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Effects of Autoclave and Chemical Disinfectant on the Mechanical properties of Polyvinyl Silicone Impression material: A comparative study

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Abstract

Ensuring the sterility of dental impressions is crucial for preventing cross-contamination in clinical settings. However, sterilisation and disinfection methods may alter the mechanical properties of impression materials, potentially affecting their accuracy.

This study aims to compare the effects of Foster plus class B autoclave and Bacillol disinfectant spray on the mechanical properties of polyvinyl siloxane (PVS) impression material.

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A total of 36 samples were prepared for both 3M and Zermack PVS impression material with 12 samples allocated to each of the three groups.

Group A were Control, Group B were subjected to autoclave sterilization and Group C were sprayed with Bacillol disinfectant spray. All the samples were tested for tear strength, elastic recovery and dimentional stability.

The data collected subjected to statistical analysis using ANOVA followed by post-hoc tests.

Both Autoclaving and chemical disinfection preserve dimensional stability, Autoclaving enhances elastic recovery but reduce tear strength and 3M PVS material showed better tear strength.

Key words : Tear Strength, Elastic Recovery and Dimensional Stability.

Key Messages : Further research is recommended to explore alternative disinfection methods that minimise the impact on impression materials.

Polyvinyl siloxane (PVS) impression materials are the most modern elastomeric impression materials currently in use within restorative dentistry.[9] According to a survey conducted by dentists in general practice, half of the dentists questioned would prefer an impression material that is auto-clavable.[7] Over exposure to some disinfectant solutions can create dramatic changes in impression.[1] Impression materials that can withstand high temperature and are called autoclavable impression materials became available in market these days.[5] There is disagreement over the findings of many research about how various disinfection techniques affect the dimensional stability, tear strength, and elastic recovery of the disinfected impressions.[13]

In this *In vitro* study high-quality PVS impression materials 3M and Zermack were selected. A total of 36 samples were prepared for each impression material with 12 samples allocated to each of the three groups. All samples were prepared according to standardized dimensions for mechanical testing, ensuring uniformity across all groups. Group A were Control Group in which samples are not subjected to sterilisation and disinfection, Group B samples were subjected to foster plus Class B Autoclave Sterilization at a temperature of 134° C and pressure of 2.1 bar for 15 minutes and Group C were sprayed with Bacillol disinfectant spray ensuring even coverage of the material' s surface. The spray was allowed to act for the manufacturer-recommended time, followed by air drying. Each sample was tested for tensile strength using a universal testing machine. Tear strength strips were produced using a standard mould (Figure 1). This mould was sandwiched between two sheets of glass to maintain a standard thickness of 1 mm. Following removal, the tear strength strips were trimmed and an incision was made in the centre

(10 mm from either side). This involved clamping the opposing "tongues" of the tear strip into the universal testing machine calibrated to move at 10 mm per minute. The clamps would move in opposite directions until a tear was initiated and maintained and the force required to break the sample was recorded.

Elastic recovery was assessed by measuring the percentage of recovery after the samples were deformed under a controlled load. The specimens prepared for elastic recovery were dumbbell shaped. These typical dumbbell-shaped specimens were created to exert a uniform pressure across the gripping surfaces. The broken Pieces after Tear Strength testing are fitted back together (Figure 2) and the distance between the marks was measured using an electronic vernier caliper with a resolution of 0.01 mm after 2 hours. The change in length (Δ L) was measured, and percentage deformation was calculated.

For Dimensional Stability the stainless steel mould (Figure 3) was taken based on the recommendations by American Dental Association Specification No. 19. The undersurface area of die was applied by material with the help of fine-tipped impression syringe. The top surface of mould was covered with glass plate with pressure applied on top of it with dental flask and the impression models are retrieved from the mould. The dimensional changes were tested under Stereo Microscope at intervals of 1 day, 1 week and 2 weeks.

