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Comparative Evaluation of elastic recovery of three different elastomeric impression materials after chemical disinfection and autoclaving: In vitro study

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Abstract

The aim of the study was to investigate the effect of disinfectant and steam autoclaving on the elastic recovery of three different elastomeric impression materials where 90 dumbbell shaped specimens of addition silicone (Zhermack hydrorise), polyether (3MESPE, Impregum), vinylsiloxane ether (Identium) were prepared and treated with chemical disinfectant (2% glutaraldehyde, CIDEX) and steam autoclaving (Class-B, Fomos Dental Foster Plus, European company). Specimens were seal packed and sent to laboratory for tensile testing. After the specimen had been pulled to failure in Universal Testing Machine then the change in length (ΔL) was measured, and percentage deformation was calculated which ultimately provided the elastic recovery. One Way ANOVA test and Post Hoc Tuckey Test were done for multiple comparison.

Results:. The result displayed statistically significant difference in elastic recovery in ANOVA test when it was disinfected and steam autoclaved, whereas in Post hoc test, results showed no significant difference in elastic recovery when Vinylsiloxane ether were disinfected and steam autoclaved. The results were alike when Polyether were disinfected and autoclaved with having 4.86% and 57.86% respectively and

showed statistical significant difference. Similarly, the results showed statistical significant difference in elastic recovery when addition silicone were disinfected and autoclaved with mean value of 61.12% and 1.07% respectively. Within the limitations of this *in vitro* study, conclusion was made that In control group, Vinylpolysiloxane ether showed the excellent elastic recovery. In chemical disinfectant group, addition silicone showed better elastic recovery and in steam autoclaving group, polyether showed better elastic recovery followed by vinylpolysiloxane ether. Comparatively, vinylpolysiloxane ether, also showed good results in elastic recovery after chemical disinfection and autoclaving. Hence, these newer elastomeric impression materials can be disinfected & safely autoclaved with good elastic recovery from a clinical point of view.

Keywords: autoclave, Disinfection, elastic recovery, , polyvinyl siloxane, sterilization, vinylsiloxane ether.

1. Introduction

The fabrication of precisely fitting prosthesis fully depends on an accurate impression making. An ideal impression material should exhibit characteristics such as it should be dimensionally stable, resistant to deformation, biocompatibility, and cost effective.[1] Different impression materials have evolved due to their better physical and handling properties which are irreversible hydrocolloids, polysulfides, polyvinyls & polyethers[1]. Addition silicone impression material have been widely accepted due to excellent dimensional stability and good elastic recovery. Polyether impression materials are moderately hydrophilic and capture accurate impressions in the presence of saliva or blood.

Clinically, a set impression is a pool for pathogens after its removal from the patient's mouth. Disinfection of impressions is a major concern with respect to transmissible diseases such as Hepatitis B, AIDS(HIV), herpes simplex and Covid-19. Hence a standard disinfection protocol must be followed to prevent the trasmission of microorganisms to gypsum casts and to laboratory personnel. [2]. The two important parameters are evaluated after disinfection of an impression are antibacterial efficiency and dimensional stability[3]. Various disinfectants such as sodium hypochlorite, glutaraldehyde, iodophors, and phenols are used for disinfecting impressions. Glutaraldehyde has been classified as higher level disinfectant which kills the microbial forms.[4] Doddamani et al (in 2011) observed that 2% Glutaraldehyde destroyed S.aureus and S.viridans effectively[5,6,7,9]. However, sterilization is considered more effective as it destroys all forms of microorganisms such as viruses, bacteria, fungi ,including spores.[8][9]. Warden et al (1995) investigated the sterilization methods and reported safe method for microbial reduction for impression materials [10]. Clinically, dental impressions containing large undercuts or thin sections which are susceptible to elastic deformation from tensile stresses. Thus, the material should possess sufficient elastic recovery that will return to its original dimensions and can be retrieved without permanent deformation so that same impression can be used more than once for accurate cast.[1,12] Nowadays, the newer impression materials can withstand high temperature and can be sterilized; are known as autoclavable impression materials. In 2009, the Kettenbach Company (Eschenburg, Germany) launched new impression material called vinylsiloxane ether "Identium" into dental markets. .[29]

