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Original Research Article

Evaluation and comparison of the effect of autoclave and chemical sterilization on the dimensional accuracy and stability of two elastomeric impression materials-an *in vitro* study

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ABSTRACT

Background: Infection control has been an important parameter in day-to-day dental practice is infection control. But sometimes while the execution of treatment, during impression making an unforeseen complication may arise due lack of proper disinfection protocol which might lead to transfer of infection between patient to other personnel. The purpose of this study is to evaluate and compare the effect of autoclave and chemical sterilization on the dimensional accuracy and stability of two elastomeric impression materials.
Methods: A total of 40 impressions were made with a special impression making device with 2 types of elastomeric impression materials polyvinyl siloxane and polyether. The samples were divided into 2 groups, group 1 was chemically disinfected, whereas group 2 was autoclaved of each material respectively. Measurements were made immediately after the impression is made. Immediately after sterilization and 7 days (168 hours) after sterilization.
Results: the dimensional accuracy of polyether was seen to be slightly better than polyvinyl siloxane when measured before chemical and autoclave sterilization.
Conclusions: The dimensional stability of polyvinyl siloxane was seen to be better than polyether when measured after autoclave and chemical sterilization but is statistically insignificant at a 0.05 level of significance.

Keywords: Polyvinyl siloxane, Polyether, Autoclave, Glutaraldehyde, Dimensional stability

INTRODUCTION

The most important parameter in day-to-day dental practice is infection control. For over centuries dentistry has evolved in treating patients with partial or complete edentulism with prothesis that would retain the normal function and correct the aesthetics. But sometimes while the execution of treatment, during impression making, an unforeseen complication may arise due lack of proper disinfection protocol which might lead to transfer of infection between patient to other personnel.[1]

Impression is first milestone in sequence of procedures performed for the fabrication of any prosthesis. An ideal impression material should act like a blueprint of the oral cavity and accurately replicate the tooth preparation and records the precise arch position with minimal distortion. For that purpose, various impression materials have been advocated like addition silicone, polyether and hydrocolloids. American dental association (ADA) specification no. 19 identifies these materials to be "non-aqueous elastomeric dental impression materials."[2]

Out of other elastomers, polyether and silicones impression materials are highly stable and accurate. They can maintain their accuracy for up to 1 week or even later. Maintaining the accuracy of the impression material after disinfection is of significance and a matter of interest. Disinfection of an impression material can be executed by immersion or spraying of various chemical

disinfectants like glutaraldehyde and sodium hypochlorite. Glutaraldehyde, is known to be a "high-level disinfectant", and is an effective disinfectant for silicone impressions because of its bactericidal, virucidal, and fungicidal properties whereas Sodium hypochlorite, in a concentration of 1% has been reported as an "intermediate-level disinfectant". Immersion of PVS impressions in 2% glutaraldehyde and 1% sodium hypochlorite has resulted in successful disinfection as revealed in various studies.[3] Disinfection by immersion exposes all the impression surfaces more favourably to the disinfectant compared to spraying. However, it may also cause greater dimensional and surface changes of an impression as compared to spraying. [4]

Sterilization of the impressions on the other hand may eliminate all microbial contamination including spores. It can be done by exposure to ethylene oxide gas, microwave, ultraviolet light and autoclaving. Dimensional stability of an impression material reflects its ability to maintain the accuracy of the impression over time. Obtaining an undistorted impression after disinfection is critical to the fit of future prostheses. Hence disinfection procedures that provide adequate antimicrobial efficacy without affecting the changes in impression dimensions are the focus of this study. A stereomicroscope has been used to measure dimensional changes of impressions directly or indirectly. PVS impression material seems to be relatively unaffected dimensionally by immersion in disinfectants such as glutaraldehyde. Data on dimensional changes obtained by direct evaluation of PVS impression is sparse. Therefore, this study aims to evaluate and compare effect of autoclave and chemical sterilization on dimensional accuracy a stability of 2 elastomeric impression materials.

METHODS

The present study was conducted in the department of prosthodontics and crown and bridges, Subharti dental college and hospital, Meerut to evaluate and compare the effect of autoclave and chemical sterilization on the dimensional accuracy and stability of two elastomeric impression materials.