Statistical Analysis :

The data collected from the mechanical tests were subjected to statistical analysis using spss version 26 and inferential statistics done using ANOVA followed by post-hoc tests (Table-1) to determine significant differences between the groups. $p<=0.05$ will be considered statistically significant. Data were analyzed using statistical software to compare the impact of the autoclave and disinfectant spray on the PVS material.

This *In-vitro* study to to compare the effects of Foster plus class B autoclave and Bacillol disinfectant spray on the mechanical properties of polyvinyl siloxane (PVS) impression material. Out of 72 samples 36 samples (PVS 3M) and 36 samples (PVS Zermack). Each group id dived into three sub groups like control group, disinfection group and sterilization group. The data collected from the mechanical tests were subjected to statistical analysis will be done using spss version 26 and inferential statistics will be done using ANOVA followed by post-hoc tests to determine significant differences between the groups. $p<=0.05$ will be considered statistically significant. Data were analyzed using statistical software to compare the impact of the autoclave and disinfectant spray on the PVS material. The results are presented in the form of tables and figures.

The mean values of the various properties of 3M material are displayed in Table-1 shows that the three groups elastic recovery mean values were 98.00, 98.00, and 98.66 for control, disinfection, and sterilization, respectively. The mean values for the three groups tear strength were 7.76, 7.90, and 6.65 for control, disinfection, and sterilization, respectively. After one day, the mean values for dimensional stability in the three groups namely control, disinfection, and sterilization

were 6.21, 6.26, and 6.22, respectively. After one week, the mean values for dimensional stability in the three groups namely control, disinfection, and sterilization were 6.20, 6.28, and 6.23, respectively.

Table-2 shows tukey post hoc pairwise comparisions of all three groups in 3M material control, disinfection and sterilization respectively with *p≤0.05 was considered statistically significant.

Table-3 shows the mean values of Different Properties of Zermack Material. Elastic recovery of three groups control, disinfection and sterilization got mean values of 97.50, 97.16 and 98.11 respectively. Tear strength of three groups control, disinfection and sterilization got mean values of 5.75, 6.01 and 3.70 respectively. Dimensional stability after one day of three groups control, disinfection and sterilization got mean values of 6.23, 6.23 and 6.21 respectively.

Dimensional stability after one week of three groups control, disinfection and sterilization got mean values of 6.22, 6.22 and 6.22 respectively. Dimensional stability after two weeks of three groups control, disinfection and sterilization got mean values of 6.22, 6.21 and 6.22 respectively. In this one way ANOVA test **p≤0.000 was considered highly statistically significant.

Table-4 shows tukey post hoc pairwise comparisions of all three groups in Zermack material control, disinfection and sterilization respectively with *p≤0.05 was considered statistically significant.

The mean values of the Control Group in both 3M and Zhermack Material are displayed in Table 5. For this group, the mean values for elastic recovery for Zhermack and 3M materials were 97.50 and 98.00, respectively. For this group, the mean values for Tear Strength for Zhermack and 3M materials were 5.75 and 7.76, respectively.

After a day, the mean values for Dimensional Stability for Zhermack and 3M materials were 6.23 and 6.21, respectively. After a week, the mean values for Dimensional Stability for Zhermack and 3M materials were 6.22 and 6.20, respectively. After two weeks, the mean values for Dimensional Stability for Zhermack and 3M materials were 6.22 and 6.18, respectively. In this independent samples t-test **p≤0.000 was considered highly statistically significant.

Table-6 shows the mean values of disinfection Group in both 3M and Zhermack Material. Elastic recovery for 3M and Zhermack materials got mean values of 98.00 and 97.17 respectively for this group.

Tear Strength for 3M and Zhermack materials got mean values of 7.91 and 6.02 respectively for this group. Dimensional Stability after one day for 3M and Zhermack materials got mean values of 6.26 and 6.24 respectively for this group. Dimensional Stability after one week for 3M and Zhermack materials got mean values of 6.28 and 6.22 respectively for this group. Dimensional Stability after two weeks for 3M and Zhermack materials got mean values of 6.25 and 6.21 respectively for this group. In this independent samples t-test **p≤0.000 was considered highly statistically significant.

