Effect of Disinfection on the Dimensional Stability of Polyether Impression Materials

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Purpose: **Difficulties in sterilizing impressions have led to chemical disinfection solutions as an alternative; however, some impression materials are more sensitive to humidity. For example, polyether impression materials are more hydrophilic. This study investigated the effect of three disinfecting methods on the dimensional stability of three polyether impression materials.**

Materials and Methods: **Three polyether impression materials (P2, Impregum Penta Soft, and Impregum Penta) were submitted to the following treatments: spray disinfectant (Mikrozid Liquid), immersion in 2% glutaraldehyde solution (Super-On), immersion in 0.525% sodium hypochlorite solution for 10 minutes, and a control group (not disinfected). Each group included five samples. After treatment, dimensional change was evaluated according to ISO 4823. The data were analyzed by 2-way analysis of variance at $\alpha = 0.05$.**

Results: **The mean percentages of linear dimensional change of materials P2, Penta Soft, and Penta were –0.040%, 0.098%, and 0.100%, respectively. The dimensional change associated with different disinfectant agents mikrozid liquid, 2% glutaraldehyde, room air (control), and 0.525% sodium hypochlorite was 0.013%, 0.024%, 0.077%, and 0.096%, respectively. The interaction between the impression materials and the disinfectant treatment was not significant. The disinfectant agents can be classified in two groups as low- and high-effected. The control group did not significantly differ from either group.**

Conclusion: **From the standpoint of dimensional change, the disinfectants tested for 10 minutes caused no significant linear dimensional change in the polyether impression materials, compared with the control group.**

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INDEX WORDS: disinfection, dimensional stability, polyethers, impression materials

A GROWING concern regarding the control of cross-infection in dentistry can be seen in the literature.[1-3] A number of bacteria, fungi, and viruses present in the dental environment have been linked to debilitating and life-threatening diseases.[4] Every effort, therefore, must be made to avoid cross-contamination of these microorganisms to prevent the potential transfer of disease in dental settings.[4]

In prosthodontics, additional problems are involved in controlling cross-infection.[5] The establishment and maintenance of a comprehensive and effective infection control program is a requirement for the dental office and the dental laboratory.[2] The primary path of transmission between the dental office and laboratory is through contaminated impressions and other prosthetic materials.[6,7]

Laird and Davenport[8] stated that it is often impossible to sterilize prosthetic materials contaminated during their manipulation in the mouth. Dental impressions can, therefore, act as means of transmitting infectious agents from patients to those who handle them subsequently.[9] To address these cross-contamination concerns, the American Dental Association (ADA) issued guidelines for disinfecting impressions in 1988, 1991, and 1996.[1,10,11] These guidelines recommend using an ADA-accepted spray or immersion disinfectant, depending on the material, for the duration suggested by the product manufacturer.[1,10,11]

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Reversible and irreversible hydrocolloids, polyethers, and some addition silicone materials are more hydrophilic in nature.[12,13] Polyether materials have been shown to be unstable under high humidity conditions and in aqueous solutions.[13] The disinfecting process should be adequate, but should not adversely affect the dimensional stability or the surface detail of the impression.[12,13]

In a 1991 ADA Report Update, recommendations for the management of dental impressions were expanded to permit a spray and an immersion technique, with an approved disinfectant, for the polyethers as well as the irreversible hydrocolloid and elastomeric impression materials.[1]

Many studies report the effects of immersion in disinfectant solutions on different impression materials.[14-19] Some studies have shown that the immersion disinfectant has no clinically relevant effect on polyethers;[18,20] however, other studies have indicated that the dimensional stability of these hydrophilic materials was adversely affected by immersion.[21,22] A recent review concluded that the disinfection by immersion is preferred, because sprayed disinfectant tends to pool, and thus all impression surfaces may not be adequately covered.[20] Later studies support immersion disinfection of polyether, hydrophilic addition silicone, and irreversible hydrocolloid impressions if recommended periods and disinfectants are used.[23-25] In a 1997 study, Lepe and Johnson[22] found that overnight immersion (18 hours) of polyether or addition silicone impressions in 2% glutaraldehyde significantly affected their occlusogingival dimensions, as well as the mesiodistal dimensions of the addition silicone. Merchant[26] also warns that polyether should be disinfected for short periods with the disinfectants accepted by the ADA, which in turn recommends immersion not exceeding 30 minutes. Owen and Goolan[27] recommended that polyether not be immersed for periods exceeding 5 hours, because it may expand. Lepe[28] stated that both silicones and polyethers are relatively hydrophobic and can be disinfected for more than 18 hours without an effect on humidification.