Armamentarium for impression making

Figure 1: Impression making device.

Special die

A stainless-steel master die was made according to ADA specification 19 in the shape of the frustum of a cone with a vertical dimension of 12 mm from the Cavo surface line angle to the occlusoaxial line angle. The diameter of the die at the Cavo surface line angle at the base was 14mm with the shoulder of 1 mm circumferentially. An occlusal convergence of 5 degree was given resulting in an occlusal diameter of 11 mm. On the occlusal surface, five lines were labelled as 1, 2, 3 and 4. All the lines were accurately parallel to each other in one plane. One groove in a plane perpendicular to the long axis of the die was scribed circumferentially into the surface of the axial wall of the die. The occlusal surface will serve as a parameter for measurement of dimensional accuracy and stability for the purpose of this study (Figure 2 A and B).

Figure 2 (A and B): Special die frontal and occlusal view.

Preparation of impression tray

Impression trays are made of stainless steel for autoclave and chemical sterilization. They are machined to accommodate impression material of 4mm uniform thickness all around the special die. The tray will have holes of 2 mm diameter on each side for the mechanical retention of the impression material.

Impression making device

An impression making device is used to guide the metal tray into the groove around the die. This alignment procedure provided uniform thickness of the impression material and seated the impression tray at the same location each time. Following are the parts of impression making device:

Metal platform: It is circular in shape with round depression of 27 mm in the centre which will accommodate the special die of 14 mm. The metal die is fixed in the centre with the help of a locking device and a space of 0.5 mm is left circumferentially around the base of the metal die and the inner walls of the depression.

Vertical arm: It connects the metallic platform with the horizontal arm, it is fixed to the lower platform at the lower end.

Horizontal arm: It is fixed to the vertical component at the one end and on the other end it had an opening through which the vertical shaft could move.

Vertical shaft: This arm moved only in the vertical axis.

Methodology

A total of 40 impressions were made from both polyvinyl siloxane (addition silicone) (n=20) and polyether impression material (n=20) using an impression apparatus as described earlier. The impressions thus obtained were divided into groups and were subjected to autoclave and chemical sterilization. Measurements were made immediately after the impression is made. immediately after sterilization and 7 days (168 hours) after sterilization. Dimensional accuracy and stability of the impression materials was analysed using a stereomicroscope. The results were tabulated, and statistical analysis was done using SPSS software followed by a comparative analysis between the two groups.

Sterilization protocols were as follows: autoclaving at 134°C for 5 min at 20psi was performed for 10 samples each of polyvinyl siloxane and polyether impression material and the 10 samples were immersed in 2% glutaraldehyde solution for 8 hours of polyvinyl siloxane and polyether impression material respectively. Measurements between the lines were made using a Stereomicroscope immediately after the impression is made, immediately after sterilization is done and 7 days (168 hours) after sterilization, to evaluate the dimensional accuracy and stability in the horizontal plane.

The dimensional change was calculated using the following formula: Dimensional change (%)=(A-B)/A×100

Where A and B were the dimensions obtained on the control i.e., the metal die and the impression surface respectively.

The data was collected and analysed the statistical software SPSS 16.0 was used for analysis of data. To test the significance between two groups was tested by unpaired-'t' test and one-way ANOVA-F test. For intragroup comparison and mean differences between the lines measured paired t test was applied. The 95% confidence interval and 5% level of significance was used for the data.

RESULTS

All impressions were studied under a stereomicroscope at 10× magnification to record readings between lines L1, L2, L3 and L4 at 3 different intervals i.e., at the time of impression, after sterilization, and 7 days after sterilization was done. The distance between the lines in the top of the master die was measured as per ADA 19 specification giving us a total of 480 readings across 2 groups. After the readings were obtained, the mean was obtained for each line before and after sterilization and the statistical evaluation was done comparing the effect of sterilization on each material followed by an inter and intragroup comparison of different materials at different time intervals. (Table 1-4 and Figure 3 and 4).