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Vinylsiloxane ether is the chemical combination of addition silicone and polyether elastomeric impression materials. The manufacturer outlines that VSE material has 5% to 20% polyether, as hydrophilic property and rest consisted of Vinyldimethyl Polysiloxane (10-50%), Methyl hydrogen dimethyl Polysiloxane (3-10%) and silicone dioxide (30– 65%) and claimed to have superior elastic recovery and good tear strength.[29] A study was conducted by Stober et al (2010) in which he concluded that vinyl siloxanether monophase impressions and vinyl siloxanether dual-viscosity impressions displayed acceptable accuracy for clinical use with immersion disinfection, comparable to polyether and vinyl polysiloxane materials[19]. The aim of the study was to investigate the effect of disinfection and steam autoclaving on the elastic recovery of 3 different elastomeric impression materials. The null hypothesis was that there was no difference on elastic recovery of the materials when they are chemically disinfected or steam autoclaved.

2. MATERIALS AND METHODS

A Customized aluminium Die were fabricated with upper and lower member at- Industrial foundary, Susen-Tarsali road, Makarpura GIDC, Vadodara Gujarat. The lower member had dimensions of 11.5cm × 5cm × 1cm [3].(**Figure: 1**) and mold cavity of dumbbell shaped had dimensions of 10cm length, 3cm width, and 1mm thickness with two escape holes diagonally as stops present in upper member.[32, 33].(**Figure: 2)** The specimens were prepared in Manubhai Patel Dental College, Vadodara ,Gujarat where impression material were loaded into mold cavity of lower member and cover it with upper member aluminium lid and placed into the Bench Pressing Machine, Clifradent Company (figure:-2a) so that excess material flows out of escape holes to get uniform consistency 1mm thickness and excess scrapped off with Bard Parker Blade No.15 and then evaluated with digital vernier caliper under resolution of 0.01mm (figure:- 2b). Total 90 specimens were prepared which were divided into 3 groups described in tabular form.(Table-1).(Figure:3, 3a).

Figure 1: Customized Aluminium Die with Upper & Lower Lid

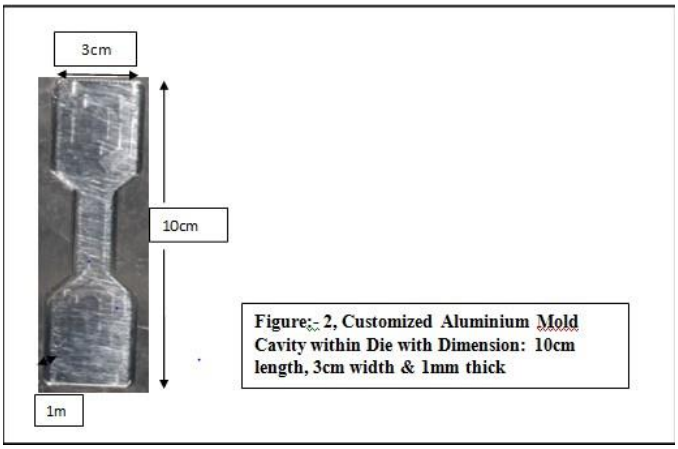

Figure:- 2, Customized Aluminium Mold Cavity within Die with Dimension: 10cm length, 3cm width & 1mm thick

