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ORIGINAL RESEARCH

Surface Roughness of Polyvinyl Siloxane Impression Materials Following Chemical Disinfection, Autoclave and Microwave Sterilization

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ABSTRACT

Background: Autoclave sterilization and microwave sterilization has been suggested as the effective methods for the disinfection of elastomeric impressions, but subjecting elastomeric impressions to extreme temperature may have adverse effects on critical properties of the elastomers.

Aim: To evaluate the effect of chemical disinfection as well as autoclave and microwave sterilization on the surface roughness of elastomeric impression materials.

Materials and methods: The surface roughness of five commercially available polyvinyl siloxane impression materials (Coltene President, Affinis Perfect impression, Aquasil, 3M ESPE Express and GC Exafast) were evaluated after subjecting them to chemical disinfection, autoclaving and microwave sterilization using a Talysurf Intra 50 instrument. Twenty specimens from each material were fabricated and divided into four equal groups, three experimental and one control (n = 25). The differences in the mean surface roughness between the treatment groups were recorded and statistically analyzed.

Results: No statistically significant increase in the surface roughness was observed when the specimens were subjected to chemical disinfection and autoclave sterilization, increase in roughness and discoloration was observed in all the materials when specimens were subjected to microwave sterilization.

Conclusion: Chemical disinfection did not have a significant effect but, since it is less effective, autoclave sterilization can be considered effective and autoclaving did not show any specimen discoloration as in microwave sterilization. Microwave sterilization may be considered when impressions are used to make diagnostic casts. A significant increase in surface roughness may produce rougher casts, resulting in rougher tissue surfaces for denture and cast restorations.

Clinical significance: Autoclave sterilization of vinyl polysiloxane elastomeric impressions for 5 minutes at 134°C at 20 psi may be considered an effective method over chemical disinfection and microwave sterilization, because chemical disinfection does not eliminate all disease-causing microorganisms and microwave sterilization leads to a rougher impression surface.

Keywords: Laboratory research, Surface roughness, Autoclave sterilization, Microwave sterilization, Chemical disinfection, Elastomeric impression materials.

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INTRODUCTION

Dental impressions are exposed to various microorganisms because of contamination with saliva and blood in the clinical environment,[1,2] leading to cross-infection in gypsum casts in the laboratory.[3-7] Elastomeric impression materials are the most commonly used impression materials because of their good physical properties. However, no universally accepted disinfection protocol has been established. According to American Dental Association (ADA) guidelines, the impressions can be disinfected by spraying or immersing in a chemical disinfectant, but many authors have suggested other techniques, such as the use of steam autoclave, ethylene oxide gas autoclave, and radiofrequency glow discharge and microwave sterilization and different findings have been reported.[8-17]

The objective of dental impression making is to accurately reproduce the negative replica of the oral tissues, which will later be filled with plaster or artificial stone (gypsum) to obtain a positive replica, which is as a master cast for the fabrication of a dental prosthesis. Any surface defects or irregularities in the impression may result in an

irregular and ill-fitting prosthesis.[18] A smooth surface is desirable because it not only prevents plaque and calculus accumulation but also improves esthetics. Furthermore, surface roughness (Ra) on the tissue surface of the prosthesis may affect the fit and acceptance of the prosthesis. Surface defects or irregularities may be caused by the use of an improper technique and are most commonly the result of changes in the material's properties resulting from the disinfection procedure.[4-8,19]

The purpose of this study was to evaluate the effect of chemical disinfection, autoclave sterilization and microwave sterilization on the surface roughness of 5 commercially available elastomers. Currently the null hypothesis for this study is that chemical disinfection, autoclave and microwave sterilization does not have any effect on the surface roughness of elastomeric impression materials.

MATERIALS AND METHODS

Five elastomeric (polyvinyl siloxane) impression materials (Table 1) of putty soft consistency (tray material) and light body (syringe material) were selected for this study. A stainless steel mold recommended for dimensional stability by the ADA was used to fabricate 100 disk-shaped specimens, 20 for each material. The mold was composed of 3 parts: the base, a 3.8 cm diameter polished platform, a steel ring with an internal diameter of 3.8 cm that could be accurately positioned on the base, and a perforated steel plate used to apply pressure[4] after loading the elastomers. The perforations were made for retention and to allow the escape of excess material. The multiple mix technique was used to prepare specimens in which two consistencies were mixed simultaneously and separately. The syringe material was directly dispensed from a cartridge onto the surface, and the tray material was placed over the light body.[20]

The metal ring was placed on the base of the mold, and the light body material (green) directly injected onto the platform; the putty-consistency tray material (tan) was then mixed according to the manufacturer's recommendations and loaded (Fig. 1). The perforated plate was pressed against the ring to remove any excess material. The specimens were allowed to set in a thermostatically controlled water bath at 35°C to simulate oral temperature and were retrieved after the manufacturer-recommended setting time. The samples were then divided into four equal groups, according to the type of disinfection or sterilization technique to be used, as follows:

Group 1 specimens were immersed in Septodont (Table 2) for manufacturer recommended time of 10 minutes. Group 2 specimens were sterilized in an autoclave (Domina plus B, Dental X spa, Marzotto, 1136031, Dueville) for 5 minutes at 134°C and 20 psi (138 kPa). Group 3 specimens were dry sterilized using microwave energy (LG, MS-1944V/00, 1000 W, 2450 MHz, China) at a high power for 10 minutes with water ballast to prevent damage to Thyratron tube. Group 4 (control): no sterilization was used.