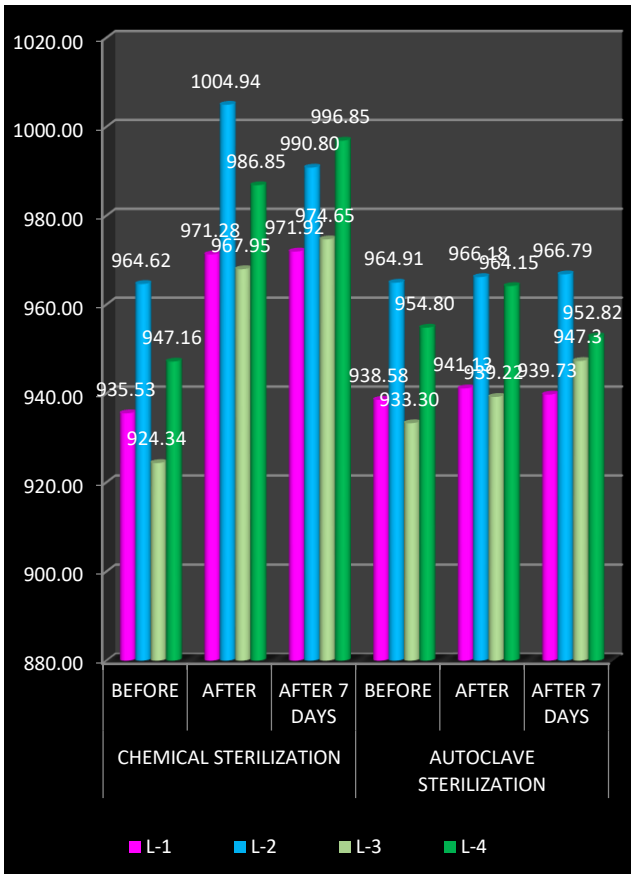

Figure 3: Immediate after and after 7 days of chemical and autoclave sterilization for polyether.

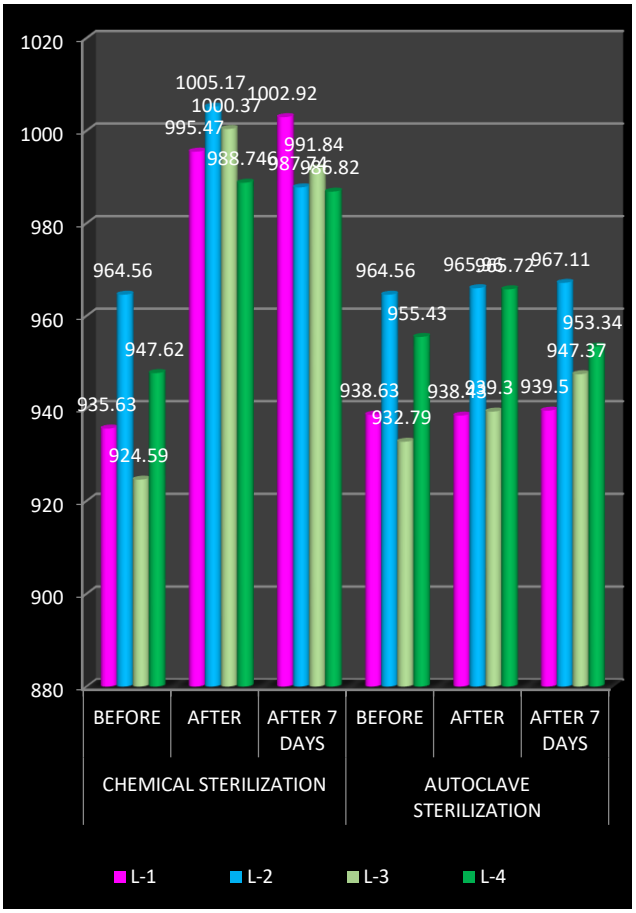

Figure 4: Immediate after and after 7 days of chemical and autoclave sterilization for polyvinyl siloxane.

Table 1: Comparison of differences b/w before and after sterilization in polyether.

