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# The Effect of Chemical Disinfection, Autoclave and Microwave Sterilization on the Dimensional Accuracy of Polyvinylsiloxane Elastomeric Impression Materials

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**Abstract:** This study evaluated the effects of chemical disinfection, autoclaving and microwave sterilization on five elastomers. Specimens were fabricated following the American Dental Association (ADA) guidelines. Measurements were taken using a measuring microscope with an accuracy of 0.005 mm before and after subjecting the samples to disinfection procedures. Paired sample T test was used for the statistical analysis. The linear dimensional changes were tested using the International Organization for Standardization (ISO) International Standard 4823 and the Japanese Industrial Standards (JIS). The results showed that the chemically disinfected specimens exhibited the least amount of linear dimensional change, ranging from +0.0021% (Affinis and Aquasil) to +0.0035% (3M express, President and GC Exafast). The microwave-sterilized specimens showed significant linear dimensional change, ranging from -0.024% (Affinis) to -0.028% (President). Despite significant changes, autoclave and microwave sterilization are considered acceptable methods because the observed changes met the American Dental Association (ADA) recommendations (≤0.5%).

**Key words:** Infection control · Dimensional change · Autoclave sterilization · Microwave sterilization · Chemical disinfection · Polyvinylsioxane impression materials

## INTRODUCTION

Infection control in dental offices and laboratories has become an important concern in recent years due to the increased risk of cross-contamination with disease-causing microorganisms, such as the human immunodeficiency virus (HIV) and hepatitis B [1]. The principal route of transmission between dental offices and laboratories is via contaminated impressions and other prosthetic materials [2]. This hazard can be reduced by disinfecting the impressions before they are sent to the laboratory. A number of methods have been proposed to disinfect dental impressions. Most of these methods involve immersing the impressions in or spraying them with disinfection solution because chemical disinfection is believed to be the simplest infection control procedure. However, this procedure is less effective against pathogens than any other infection control procedure because it is intended to kill disease-causing organisms but not bacterial spores [3, 4]. Therefore, sterilizing the impressions would be preferable. Some authors recommend common sterilization methods, such as steam autoclaving, ethylene oxide gas autoclaving and microwave radiation sterilization [4, 5].

Addition silicone impression materials are widely used because of their excellent dimensional stability and their ability to produce accurate impressions with minimal distortion [5]. Another major requirement is the ability of an elastomer to retain these properties even after the disinfection procedure and several studies have shown that the elastomers to be stable after autoclaving [6]. Accordingly, a recent approach involving microwave radiation sterilization has been suggested by some authors [4]. Hence the aim of this study was to evaluate and compared the effects of chemical disinfection, autoclave and microwave sterilization on the dimensional stability of five polyvinylsiloxane elastomeric impression materials.

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Table 1: Elastomeric impression materials used in this study

| Product trade name | Type | Manufacturer |
|---|---|---|
| Coltene PRESIDENT | Polyvinylsiloxane syringe and putty | Coltene whaledent, Feldwiesenstrasse 20, 9450 Altstatten, Switzerland. |
| Coltene AFFINIS | Polyvinylsiloxane syringe and putty | Coltene whaledent, Feldwiesenstrasse 20, 9450 Altstatten, Switzerland. |
| Dentsply AQASIL | Polyvinylsiloxane syringe and putty | DENTSPLY DeTrey GmbH, 78467 Konstanz, Germany. |
| 3M ESPE Express | Polyvinylsiloxane syringe and putty | 3M ESPE Dental Products, St. Paul, MN 55144-1000 |
| GC Exafast | Polyvinylsiloxane syringe and putty | GC Europe N. V, Interleuvenlaan 13 B-3001 Leuven |

## MATERIALS AND METHODS

Five elastomeric impression materials (addition type), each with a light body (syringe material) and putty (tray material) consistency, were examined in this study (Table 1). The impression materials were used according to the manufacturer's guidelines. The standard stainless steel die recommended by American Dental Association specification no. 19 [7] and ISO International Standard 4823 was used to fabricate the specimens [3, 4, 8-10]. Multiple mixing techniques were used to prepare specimens in which the two consistencies were mixed simultaneously or separately. The syringe material was directly dispensed from the cartridge onto the surface and the tray material was placed over the light body [11].