The purpose of this study was to evaluate the effect of disinfection methods on the dimensional stability of three commonly used polyether impression materials.

Materials and Methods

The names of the polyether impression materials for the monophase technique used in this study, their type, batch numbers, viscosities, and codes are listed in Table 1. Plates of 50 × 50 × 3 mm^3 thermoplastic tray material (Superior Impression Compound, Cavex, Keur & Sneltjes Dental Mfg Co., Haarlem, The Netherlands) were formed with a separating disk. The tray adhesive for each impression material was applied and allowed to dry for the duration specified by the manufacturer. Polyether impression materials were mixed in an automatic mixing machine (Pentamix 2, 3M ESPE, Minneapolis, MN) to obtain uniform proportions and homogeneity of the material. For mixing, cartridges or tubular bags were available and were processed with dosing and mixing equipments. The first few centimeters of mixed paste were discarded to ensure complete mixing. Sixty impressions of a standardized, highly polished, round stainless steel test block (Fig 1) with five lines were made, in the testing conditions detailed in International Standard Organization (ISO) 4823.[29] The test block included three horizontally ruled lines (x, y, and z) for evaluation of detailed reproduction. Cross lines were provided for the determination of linear dimensional stability. The test block also had a stainless steel ring that fit around the borders as a mold for the impression material. The linear dimension of the polyether impression material was measured after treatment with four test agents (Table 2). The test agents included three disinfectants and one control group. Five impressions were made for each testing agent, from each of the polyether impression materials ($n = 5$).

After formation of the individual trays, the material was auto-mixed and injected directly onto the surface

Table 1. Impression Materials Used

Product	*Type*	*Manufacturer*	*Technique*	*Batch Numbers*	*Viscosities*	*Codes*
P2	Polyether	Kulzer, Germany	Automatic mixing	66009582	Monophase	P2
İmpregum Penta Soft	Polyether	3M ESPE, Germany	Automatic mixing	31734	Monophase	Penta Soft
Impregum Penta	Polyether	3M ESPE, Germany	Automatic mixing	31684	Monophase	Penta

Figure 1. A round stainless steel test block with a stainless steel ring.

of the test block. The thermoplastic tray material was placed over the impression material with the tray adhesive in contact with the material. A glass plate was pressed against the thermoplastic tray material, and excess material was extruded. This impression assembly was secured with a C clamp and immersed in double-distilled deionized water at 32 ± 2°C. The polymerization period was the intraoral duration specified by the manufacturer, plus 3 minutes to ensure complete set (Table 3). After removal and close examination, the impressions were treated with four different test agents. The first group of five samples was not treated with a disinfectant solution (room air, dry). The second group of five samples was applied with spray disinfectant (Mikrozid Liquid) for 10 minutes at room temperature. The third group of five samples was immersed in 2% glutaraldehyde solution (Super-On) for 10 minutes at room temperature. The fourth group of five samples was immersed in 0.525% sodium hypochlorite solution for 10 minutes at room temperature.

After the polymerization of the polyether impression material, the impression and the tray materials were separated from the test block-mold apparatus and subjected to one of the testing procedures. Selection of the impression samples and the testing procedures were randomized.

On each procedure, new immersion baths of 300 mL of each solution were prepared. After the immersion period, the specimens were rinsed with 150 mL double-distilled deionized water and dried in room air until measurement. Measurements of the polyether impression specimens were taken after 24 ± 1 hours. All measurements were performed by the same operator. An XY traveling stage microscope (Clevelant, Prazisions-Systeme, GmbH 79843 Löffingen, Germany) with sensitivity of 0.01 mm was used for the measurements. The impression was evaluated by measuring the linear dimension of the widest line between the vertical lines. Three readings were made for each measurement, and mean values were calculated. The test block was also measured ten times to produce a mean value of 24.86 mm. This value was used as the initial (pretreatment) measurement for each sample. According to ISO 4823, the following equation was used to