Table-7 shows the mean values of Sterilisation Group in both 3M and Zhermack Material. Elastic recovery for 3M and Zhermack materials got mean values of 98.67 and 98.12 respectively for this group. Tear Strength for 3M and Zhermack materials got mean values of 6.65 and 3.70 respectively for this group. Dimensional Stability after one day for 3M and Zhermack materials got mean values of 6.22 and 6.21 respectively for this group. Dimensional Stability after one week for 3M and Zhermack materials got mean values of 6.24 and 6.22 respectively for this group. Dimensional Stability after two weeks for 3M and Zhermack materials got mean values of 6.24 and 6.22 respectively for this group. In this independent samples t-test **p≤0.000 was considered highly statistically significant.

This study aims to compare the effects of Foster plus class B autoclave and Bacillol disinfectant spray on the mechanical properties of polyvinyl siloxane (PVS) impression material. To compare the effectiveness of two PVS impression materials (3M and ZENMARK) Specifically, to evaluate the impact of Foster plus class B autoclave sterilization on the mechanical properties of polyvinyl siloxane (PVS) impression material, specifically focusing on tear strength, elastic recovery, and dimensional stability; to assess the effects of Bacillol disinfectant spray on the same mechanical properties of PVS impression material, comparing the results to both untreated (control) samples and those subjected to autoclave sterilization and to compare the degree of alteration in mechanical properties between PVS samples treated with Foster plus class B autoclave and Bacillol disinfectant spray, identifying which method is less detrimental to the integrity of the material.

Lot of impression materials are being used in the past to record intraoral structures for definitive restorations. One such feature is the advancement in Impression materials. Background Polyvinyl siloxane (PVS) impression materials are the most modern elastomeric impression materials currently in use within restorative dentistry and prosthodontics; they can be used to record impressions of both dentulous and edentulous arches as well as for duplication of casts and bite registrations. This combination of handling properties with strength characteristics are used to pin point elastomeric impression materials, although new options have recently become available with extreme elastic recovery at the sacrifice of less than ideal tear strengths.[9]

Due to this cross-infection risk, there is a growing awareness of the issue within dental practice and as such autoclave sterilisation represents the treatment of choice for non-disposable items that have contacted human oral tissues. Sterilisation is the destruction of all micro-organism and spores.[7]

PVS has unique modification of polyvinyl siloxane (PVS) results in several key benefits.[5]

1. ***Excellent tear strength :*** The polymer chain of the material, along with the surface active agent, provides very high tear strength that is not matched by other impression materials.

2. ***Superior wettability :*** The surface-active agent gives the material wettability comparable to polyether impression materials, allowing it

to record excellent surface details even in humid environments.

3. ***High hydrophilicity :*** The cross-linked polymer and surface-active element work together to give the material a strong hydrophilic (water-attracting) property, which is crucial for capturing fine details in an impression. In summary, the quadrafunctional property of this modified PVS material provides a rare combination of exceptional tear strength, enhanced wettability, and high hydrophilicity - features that are highly desirable for accurate impression taking, especially in challenging conditions.

This *in-vitro* study to to compare the effects of Foster plus class B autoclave and Bacillol disinfectant spray on the mechanical properties of polyvinyl siloxane (PVS) impression material.

Out of 72 samples 36 samples (PVS 3M) and 36 samples (PVS Zermack). Each group id dived into three sub groups like control group, disinfection group and sterilization group. The data collected from the mechanical tests were subjected to statistical analysis will be done using spss version 26 and inferential statistics will be done using ANOVA followed by post-hoc tests.