The mold consisted of a base that was scored with three horizontal lines running perpendicular to two vertical lines (Figure 1) (each of which was 0.050 mm wide [12]), a steel ring with a 3.8-mm internal diameter that could be accurately positioned on the base and a perforated steel plate that was used to apply pressure after loading the elastomers. Perforations were created for retention purposes and to allow the excess material to drain. First, the metal ring was placed on the base of the mold and the light body material was directly injected onto the platform. Then, the tray material was mixed according to the manufacturer's recommendations and loaded (Figure 2). The perforated plate was pressed against the ring to remove the excess material. The specimens were allowed to set in a thermostatically controlled water bath at 37°C to simulate oral temperature and retrieved after the manufacturer's recommended setting time. A total of 75 specimens (15 specimens from each material) were fabricated and divided into 3 groups of 25 samples (5 samples from each material). After fabricating the samples, the distance between the inner profiles of the horizontal line was measured to an accuracy of 0.005 mm using the measuring microscope (Figure 3) (Titan measuring microscope, Buffalo, New York - 14216. Model no 81016) and recorded as reading A. The specimens were then subjected to the following disinfection procedures.

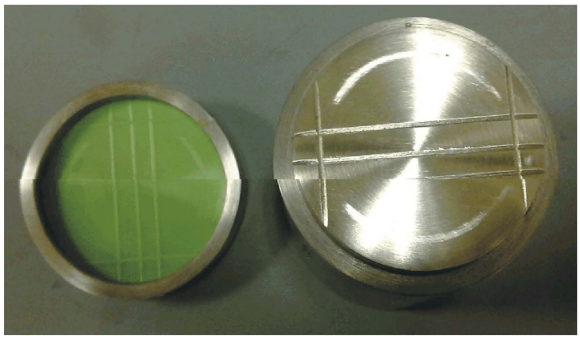

Fig. 1: The stainless steel metal mold and specimen

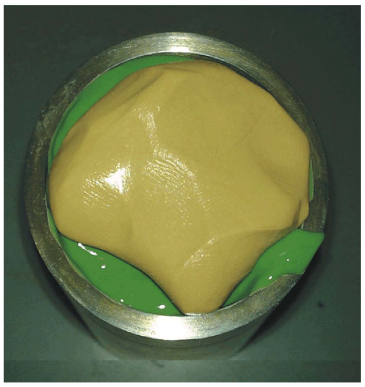

Fig. 2: Fabrication of the specimen

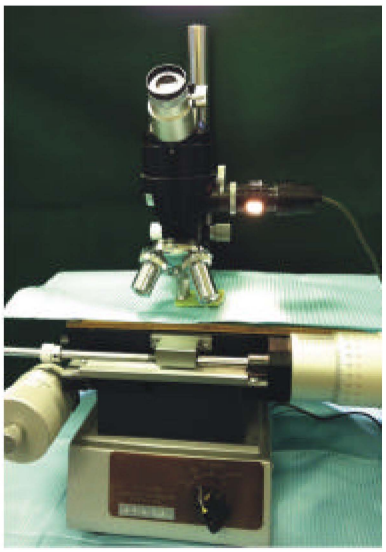

Fig. 3: The measuring microscope

Table 2: Composition of chemical disinfectant

| Trade name | Composition in 100g | Manufacturer |
|---|---|---|
| ASEPTODENT | 7.7 g alkylamine,<br>22.5 g benzalkonium chloride, surfactants, cleaning booster, auxiliaries, | Oro Clean Chemie AG<br>Allmendstrasse 21<br>8320 Fehraltorf<br>Switzerland |

Group 1 Specimens were sterilized in an autoclave (Domina plus B, Dental X spa, Marzotto, 1136031, Dueville) for 5 min at 134°C and 20 psi.

Group 2 Specimens were immersed in Aseptodent (Oroclean chemie AG, Allmendstrasse 21, 8320 Fehraltorf, Switzerland) for 30 min (Table 2).

Group 3 Specimens were sterilized using microwave energy (LG, MS-1944V/00, 1000W, 2450 MHz, China) at high power for 10 min.

After subjecting the samples to their disinfection procedures, the distance between the inner profiles of the horizontal line was measured in the same manner by the same individual and recorded as reading B. The mean values were tabulated and analyzed using Paired sample T test. All of the statistical tests were conducted with the SPSS software (SPSS Inc., Chicago) and $p<0.05$ was considered to be statistically significant. The percentage dimensional change was calculated using the following formula dimensional change % = (A-B)/A× 100 (according to ADA specification no. 19 for non-aqueous, elastomeric impression materials) [13], where "A" is the distance between the inner profiles of the horizontal line prior to the disinfection procedure and "B" is the distance between the inner profiles of the horizontal line after subjecting the material to a disinfection procedure.