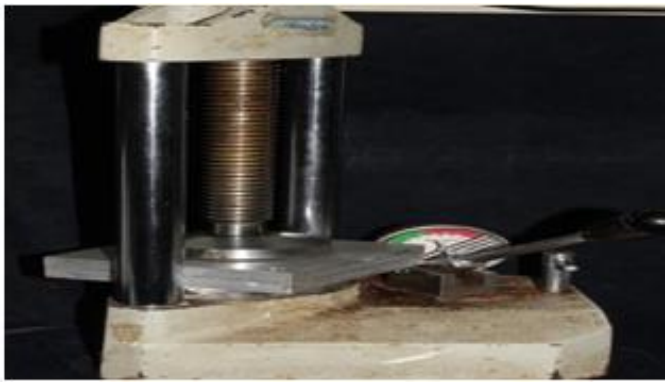

Figure 2a : Customized die placed under Bench Pressing machine

Sub group-A - 30 samples were treated as control group. (Figure 4). Sub group-B- 30 specimens were treated as Disinfected group, where specimens were placed in

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disinfectant, 2% glutaraldehyde (CIDEX) for 10 min and rinsed under the tap water for 30 seconds as recommended by the manufacturer [3, 34, [3, 34, 35, 36]. (figure:5).

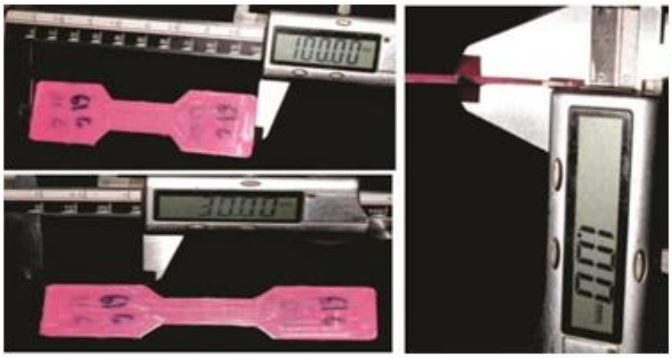

Figure 2b: Specimens Measured with vernier calliper

Figure 3: Group 1 - Vinylpolysiloxane Ether (Identium light body, kettenbach company, Germany), Group 2- Polyether (3M Impregum light body. Group 3 – Addition silicone (Zhermack hydrorise light body)

Figure 3a: Vinylpolysiloxane Ether (Identium light body, kettenbach company, Germany)

Table 1: Classification of Specimens			
GROUP (Total)	Subgroup (Total)		
	A Control	B Disinfection	C Autoclave
Group -1 (30 Specimens) Vinylpolysiloxane Ether, Light body Kettenbach,Germany	10	10	10
Group-2 (30 Specimens) Polyether 3M ESPE Impregum soft light body	10	10	10
Group -3 (30 Specimens) Addition Silicone (Zhermack Hydrorise, light body).	10	10	10

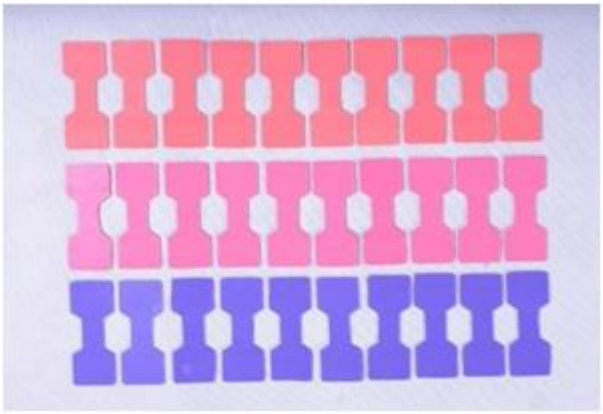

Figure 4: Specimens with Controlgroup (Sub group – A)

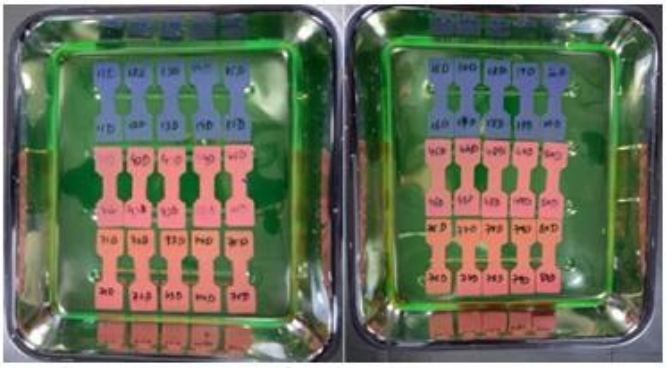

Figure 5: Specimen with Disinfection group 2% glutaraldehyde CIDEX(Subgroup-B)