Fig. 1: Loading of syringe and putty elastomeric impression material into the mold

Table 1: Elastomeric impression materials used in this study

Product trade name	*Type*	*Manufacturer*	*Lot number*
Coltene President	Vinyl polysiloxane	Coltene/Whaledent Feldwiesenstrasse 20, 9450 Altstätten, Switzerland	Putty 0223165 Light body B02161
Coltene Affinis perfect impression	Vinyl polysiloxane	Coltene/Whaledent Feldwiesenstrasse 20, 9450 Altstätten, Switzerland	Putty 0191527 Light body 0214389
Dentsply Aquasil	Vinyl polysiloxane	Dentsply DeTrey GmbH 78467 Konstanz, Germany	Putty 0902000677 Light body 091119
3M ESPE Express STD	Vinyl polysiloxane	3M ESPE Dental Products St Paul, MN 55144-1000	Putty N138824 Light body N115389
GC Exafast	Vinyl polysiloxane	GC Europe NV Interleuvenlaan 13B-3001 Leuven	Putty 1006161 Light body 1002051

Table 2: Composition of chemical disinfectant

Trade name	*Composition in 100 gm*	*Manufacturer*
Septodont	7.7 gm alkylamine, 22.5 gm benzalkonium chloride, surfactants, cleaning booster, auxiliaries	Oro Clean Chemie AG Allmendstrasse 218320 Fehraltorf, Switzerland

A Talysurf Intra 50 instrument is portable, stylus type, contacting surface roughness (Ra) measuring unit (Taylor Hobson Ltd, 112/3477-02, series no. 339, Leicester, England). The instrument has a normal gauge range of 1 mm with a measurement resolution of 16 nm. Ra is the measure of mean surface roughness of the given sample.[3,21-23] During the measurement the diamond tipped stylus makes passive contact with the sample and moves forward without resistance. The equipment was calibrated so that the stylus tip would scan a 5 mm length, and the surface roughness was measured at 5 randomly selected areas in each specimen. Their mean ± SD was recorded. This test was repeated for all the specimens, and the results were tabulated and subjected to statistical analysis using Tukey's test (significance = 0.05). All of the statistical tests were conducted with the SPSS software (SPSS Inc., Chicago), and $p < 0.05$ was considered to be statistically significant.

RESULTS

The mean ± SD of Ra values are presented in Table 3. No statistically significant differences were observed in the Ra among chemically disinfected, autoclaved sterilized specimens when compared with control group for all the materials. Statistically significant difference in Ra values was observed when the specimens were subjected to microwave sterilization. Tukey's test (Table 3) showed highest mean surface roughness values after the specimens were microwave sterilized (1.5680 ± 0.3) and the lowest mean surface roughness values when chemically disinfected (0.63 ± 0.10).

Another finding observed when the specimens were subjected to microwave sterilization was the discoloration of the specimens (Fig. 2), which was not seen when the specimens were subjected to autoclave sterilization and chemical disinfection.

DISCUSSION

This study partly supports the null hypothesis because there was no statistically significant change in the surface roughness of elastomers when subjected to chemical disinfection and autoclave sterilization, whereas, microwave sterilization had significant changes in surface roughness which rejects the stated null hypothesis for these conditions.

Various techniques have been suggested to disinfect and sterilize impressions, including chemical disinfection by

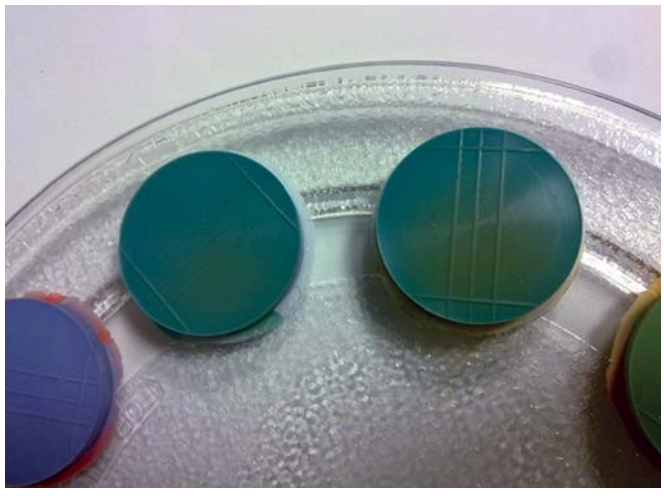

Fig. 2: Discoloration of the specimens after microwave sterilization

Table 3: Mean ± SD for the Ra of elastomeric impression materials subjected to chemical disinfection, autoclave and microwave sterilization