## RESULTS

The metal die measurement was 28.045 mm. The mean dimensions of the elastomer samples before and after the disinfection procedures and the standard deviations are presented in Table 3. All of the materials exhibited some dimensional changes and significant ($p>0.05$) differences after the disinfection treatments were detected in all of the materials other than the Affinis and Aquasil in Group 2.

The linear dimensional change test (%) results are presented in Table 4. Affinis showed the smallest dimensional change (+0.0021% after being subjected to the chemical disinfectant) and President showed the largest dimensional change (-0.028% after being subjected to the microwave sterilization).

Table 3: Mean values and SDs for the dimensional change of elstomeric impression materials subjected to treatments (Group1, 2 and 3)

| | Disinfection groups | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Group 1 | | | Group 2 | | | Group 3 | | |
| Materials | Before Mean (SD) | After Mean (SD) | P Value | Before Mean (SD) | After Mean (SD) | P Value | Before Mean (SD) | After Mean (SD) | P Value |
| President | 28.0544 (.0089) | 28.052 (.0004) | .001* | 28.0544 (.0089) | 28.055 (.00109) | .004* | 28.0544 (.0089) | 28.046 (.0005) | .000* |
| Affinis | 28.0544 (.0089) | 28.0528 (.0004) | .004* | 28.0544 (.0089) | 28.0546 (.00054) | .204 | 28.0544 (.0089) | 28.0472 (.0004) | .000* |
| Aquasil | 28.0544 (.0089) | 28.0526 (.0005) | .003* | 28.0544 (.0089) | 28.0546 (.00054) | .299 | 28.0544 (.0089) | 28.0466 (.0005) | .000* |
| 3M Express | 28.0544 (.0089) | 28.0526 (.0005) | .000* | 28.0544 (.0089) | 28.055 (.00109) | .008* | 28.0544 (.0089) | 28.0466 (.0005) | .000* |
| GC Exafast | 28.0544 (.0089) | 28.0526 (.0005) | .000* | 28.0544 (.0089) | 28.055 (.00109) | .008* | 28.0544 (.0089) | 28.0466 (.0005) | .000* |

* Statistically significant

Table 4: Linear dimensional change (%) of elastomers after disinfection procedures

| | Disinfection groups | | |
|---|---|---|---|
| Materials | Group 1 | Group 2 | Group 3 |
| Coltene President | -0.0071%* | +0.0035%* | -0.028%* |
| Coltene Affinis | -0.0042%* | +0.0021% | -0.024%* |
| Dentsply Aquasil | -0.0049%* | +0.0021% | -0.026%* |
| 3M Express | -0.0049%* | +0.0035%* | -0.026%* |
| GC Exafast | -0.0049%* | +0.0035%* | -0.026%* |