Table 2. Disinfectants Used

Product	*Formulation*	*Manufacturer*	*Location*	*Treatment Type*
Mikrozid liquid	25 g ethanol (94%), 35 g 1-propanol	S&M. Schülke & Meyer	Norderstedt, Germany	Spray
NaHCl	Sodium hypochlorite 0.525%	Prepared in Gazi University Faculty of Pharmacology	Ankara, Turkey	Immersion
Super-On	Glutaraldehyde 2%	Antiseptica	Pulheim/Brauweiler, Germany	Immersion

Table 3. Manipulation Times of the Polyether Impression Materials

	Time (min:sec)		
	P2	*Penta Soft*	*Penta*
Working (including mixing)	2:00	2:45	2:45
Setting	3:15	6:00	6:00
Total	5:15	8:45	8:45
Study	8:15	11:45	11:45

calculate the percentage of dimensional change for each specimen:

$$\Delta L = 100\frac{(L_1 - L_2)}{L_1}$$

where L_1 is the distance measured between cross lines on the test block, and L_2 is the distance measured between cross lines on the impression material specimen.

The data were statistically analyzed with 2-way ANOVA to assess the effects of the two main factors, namely the impression material and the disinfecting system, and their possible interaction. The effect of the levels' main factors was compared by Tukey multiple comparisons test using the SPSS statistical program (SPSS Inc., Chicago, IL). All hypothesis testing was conducted at $\alpha = 0.05$.

Results

Tables 4 and 5 show the mean values (%) and standard errors of the dimensional stability of each impression material and four disinfectant agents. The nondisinfected groups served as control groups. No significant interaction was found between the impression materials and the disinfecting systems. ($F = 0.993, p = 0.441$) Therefore, the levels of the impression materials and disinfectant agents were compared using the Tukey multiple comparison test. The mean percentage of linear dimensional change of the impression materials are shown in Table 4. The negative (–) value of P2 indicates that, according to the ΔL equation (ISO 4823) the distance measured between cross lines on the impression material specimen was longer than the distance measured between cross lines on the test block after the treatments. Penta and Penta Soft impression materials were smaller after the treatment. These results revealed that there are significant differences between materials ($F = 19.020, p < 0.001$). P2 (Subset 1) is significantly different from Penta and Penta Soft (Subset 2). When the effects of the disinfecting systems on the dimensional changes are compared using the Tukey multiple comparison test, statistically significant differences were found ($F = 3.584, p = 0.020$).

Table 4. Mean Values (%) and Standard Errors of the Dimensional Stability of Each Impression Material

		Mean Values (%) Subset	
Impression Materials	*SE*	1	2
P2	0.018	–0.04	
Penta Soft	0.018		0.098
Penta	0.018		0.100

Table 5. Mean Values (%) and Standard Errors of Four Disinfectant Agents

		Mean Values (%) Subset	
Disinfectant Agents	*SE*	*1*	*2*
Mikrozid liquid	0.021	0.01333	
2% Glutaraldehyde	0.021	0.02400	0.02400
Room air (control)	0.021	0.07733	0.07733
0.525% Sodium hypochlorite	0.021		0.09600

The dimensional changes (%) associated with the disinfectant agents tested are shown in Table 5. The disinfectant agents can statistically be classified in two groups as low- (Subset 1) and high-effected (Subset 2). The control group did not significantly differ from either group. A statistically significant difference was noticed between the spray appliance and the immersion of 0.525% sodium hypochlorite.

Discussion

Solutions used for the disinfection of dental impressions may affect crucial qualities of the impression material, potentially altering surface detail reproduction, surface roughness, and dimensional stability. The effect of disinfectant agents on the dimensional stability of an impression is a critical factor. It is important to weigh the effectiveness of the disinfectant used against the possible negative side effects on the material.

In 1988,[10] the ADA recommended the use of a surface disinfectant for spray disinfection of impressions. Ten minutes, 1:10 dilution of 5.25% (0.525%) sodium hypochlorite was listed as a recommended surface disinfectant. In 1991,[1] the ADA Council on Dental Materials, Instruments, and Equipment recommended immersion disinfections of irreversible hydrocolloid and polyether impression materials either in "hypochlorite, iodophor, or glutaraldehyde with phenolic buffer." There was no change in the recommended concentration and contact time of sodium hypochlorite.