Sub group-C- 30 specimens were treated as Autoclaving group, where specimens were sealed in sterilization pouches and placed in autoclaving machine (Type:- Class-B, Fomos Dental Foster Plus, European company) which underwent a standard autoclave cycle at 134°C for 30 minutes .[3,34,35,36] (as shown in figure -6,7

After experimentally procedured, all the specimens were sealed in sterilization pouches to prevent contamination from environment and transport from the dental department to the dental laboratory within 24 hours. [20].

Testing was done at TCR Advanced Engineering, Makarpura GIDC, Vadodara Gujarat. The prepared

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specimens were mounted on Universal Testing Machine by (KRUTAM Group Company, India MODEL- M10) clamping ends in the serrated jaws with tensile load of 35mm/min were applied. After the specimen had been pulled the elongation at break were measured and final guage length were calculated in millimeters.(Figure-8).All the Measurements were automatically collected in software connected with Universal Testing Machine. So that change in length (Δ L) was measured, and percentage deformation was calculated which ultimately provided the elastic recovery. Change in length (Δ L) = Final length (failure length) – Initial length. Percentage Elongation= change in length x 100% /initial length. According to Lawson in 2008 [37] Thus Elastic Recovery was calculated using the formula. Elastic Recovery (%) = 100% - Percentage Elongation .The statistical analysis was carried out using descriptive analysis (mean, SD) and results were analyzed with One Way ANOVA test and Post Hoc Tuckey Test for multiple comparison using SPSS 20 Software

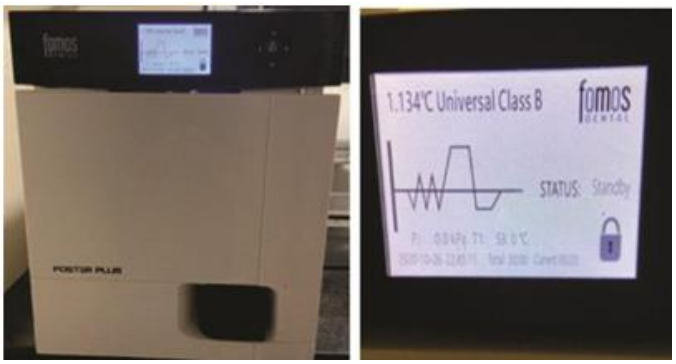

Figure 6: Fomos Dental Foster Plus Class-B, Autoclave Machine

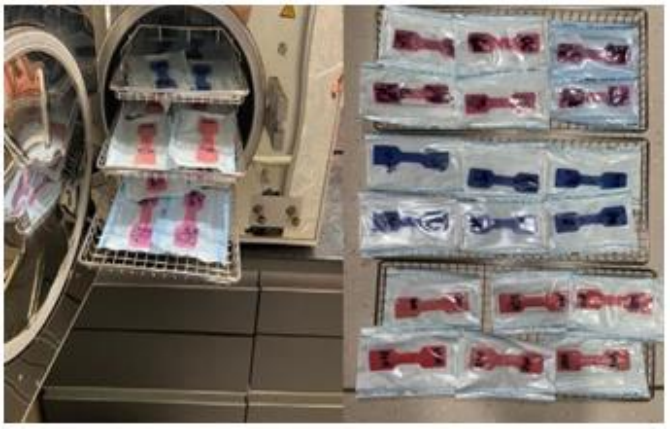

Figure 7: Specimens with Autoclaving group (Subgroup- C)