	Sterilization group						
Materials	*Chemically disinfected*		*Autoclaved*		*Microwave sterilized*		*Control*
	Mean (SD)	*p-value*	*Mean (SD)*	*p-value*	*Mean (SD)*	*p-value*	*Mean (SD)*
President	1.2502 (0.0004)	0.985	1.4364 (0.1859)	0.113	1.4165 (0.0674)	0.041*	1.2508 (0.0691)
Affinis	1.3309 (0.0005)	0.428	1.4284 (0.0980)	0.092	1.5680 (0.0839)	0.030*	1.3042 (0.0677)
Aquasil	0.7295 (0.0002)	0.288	0.9135 (0.2204)	0.128	0.8241 (0.0328)	0.009*	0.7072 (0.0406)
3M Express	0.6305 (0.0005)	0.541	0.7344 (0.0515)	0.130	0.9743 (0.2803)	0.000*	0.6132 (0.0573)
GC Exafast	1.132 (0.0002)	0.893	1.1371 (0.7619)	0.888	1.3445 (0.0605)	0.040*	1.1264 (0.8750)

*Statistically significant

spray or immersion with chloride compounds, iodophors, 2% glutaraldehydes, or a combination of synthetic phenols.[9] Ethylene oxide gas autoclave, conventional steam sterilization and sterilization using microwave energy.[9-11] Chemical disinfection is the most widely practiced disinfection method in daily practice but is considered a less lethal procedure than other approaches because it does not eliminate all forms of microorganisms and spores.[10] It is essential, therefore, to find a suitable disinfection method without reducing the quality of the impression. Polyvinyl siloxane impression materials are the most commonly used impression materials because of their superior surface detail reproduction and long-term dimensional stability, but they may undergo chemical deterioration when exposed to high temperatures.[9]

Based on the results in Table 3, a significant difference in the Ra was observed between the materials within the control group, although the specimens were fabricated under the same clinical conditions. The 3M specimen had the lowest surface roughness, and the Affinis specimen had the highest surface roughness. This difference can be explained by the variation in the color and chemical composition of the material as well as the amount, size and shape of the filler particles, which varies among the manufacturers, because a higher filler concentration increases the surface roughness.[19] This finding was in agreement with the results of Goiato et al[4] who found that MDX 4-4210 had higher surface roughness values than Silastic 732 RTV because of its higher filler concentration.[4] Rodriguez et al[24] compared the surface roughness of glass block surface and impression materials, they concluded that, surface roughness of impression material was high compared to glass block surface.[24] According to this study, the difference in surface roughness resulted from the color of the impression material, where darker impression materials had higher roughness values when tested using noncontact optical profilometry. The putty and light-body impressions were also found to have statistically significant higher roughness values than the heavy- and medium-body materials.

In the chemically disinfected and autoclave sterilized samples of the present study, the differences between these groups and the control group were not significant. This finding was in agreement with the study conducted by Goiato et al[4] in which maxillofacial elastomers did not show a statistically significant effect when disinfected with chemical disinfectants. Other authors who studied the surface quality and detail reproduction following impression material disinfection have not reported adverse surface changes with chemical immersion disinfection.[13-17]

When the samples were subjected to microwave sterilization, all the materials showed a statistically significant increase in the mean surface roughness when compared with specimens in control group. This result could be because of the chemical deterioration of the elastomer at extreme dry temperatures because an increase in the roughness was mainly observed when the specimens were sterilized using microwave sterilization which is dry heat. The surfaces of the specimens were found to be discolored which could be because of the evaporation of chemical components, which is the result of the dry nature of microwave heat (Fig. 2). In contrast, the specimens disinfected by the chemical and autoclave method did not show such discoloration.

CONCLUSION

Chemical disinfection and autoclave sterilization did not significantly increase surface roughness. Autoclave sterilization can be considered as a suitable sterilization method for vinyl polysiloxane because; chemical disinfection is less lethal than autoclave sterilization. Microwave sterilization of elastomeric impression materials may be considered when the impressions are used to make diagnostic casts; however, the significant increase in the surface roughness may produce rougher casts, resulting in rougher tissue surfaces for denture and cast restorations.

CLINICAL SIGNIFICANCE

Autoclave sterilization of vinyl polysiloxane elastomeric impressions for 5 minutes at 134°C at 20 psi may be considered an effective method over chemical disinfection and microwave sterilization, because chemical disinfection does not eliminate all disease-causing microorganisms and microwave sterilization leads to a rougher impression surface.

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