Table-1. One way ANOVA Test Shows the mean values of Different Properties of 3M PVS Impression Material

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		F VALUE	P VALUE
					Lower Bound	Upper Bound		
Elastic recovery	Control	12	98.0000	.00000	98.0000	98.0000	550.000	.000**
	Disinfection	12	98.0000	.00000	98.0000	98.0000		
	Sterilization	12	98.6667	.09847	98.6041	98.7292		
Tear strength	Control	12	7.7674	.13678	7.6805	7.8543	224.119	.000**
	Disinfection	12	7.9073	.14038	7.8181	7.9965		
	Sterilization	12	6.6513	.19417	6.5279	6.7746		
1 Day Dimensional Stability	Control	12	6.2100	.00853	6.2046	6.2154	137.303	.000**
	Disinfection	12	6.2608	.00793	6.2558	6.2659		
	Sterilization	12	6.2200	.00739	6.2153	6.2247		
1 WEEK Dimensional Stability	Control	12	6.2042	.00515	6.2009	6.2074	397.596	.000**
	Disinfection	12	6.2842	.00515	6.2809	6.2874		
	Sterilization	12	6.2375	.00965	6.2314	6.2436		
2 WEEKS Dimensional Stability	Control	12	6.1833	.00492	6.1802	6.1865	230.400	.000**
	Disinfection	12	6.2517	.00835	6.2464	6.2570		
	Sterilization	12	6.2400	.00853	6.2346	6.2454		

Table-2. Pairwise comparisons by tukey post hoc test

Dependent Variable	(I) groups	(J) groups	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Elastic recovery	Control	Disinfection	.00000	1.000	-.0570	.0570
		Sterilization	-.66667*	.000	-.7236	-.6097
	Disinfection	Sterilization	-.66667*	.000	-.7236	-.6097
Tear strength	Control	Disinfection	-.13992	.095	-.2995	.0196
		Sterilization	1.11617*	.000	.9566	1.2757
	Disinfection	Sterilization	1.25608*	.000	1.0965	1.4156
Day 1 Dimensional Stability	Control	Disinfection	-.05083*	.000	-.0588	-.0429
		Sterilization	-.01000*	.011	-.0180	-.0020
	Disinfection	Sterilization	.04083*	.000	.0329	.0488
1 WEEK Dimensional Stability	Control	Disinfection	-.08000*	.000	-.0870	-.0730
		Sterilization	-.03333*	.000	-.0403	-.0263
	Disinfection	Sterilization	.04667*	.000	.0397	.0537
2 WEEKS Dimensional Stability	Control	Disinfection	-.06833*	.000	-.0758	-.0609
		Sterilization	-.05667*	.000	-.0641	-.0492
	Disinfection	Sterilization	.01167*	.002	.0042	.0191

Table-3. One way ANOVA Test Shows the mean values of Different Properties of ZENMARK PVS Impression Material.

		N	Mean	Std. Deviation	95% Confidence Interval for Mean		F VALUE	P VALUE
					Lower Bound	Upper Bound		
Elastic Recovery	Control	12	97.5000	.13484	97.4143	97.5857	130.801	.000**
	Disinfection	12	97.1667	.18749	97.0475	97.2858		
	Sterilization	12	98.1167	.10299	98.0512	98.1821		
Tear strength	Control	12	5.7599	.12119	5.6829	5.8369	1770.248	.000**
	Disinfection	12	6.0197	.08427	5.9661	6.0732		
	Sterilization	12	3.7029	.10475	3.6364	3.7695		
1 Day Dimensional Stability	Control	12	6.2392	.00793	6.2341	6.2442	56.618	.000**
	Disinfection	12	6.2392	.00793	6.2341	6.2442		
	Sterilization	12	6.2100	.00739	6.2053	6.2147		

1 Week Dimensional Stability	Control	12	6.2208	.00793	6.2158	6.2259	.152	.859
	Disinfection	12	6.2208	.00900	6.2151	6.2266		
	Sterilization	12	6.2225	.00866	6.2170	6.2280		
2 Weeks Dimensional Stability	Control	12	6.2217	.00835	6.2164	6.2270	14.795	.001**
	Disinfection	12	6.2100	.00739	6.2053	6.2147		
	Sterilization	12	6.2208	.00900	6.2151	6.2266		