Thus, in this study, spray application of 2% glutaraldehyde and 0.525% sodium hypochlorite were used for disinfection, and three polyether impression materials were immersed in these disinfectants for 10 minutes. Polyethers were chosen as the impression material because of their hydrophilic nature and sensitivity to disinfection procedures. The material versus disinfectant interaction revealed no statistically significant difference, and demonstrated no interference of one factor with the other. This result is in agreement with the results of Adabo et al.[18]

Tullner et al[14] did not observe any negative effect after immersing different impression materials in iodophor, 0.525% sodium hypochlorite, and neutral 2% glutaraldehyde. Langenwalter et al,[15] who studied the same materials immersed in iodophor, sodium hypochlorite, glutaraldehyde or double-deionized water or exposed to room air for 10 minutes, obtained similar results. In this study, disinfectants were also applied for 20 minutes.

Matyas et al[16] concluded that there were no adverse effects of the various disinfecting media on the different impression materials. Kern et al[17] worked with glutaraldehyde and ammonium chloride spray and glutaraldehyde and glyoxalin solution (immersion system). These two systems were applied for the same period (10 minutes), and the systems used did not cause any clinically significant effects.

Statistical analysis of the present study revealed significant differences in the material behavior and the disinfection treatment. Among the polyether impression materials used, P2 polyether impression material showed the lowest dimensional change. Penta Soft and Penta followed. No significant difference was observed between Penta Soft and Penta.

The measures in the dimensional changes of the three polyether impression materials are far below 1.5%, which is the maximum measure recommended by ISO 4823. The dimensional changes related to the three disinfecting procedures were clinically of slight significance. The disinfectant agents can be classified into two groups. Both groups showed no significant difference with the control group (room air); however, there was a statistically significant difference between the spray application and sodium hypochlorite immersion. The reason for this difference is perhaps that the content of spray disinfectant is ethanol-1-propanol, and all of the impression surfaces may not be adequately covered with disinfectant solution. On the other hand, sodium hypochlorite disinfectant is a stronger chemical. Based on the results of this study, from the standpoint of the dimensional stability, the three disinfection systems can be recommended on the polyether impression materials for clinical and laboratory usage.

Thouati et al[22] observed that the elastomer immersion in 5.25% sodium hypochlorite solution for 30 minutes caused expansion of the impressions, whereas immersing in quaternary ammonia and aldehyde solution did not cause any significant dimensional changes.

Adabo et al[18] investigated the effect of disinfecting methods on the dimensional stability of six elastomeric materials. They concluded that there was a significant difference among the elastomers used and that the interaction between the material and the treatment was not significant. The above investigators stated that the disinfecting treatments did not differ from the control group. Those results are also similar to the results of the present study.

Lepe and Johnson[22] used overnight disinfections for 18 hours in a full strength 2% acid glutaraldehyde solution, and they demonstrated that the accuracy of the polyether or the addition silicone impression materials were adversely affected with 18 hours of immersion disinfections.

Johnson et al[19] investigated the dimensional stability and the surface quality of the gypsum casts retrieved from disinfected impressions (irreversible hydrocolloids, a polyether, and an addition silicone) and compared the results to a control group. The disinfectants used in their study were an iodophor, a glyoxal glutaraldehyde,

and a phenol glutaraldehyde (at room temperature for 10 minutes). The above investigators demonstrated that the polyether and addition silicone impressions could be disinfected by immersion with any of the disinfectants without a loss of accuracy or surface detail.

At the end of this study, in the dimensional change of each of the three hydrophilic polyether impression materials, disinfectants showed no significant effect when compared to the control group. The results of this study show similarities to other investigations; however, there were not many studies related to microbiologic effects of disinfectants used for 10 minutes on polyether impression materials. It is necessary to investigate the microbiologic effects of the disinfectants on the recently produced polyether impression materials.

Conclusions

Based on the results of this study, the following conclusions were drawn:

1. There was a significant difference between the elastomers used. P2 has the highest dimensional stability among the tested materials.
2. For the treatment factor, a significant difference was observed among the disinfecting treatments, but no significant difference was found between the control group (room air) and the disinfecting treatments with 0.525% sodium hypochlorite solution, 2% glutaraldehyde solution, and mikrozid liquid.
3. The dimensional changes for each specimen of polyether impression materials were lower than the maximum linear dimensional changes (%) recommended by ISO 4823.
4. The interaction between the material and the disinfecting treatment was not significant.

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