* Statistically significant

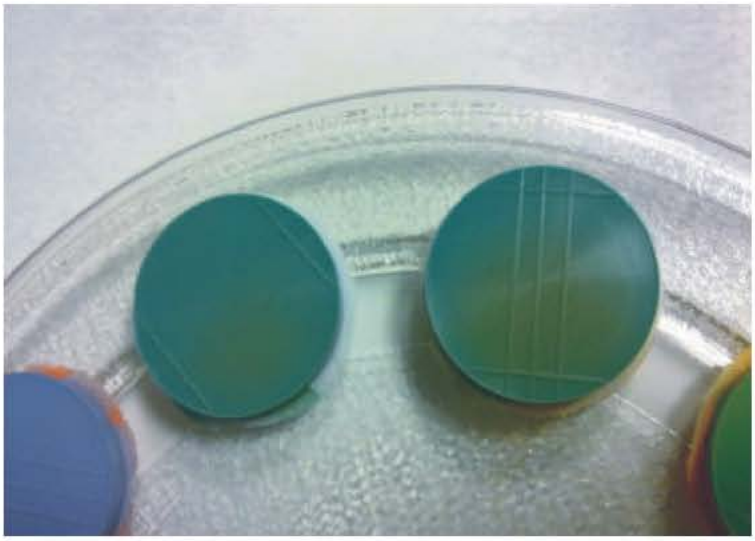

Fig. 4: Discoloration of the specimen when sterilized using microwave energy

## DISCUSSION

The risk of contamination and cross-infection through dental impressions has been a topic of interest for many years [14]. The ADA has recommended high disinfection standards for dental equipment, including dental impressions, to prevent cross infection between members of the dental team [10, 12]. Unfortunately, to prevent the adverse effects of autoclave sterilization on impression materials, most of the currently used disinfection procedures are based on chemical disinfection. However, chemical disinfection alone is insufficient and autoclave sterilization at high temperatures is required to kill all of the disease-causing microorganisms and microbial spores that may be present. Recently, microwave sterilization has been used as an alternative approach and has been widely applied in the medical and microbiological fields. The electromagnetic energy from the microwave is considered to be alternative to a conventional autoclave because the sterilization can be achieved in a short period of time. One study has indicated that microwave sterilization can be achieved in 8 min using microwave energy [15, 16]. In addition, these procedures should not adversely affect the critical properties of the elastomers. Therefore, we conducted this study to investigate the effects of three different sterilization methods on the dimensional stability of elastomers.

We recorded the dimensional stability measurements of the impressions before and after chemical disinfectant, autoclave and microwave sterilization treatments and expressed them as percentages of the linear dimensional changes. All of the impression materials were quite accurate when tested before the disinfection treatment and suffered statistically significant dimensional changes afterwards, although these changes were well below the ADA specification standard of ≤0.5%. These study results are consistent with those of Cynthia S *et al.*, who reported that the dimensional accuracies of polyvinyl siloxane impression materials under dry, moist and wet conditions meet ADA recommendations [17]. Our results (Table 3) showed that the impression materials disinfected by autoclave and microwave sterilization contracted (-0.0042 to -0.0071% and -0.024 to -0.028%, respectively), whereas the chemical sterilization lead to expansion (+0.0021 to +0.0035). The differences in dimensional stability were statistically significant, with the exception of the dimensional changes seen in Affinis and Aquasil after the chemical disinfection.

The specimens sterilized with microwave energy showed mild contraction. These findings are consistent with the results of K.M. Abdulaziz *et al.* [4]. The resulting contraction may be attributable to the loss of chemical constituents from the elastomers when subjected to dry microwave heat. This hypothesis was supported by observations made after the specimens were subjected to the microwave sterilization. The dry nature of the microwave heat discolored the surface of the elastomer specimens (Figure 4).

The specimens sterilized by steam autoclave also showed significant dimensional changes, but these changes were smaller than those of the specimens that were sterilized using microwave energy. This dimensional change may have been caused by elastomer fluid intake.

Corso *et al.,* studied the effects of temperature changes on the dimensional stability of polyvinyl siloxane impression material and reported a mean dimensional change of 1 to 18 μm [18]. These data are consistent with our study. Warden *et al.,* investigated microbial reduction and/or sterilization methods for impression materials and reported that steam autoclaving of impressions is a safe method of microbial reduction [19].

The chemical disinfection caused minimal linear dimensional changes compared with the other disinfection techniques. Melilli *et al.,* investigated the effects of Sterigum powder and glutaraldehyde on the dimensional stability of two elastomeric impression materials and reported that the dimensional change was ≤0.5% [3]. Walker *et al.,* studied the effects of dual phenol and sodium hypochlorite on the surface quality and long term dimensional stability of two elastomeric impression materials and concluded that the dimensional changes met the ADA standards [10]. John B. Tullner and colleagues examined the effects of iodophor, 5.25% sodium hypochlorite and 2% neutral glutaraldehyde on the linear dimensional changes of dental impressions and found that none of the materials tested exhibited clinically significant changes [20].

It is difficult to explain why the elastomers expanded when chemically disinfected and contracted when sterilized by autoclave and microwave. These changes may have occurred due to fluid absorption during the chemical disinfection and fluid loss during the autoclave and microwave sterilizations. Although the tested materials displayed significant linear dimensional changes, the changes were acceptable because the values were within the range of the ADA specifications. Our data suggest that autoclave and microwave sterilization are acceptable disinfection methods for elastomeric impression materials.

## CONCLUSIONS

From the results of the present study, we concluded that sterilizing elastomers by autoclave and microwave is associated with mild linear dimensional changes. Although statistically significant dimensional changes were observed, it is important to note that the dimensional changes were less than 0.3%, which is well within the ADA recommended dimensional change (≤0.5%). Therefore, the elastomeric impressions should be safely sterilized using autoclave and microwave energy because chemical disinfection alone is less lethal and does not eliminate all bacterial forms.

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