Table-4. Pairwise comparisons by tukey post hoc test

Dependent Variable	(I) groups	(J) groups	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Elastic recovery	Control	Disinfection	.33333*	.000	.1871	.4796
		Sterilization	-.61667*	.000	-.7629	-.4704
	Disinfection	Sterilization	-.95000*	.000	-1.0962	-.8038
Tear strength	Control	Disinfection	-.25975*	.000	-.3644	-.1551
		Sterilization	2.05700*	.000	1.9523	2.1617
	Disinfection	Sterilization	2.31675*	.000	2.2121	2.4214
Day 1 Dimensional Stability	Control	Disinfection	.00000	1.000	-.0078	.0078
		Sterilization	.02917*	.000	.0214	.0369
	Disinfection	Sterilization	.02917*	.000	.0214	.0369
1 WEEK Dimensional Stability	Control	Disinfection	.00000	1.000	-.0086	.0086
		Sterilization	-.00167	.882	-.0102	.0069
	Disinfection	Sterilization	-.00167	.882	-.0102	.0069
2 WEEKS Dimensional Stability	Control	Disinfection	.01167*	.004	.0034	.0200
		Sterilization	.00083	.967	-.0075	.0091
	Disinfection	Sterilization	-.01083*	.008	-.0191	-.0025

The findings from this comparative study have significant implications for clinical practice in dentistry, particularly regarding infection control and the preservation of material properties essential for accurate dental impressions. The study highlights the following key points:

1. Infection Control Balance: While ensuring sterility is paramount to prevent cross contamination, this study suggests that the choice of sterilization or disinfection method can directly affect the mechanical properties of polyvinyl siloxane (PVS) impression material. This underscores the need for clinicians to carefully consider the sterilization method, balancing infection control with the maintenance of material integrity.

Table-5. Independent samples t-test for Control Group

Control group	Groups	N	Mean	Std. Devi-ation	Mean diffe-rence	T value	P value
Elasticity	3M	12	98.0000	.00000	.50000	12.845	.000**
	Zenmark	12	97.5000	.13484			
Tear Strength	3M	12	7.7674	.13678	2.007	38.054	.000**
	Zenmark	12	5.7599	.12119			
1 Day Dimensional Stability	3M	12	6.2100	.00853	-.0291	-8.676	.000**
	Zenmark	12	6.2392	.00793			
1 Week Dimensional Stability	3M	12	6.2042	.00515	-.01667	-6.106	.000**
	Zenmark	12	6.2208	.00793			
2 Weeks Dimensional Stability	3M	12	6.1833	.00492	-.03833	-13.701	.000**
	Zenmark	12	6.2217	.00835			

Table-6. Independent samples t-test for Disinfection Group

Control group	Groups	N	Mean	Std. Devi-ation	Mean diffe-rence	T value	P value
Elasticity	3M	12	98.0000	.00000	0.833	15.397	.000**
	Zenmark	12	97.1667	.18749			
Tear Strength	3M	12	7.9073	.14038	1.867	39.939	.000**
	Zenmark	12	6.0197	.08427			
1 Day Dimensional Stability	3M	12	6.2608	.00793	.021	6.693	.000**
	Zenmark	12	6.2392	.00793			
1 Week Dimensional Stability	3M	12	6.2842	.00515	0.063	21.153	.000**
	Zenmark	12	6.2208	.00900			
2 Weeks Dimensional Stability	3M	12	6.2517	.00835	0.0416	12.949	.000**
	Zenmark	12	6.2100	.00739			

2. Material Integrity Preservation: The results indicate that Bacillol disinfectant spray has a less pronounced negative impact on the mechanical properties of PVS compared to Foster plus class B autoclave sterilization. This suggests that chemical disinfection with Bacillol may be a more suitable option in scenarios where the mechanical integrity of the impression material is critical, such as in the creation of high-precision dental restorations.