Type of lines	Probable values of un-paired 't' test for differences b/w before and after sterilization in polyether
L-1	0.0092*p<0.05 (significant)
L-2	0.9874**p>0.05 (n. s.)
L-3	0.0670**p>0.05 (n. s.)
L-4	0.8771**p>0.05 (n. s.)

*Shows a significant difference at 0.05 level of significance (p<0.05), **shows no significant difference at 0.05 level of significance (p<0.05).

Table 2: Comparison of differences b/w before and after sterilization in polyvinyl siloxane.

Type of lines	Probable values of un-paired 't; test for differences b/w before and after sterilization in polyvinyl siloxane
L-1	0.5302**p>0.05 (n. s.)
L-2	0.9859**p>0.05 (n. s.)
L-3	0.9471**p>0.05 (n. s.)
L-4	0.8753**p>0.05 (n. s.)

*Shows a significant difference at 0.05 level of significance (p<0.05), **shows no significant difference at 0.05 level of significance (p<0.05).

Table 3: Comparison of differences b/w before and after of polyether before and after sterilization and impression materials-after 7 days

Type of lines	Probable values of un-paired 't' test for differences b/w before and after sterilization in polyether	
	Before polyether sterilization	**After polyether sterilization**
L-1	0.0003*p<0.05 (significant)	0.0021*p<0.05 (significant)
L-2	0.0002*p<0.05 (significant)	0.0015*p<0.05 (significant)
L-3	0.0012*p<0.05 (significant)	0.0032*p<0.05 (significant)
L-4	0.0017*p<0.05 (significant)	0.0004*p<0.05 (significant)

*Shows a significant difference at 0.05 level of significance (p<0.05), **shows no significant difference at 0.05 level of significance (p<0.05).

Table 4: Comparison of differences b/w before and after of polyvinyl addition silicone before and after sterilization and impression materials after 7 days.

Type of lines	Probable values of un-paired 't' test for differences b/w before and after sterilization in polyvinyl siloxane	
	Before polyvinyl siloxane sterilization	**After polyvinyl siloxane sterilization**
L-1	0.0019*p<0.05 (significant)	0.0041*p<0.05 (significant)
L-2	0.0033*p<0.05 (significant)	0.0017*p<0.05 (significant)
L-3	0.0018*p<0.05 (significant)	0.0024*p<0.05 (significant)
L-4	0.0029*p<0.05 (significant)	0.0008*p<0.05 (significant)

*Shows a significant difference at 0.05 level of significance (p<0.05), **shows no significant difference at 0.05 level of significance (p<0.05).

The results obtained were compiled, tabulated, and subjected to one way ANOVA-F-test, and an unpaired "t" test for comparison of inter-group measurements**.**

From the tabulated observations and statistical analysis for the present study the following results can be drawn:

When comparing the mean difference between the lines measured as L1, L2, L3, and L4 before chemical sterilization of polyether in groups 1A and 2A showed a statistically no significant difference between lines and master die resulting in a no change in dimensional accuracy.

When comparing the mean difference between the lines measured as L1, L2, L3, and L4 before, after, and 7 days after chemical sterilization of polyether in group 1A are statistically significant showing that the sterilization

procedure does produce a linear dimensional change in the impression material

When comparing the mean difference between the lines measured as L1, L2, L3, and L4 before, after, and 7 days after autoclave sterilization of polyether in group 2A are statistically not significant after sterilization however after 7 days a statistically significant difference was seen in the material after 7 days after the impression procedure was performed

When comparing the mean difference between the lines measured as L1, L2, L3, and L4 before, after, and 7 days after chemical sterilization of polyvinyl siloxane in group 1B are statistically non-significant showing that the sterilization procedure does not produce a linear dimensional change in the impression material

When comparing the mean difference between the lines measured as L1, L2, L3, and L4 before, after, and 7 days after autoclave sterilization of polyvinyl siloxane in group 2B are statistically not significant after sterilization

When comparing the two impression materials i.e., polyether and polyvinyl siloxane, polyvinyl siloxane showed better dimensional stability than polyether after sterilization.

