The first immersion in the disinfectant induced some expansion of the impression material, whereas in the following hours after first disinfection, the behavior changed depending on the different disinfectant/material combination. However, the dimensional changes of all materials were always within the ADA specification (23). Therefore, given all of the factors associated with fabrication of prosthesis, including pouring casts, combinations and interaction of materials, skills of the dental technician, the effects of immersion disinfection on the dimension of elastomers in MD or SP are not clinically relevant (23). Moreover, the second immersion disinfection did not induce any significant dimensional change. So the second disinfection carried out by the technician when he receives the impression, does not affect its dimensional accuracy.

References

1. Powell GL, Runnels RD, Saxon BA, Whisenant BK (1990) The presence and identification of organisms transmitted to dental laboratories. J Prosthet Dent 64, 235-237
2. Gerhardt DE, Sydiskis RJ (1991) Impression materials and virus. J Am Dent Assoc 122, 51-54
3. Rice CD, Dykstra MA, Gier RE, Cobb CM (1991) Microbial contamination in four brands of irreversible hydrocolloid impression materials. J Prosthet Dent 65, 419-423
4. Samaranayake LP, Hunjan M, Jennings KJ (1991) Carriage of oral flora on irreversible hydrocolloid and elastomeric impression materials. J Prosthet Dent 65, 244-249

5. Mitchell DL, Hariri NM, Duncanson MG Jr, Jacobsen NL, McCallum RE (1997) Quantitative study of bacterial colonization of dental casts. J Prosthet Dent 78, 518-521
6. McNeil MR, Coulter WA, Hussey DL (1992) Disinfection of irreversible hydrocolloid impressions: a comparative study. Int J Prosthodont 5, 563-567
7. Beyerle MP, Hensley DM, Bradley DV Jr, Schwartz RS, Hilton TJ (1994) Immersion disinfection of irreversibile hydrocolloid impressions with sodium hypochlorite. Part I: microbiology. Int J Prosthodont 7, 234-238
8. Council on Dental Materials, Instruments and Equipment (1991) Disinfection of impression. J Am Dent Assoc 122, 110
9. Kern M, Rathmer RM, Strub JR (1993) Three-dimensional investigation of the accuracy of impression materials after disinfection. J Prosthet Dent 70, 449-456
10. ADA Council on Scientific Affairs and ADA Council on Dental Practice (1996) Infection control recommendations for the dental office and the dental laboratory. J Am Dent Assoc 127, 672-680
11. Al-Omari WM, Jones JC, Wood DJ (1998) The effect of disinfecting alginate and addition cured silicone rubber impression materials on the physical properties of impressions and resultant casts. Eur J Prosthodont Restor Dent 6, 103-110
12. Kohn WG, Harte JA, Malvitz DM, Collins AS, Cleveland JL, Eklund KJ (2004) Guidelines for infection control in dental health care settings/2003. J Am Dent Assoc 135, 33-47
13. Lepe X, Johnson GH (1997) Accuracy of polyether and addition silicone after long-term immersion disinfection. J Prosthet Dent 78, 245-249
14. Council on Dental Materials, Instruments and Equipment, the Council on Dental and Practice, Council on Dental Therapeutic (1988) Infection control recommendation for the dental office and the dental laboratory. J Am Dent Assoc 116, 241-248
15. Langenwalter EM, Aquilino SA, Turner KA (1990) The dimensional stability of elastomeric impression materials following disinfection. J Prosthet Dent 63, 270-276
16. Matyas J, Dao N, Caputo AA, Lucatorto FM (1990) Effects of disinfectants on dimensional accuracy of impression materials. J Prosthet Dent 64, 25-31
17. Davis BA, Powers JM (1994) Effect of impression disinfection on properties of impression materials. J Prosthodont 3, 31-34
18. del Pilar Rios M, Morgano SM, Stein RS, Rose L (1996) Effects of chemical disinfectant solutions on the stability and accuracy of the dental impression complex. J Prosthet Dent 76, 356-362
19. Thouati A, Deveaux E, Iost A, Behin P (1996) Dimensional stability of seven elastomeric impression materials immersed in disinfectants. J Prosthet Dent 76, 8-14
20. Johnson GH, Chellis KD, Gordon GE, Lepe X (1998) Dimensional stability and detail reproduction of irreversible hydrocolloid and elastomeric impressions disinfected by immersion. J Prosthet Dent 79, 446-453
21. Adabo GL, Zanarotti E, Garcia Fonseca R, dos Santos Cruz CA (1999) Effects of disinfectant agents on dimensional stability of elastomeric impression materials. J Prosthet Dent 81, 621-624
22. Kugel G, Perry RD, Ferrari M, Lalicata P (2000) Disinfection and communication practices: a survey of U.S. dental laboratories. J Am Dent Assoc 131, 786-792
23. Councils on Dental Materials and Devices (1977) Revised American Dental Association specification No. 19 for non-aqueous, elastomeric dental impression materials. J Am Dent Assoc 94, 733-741
24. International Organization for Standardization (2000) Dentistry – Elastomeric impression materials. ISO 4823, Geneve
25. Jagger DC, Hugget R, Harrison A (1995) Cross-infection control in dental laboratories. Br Dent J 179, 93-96
26. Johansen RE, Stackhouse JA Jr (1987) Dimensional changes of elastomers during cold sterilization. J Prosthet Dent 57, 233-236
27. Jagger DC, Al Jabra O, Harrison A, Vowies RW, McNally L (2004) The effect of a range of disinfectants on the dimensional accuracy of some impression materials. Eur J Prosthodont Restor Dent 12, 154-160
28. Jagger DC, Vowles RW, McNally L, Davis F, O'Sullivan DJ (2007) The effect of a range of disinfectants on the dimensional accuracy and stability of some impression materials. Eur J Prosthodont Restor Dent 15, 23-28
29. Johnson GH, Drennon DG, Powell GL (1988) Accuracy of elastomeric impressions disinfected by immersion. J Am Dent Assoc 116, 525-530

The authors report no financial relationships related to any products involved in this study.