Table-7. Independent samples t-test for Sterilization Group

Sterilization group	Groups	N	Mean	Std. Devi-ation	Mean diffe-rence	T value	P value
Elasticity	3M	12	98.6667	.09847	.550	13.371	.000**
	Zenmark	12	98.1167	.10299			
Tear Strength	3M	12	6.6513	.19417	2.948	46.293	.000**
	Zenmark	12	3.7029	.10475			
1 Day Dimensional Stability	3M	12	6.2200	.00739	.010	3.317	.003*
	Zenmark	12	6.2100	.00739			
1 Week Dimensional Stability	3M	12	6.2375	.00965	.015	4.007	.001**
	Zenmark	12	6.2225	.00866			
2 Weeks Dimensional Stability	3M	12	6.2400	.00853	.019	5.354	.000**
	Zenmark	12	6.2208	.00900			

3. Guidelines for Practice: The study's findings could inform the development of clinical guidelines, recommending Bacillol spray for disinfection when preserving mechanical properties is essential, while reserving autoclave sterilization for situations where maximum sterility is required, and minor alterations to material properties are acceptable.

4. Future research should explore alternative sterilization and disinfection methods that offer a better balance between ensuring sterility and preserving the mechanical properties of dental impression materials. Additionally, clinical studies are needed to validate these in vitro findings and their implications for actual patient care.

The limitations of this study are:

1. As it is an *in vitro* study, it could not simulate the oral mucosal conditions.

2. Other properties like surface roughness should be investigated.

1. The findings of the study indicate that both 3M and Zhermack PVS impression materials experience dimensional changes after disinfection and autoclaving, but these changes remain within clinically acceptable limits suggesting that both autoclaving and chemical disinfection is a viable sterilization method.

2. The control group of the Zhermack impression material showed the least elastic recovery compared to the 3M impression material. Both impression material's elastic recovery after chemical disinfection was discovered to be nearly identical in the control groups. Both impression materials demonstrated

a notable improvement in their elastic recovery upon steam autoclaving.

3. PVS impressions subjected to sterilization had decreased tear strength compared to the control group. The 3M PVS impression material showed better tear strength compared to the Zhermack PVS impression material.

Further research is recommended to explore alternative disinfection methods that minimise the impact on impression materials.

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Ehical approval :

The present study was approved by the ethical committee of Vishnu Dental College, Bhimavaram, India (IECVDC/24/UG01/PCB/IVT/74).

Conflicts of interests :

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

Study highlights

Current Knowledge :

Multiple in vitro and clinical-simulation studies support minimal, clinically acceptable dimensional change in auto-clavable PVS after standard steam cycles. Results vary with material brand, tray rigidity, autoclave temperature/time, and post-sterilization timing; adhering to specific product IFUs remains essential. Older studies on non-autoclavable or legacy PVS suggested limitations for definitive prosthodontics after steam sterilization.

New here

1. Infection Control Balance : While ensuring sterility is paramount to prevent cross contamination, this study suggests that the choice of sterilization or disinfection method can directly affect the mechanical properties of polyvinyl siloxane (PVS) impression material. This underscores the need for clinicians to carefully consider the sterilization method, balancing infection control with the maintenance of material integrity.

2. Material Integrity Preservation: The results indicate that Bacillol disinfectant spray has a less pronounced negative impact on the mechanical properties of PVS compared to Foster plus class B autoclave sterilization. This suggests that chemical disinfection with Bacillol may be a more suitable option in scenarios where the mechanical integrity of the impression material is critical, such as in the creation of high-precision dental restorations.

3. Guidelines for Practice: The study's findings could inform the development of clinical guidelines, recommending Bacillol spray for disinfection when preserving mechanical properties is essential, while reserving autoclave sterilization for situations where maximum sterility is required, and minor alterations to material properties are acceptable.

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