DISCUSSION

The widespread use of elastomeric impression materials has led to the indirect techniques for the fabrication of prosthodontic restorations. These impression materials are commonly preferred because of their good physical properties.[5] the elastomeric impression materials have certain advantages of intrinsic hydrophilicity, and is accurate in dimensional stability; surface reproduction and can be poured repeatedly. Two widely used elastomeric impressions are vinyl polysiloxane (also called addition silicone, VPS) and polyether.

Studies show that micro-organisms survive on, or inside, the impressions. Even though their number decreases rapidly after impression making and rinsing with water further eliminates them. However, a measurable amount of bacterial load remains on impressions and can be transferred to casts. Therefore, the effort to eliminate as many potential risks as possible seems logical and the application of a disinfection treatment on impressions is considered mandatory.[6]

Various alternative methods are proposed, such as ethylene oxide autoclave, microwave, ultraviolet radiation, or even immediate pour and disinfection of the casts for disinfection. The preferable method for the chemical disinfection is seen to be by immersion method but it has shown to have an adverse effect on the dimensional stability of the impression material which is a matter of concern. A considerable number of articles have reported that addition silicone was the most frequently used impression material, followed by polyether, irreversible hydrocolloid, polysulphide, condensation silicone, and reversible hydrocolloid.[6]

Addition silicone (polyvinyl siloxane) and polyether elastomeric impression materials are widely used because of their dimensional accuracy with minimal distortion it has been thought that disinfectants can alter the dimensional accuracy of impression materials.[7] Hence, purpose of this study was done to evaluate and compare the dimensional accuracy of elastomeric impression materials when tested with autoclave, microwave, and chemical disinfection.

In the present study, impressions were taken of the model using both addition silicone and polyether impression materials following which the impressions were immersed in chemical disinfectant and the measurements were made between the lines that were present on the impression obtained; following which statistical analysis was done as mentioned earlier. It was found that when the polyether impression materials were immersed in 2% glutaraldehyde solution for 8 hours, the measurements were slightly larger than the measurements obtained before sterilization. The un-paired-'t' test for differences before and after sterilization revealed a statistical difference of 0.0092, 0.9874, 0.0670, 0.8771 in line L1, L2, L3, and L4 respectively, showing no significant difference at a 0.05 level of significance. ($p<0.05$) (Table 1) When measured 7 days after the sterilization process statistically significant difference of 0.0021, 0.0015, 0.0032, and 0.0004 respectively was the observed (Table 3).

Johnson et al among others, warned that polyether is particularly sensitive to immersion and that disinfection by immersion is contraindicated for this material.[8] Thus, suggesting that polyether after chemical sterilization statistically shows a significant dimensional change.

However, for statistical analysis of addition silicone unpaired-'t' test revealed the probable values of 0.5302, 0.9859, 0.9471, 0.8753 in lines L1, L2, L3, and L4 respectively. resulting in no significant difference at a 0.05 level of significance ($p<0.05$) (Table 2). The probable values of unpaired "t" test revealed a significant difference of 0.0041, 0.0017, 0.0024, 0.0008 for the same lines discussed earlier which showed statistically significant difference at 0.05 level of significance ($p<0.05$) (Table 3). The variation between the lines of the polyvinyl siloxane impression material 7 days after sterilization one way ANOVA-F test was done which revealed that there was a variation of 0.2693μm among the lines resulting in no significant difference at a 0.05 level of significance. ($p<0.05$) (Table 6). The bar diagrams (Figure 4) also revealed no significant difference between before and immediately after sterilization. However, 7 days after sterilization revealed a significant change in dimensions between the lines L1, L2, L3, and L4.

Tullner et al did not observe any negative effect after immersing polysulfide, polyether, and addition reaction silicone impressions in iodophor, 5.25% sodium hypochlorite, or neutral 2% glutaraldehyde.[9] Similar results obtained by Langenwalter et al who studied the same materials immersed in iodophor, sodium hypochlorite, glutaraldehyde, or twice deionized water or exposed to room air for 10 minutes.[10] Similarly, Matyas et al concluded that there was no adverse effect of various disinfecting media on the different impression materials.[11]

On the effect of autoclave sterilization on dimensional accuracy and stability. Sterilization is best achieved by physical methods such as autoclaving which is less time-consuming and more reliable than chemical disinfection. Though disinfection of the impressions is routinely followed autoclaving elastomeric impressions is an effective method of sterilizing them.

This study compared the effect of autoclaving on elastomeric impressions at 134°C for 5 min at 20 psi on the dimensional stability of polyvinyl siloxane impression material and polyether at three different time intervals; that is before autoclaving, immediately after autoclaving, and 7 days after autoclaving.

The statistical analysis of polyether was done after the measurements using stereomicroscope and it was found the polyether did show significant dimensional change. On comparing the differences between before and after sterilization in polyether it was observed that the probable values of unpaired ‘t; test for lines L1, L2, L3 and L4 were 0.0092, 0.9874, 0.0670 and 0.8771 respectively (Table 1).

After 7 days of sterilization one-way ANOVA F test was done and the statistical analysis revealed the variation between the pair lines seen was 0.5114 showing no significant difference at 0.05 level of significance ($p<0.05$) (Table 6).

This result is in agreement with the report of stackhouse on hydrophilic polyether where they showed an increase in dimension of the dies obtained after autoclaving of polyether impression material.[12]

Polyvinyl siloxane statistically showed non-significant dimensional change between the lines of autoclave sterilization among all 4 lines the difference of 0.3325 was seen revealing a statistically nonsignificant difference at a 0.05 level of significance (Table 5). Immediately after and 7 days after autoclave sterilization one-way ANOVA-F test was done and the statistical analysis revealed that between the pair lines the variation seen was 0.5114 showing no significant difference at 0.05 level of significance ($p<0.05$) (Table 6). Similar results were seen by Reddy et al, Thota et al and Kamble et al who studied the effect of autoclave on the autoclavable impression material released by Coltene which was also used in this study and Thota and Kamble et al did a comparative evaluation where they also stated that the addition silicone of Affinis in more dimensionally stable as compared to polyether after autoclaving of the two materials.[13-15] In the present study according to the statistical analysis and graphical representation (Figure 3 and 4) when comparing the lines L1, L2, L3, and L4 of polyether and polyvinylsiloxane before, immediately after, and 7 days after chemical and autoclave sterilization reveal that polyvinyl siloxane tends to have higher dimensional stability than polyether.

Addition silicone and polyether are both commonly used impression materials as far as fixed prosthesis are concerned and newer inventions such as poly-vinyl-siloxanether have improved the art of impression making further, however further development must be made to improve the autoclaving properties of these materials.

In this study when the two groups were compared to each other the highest dimensional change was seen in long immersion in case of chemical sterilization followed by the autoclave method. This could be because of the hydrophilic nature of the elastomeric impression material. The results of the study are similar to studies by Ramakrishnaiah et al and Petrie et al from their study concluded that steam autoclaving of impression is a safe method of microbial reduction.[16,17] Thota et al from their study suggested that autoclave disinfection is effective for the addition and condensation silicone compared to polyether since polyether is hydrophilic and has to be disinfected by chemical means.[14]

Every study has its own results and so has this one, similarly since laboratory testing cannot exactly simulate in vivo conditions, the results of any in vitro investigation must be viewed with caution.

It is important to note that the investigation protocol did not include the effect that various sterilization procedures would have on the impression trays and tray adhesive; However, when using a tray with adhesive, depending on the bond strength of the adhesive and the stiffness of the tray material, impression shrinkage or expansion would translate into either oversized or undersized die respectively.[18]

CONCLUSION

Within the limitations of the study; conclusions are drawn from the comparative study are as follows: The dimensional accuracy of polyether was seen to be slightly better than polyvinyl siloxane when measured before autoclave and chemical sterilization. The dimensional stability of polyvinyl siloxane was seen to be better than polyether when measured after autoclave and chemical sterilization. Chemical sterilization was seen to have the least effect on the dimensional stability of polyether impression material followed by autoclave sterilization. Autoclave sterilization was seen to have the least effect

on the dimensional stability of polyvinyl siloxane impression material followed by chemical sterilization.

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