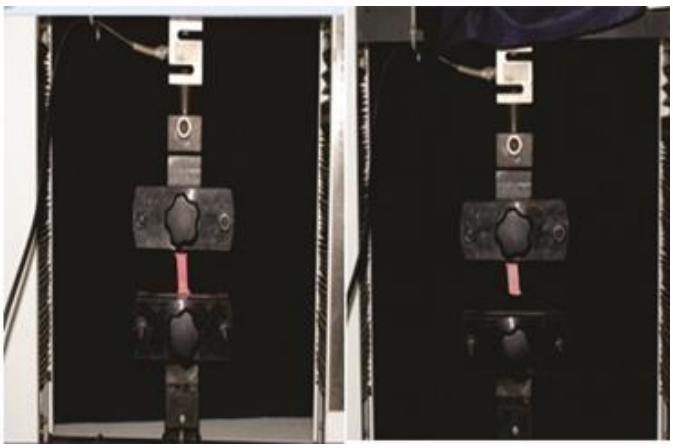

Figure 8: Specimens tested in Universal Testing Machine

Results

In the present study, all the percentage elongation values of 90 tested specimens were calculated and elastic recovery measurement values were calculated from percent elongation values(Table-2).Comparison of mean values of elastic recovery of all 3 impression material specimen were done using one-way ANOVA and further compared using Post-Hoc Tukey test, i.e for multiple comparisons.

Descriptive statistics of Elastic Recovery (Table:-3,4,5)

Oneway-ANOVA test revealed that when all three materials were compared, In control group, Identium group has the highest value, followed by Polyether and Addition Silicone. In Disinfection Group and in

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Autoclave group statistically Significant difference was observed with p value of <0.001 Posthoc Tukey tests revealed that in the control group it was NOT statistically significant. When comparison occur between Identium and Polyether group (as shown in Table 3. Graph-1). In disinfection group, comparison between Polyether and Addition it shows statistically significant with a p value of <0.001. Comparing Identium and Addition Silicone it was NOT statistically significant with a p value of 0.039. In Autoclave group, Comparison between Identium and Addition Silicone groups and between Polyether and Addition Silicone showed statistically significant with a p value of <0.001 (as shown in Table-3,4,5: Graph-1,2,3).

Descriptive statistics of Elastic Recovery (Table:- 6, 7, 8)

One way Anova test of Identium group subjected to all three treatments when compared, Autoclaving group had the highest value of 51.992 followed by disinfection group and control group which showed statistically Insignificant difference with p value of 0.098. whereas in polyether group and in Addition silicon group, statistically significant difference was observed in both the groups. In Posthoc Tukey test of Identium group, when comparison were done between Control and Disinfection group, between Control and Autoclaving group & between Disinfection and Autoclaving group showed not statistically significant. In Polyether group, between Disinfection and Autoclaving groups and in addition silicon group, between control and disinfectant group showed showed statistically significant, as shown in table 6,7,8; graph-4,5,6)

Table 2: Percentage elongation (%) & Elastic recovery (%) of all the specimens after immersion in disinfection solutions and autoclaving cycle.

Materials	Sample	% Elongation			Elastic recovery (%)		
Identium		Control	Disinfection	Autoclave	Control	Disinfection	Autoclave
	1 to 30	58	45.29	34	42	54.71	66
		42.09	53.69	51.89	57.91	46.31	48.11
		66.29	50.57	42.83	33.71	49.43	57.17
		51.34	25.83	30.49	48.66	74.17	69.51
		55.14	59.74	52.86	44.86	40.26	47.14
		51.63	56.03	55.29	48.37	43.97	44.71
		56.26	40.57	48.89	43.74	59.43	51.11
		48.69	53.06	66.83	51.31	46.94	33.17
		69.06	44.14	36.97	30.94	55.86	63.03
		74.66	53.43	60.03	25. 34	46.57	39.97
Average (%)					42.69	51.76	51.99
Polyether							

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	31 to 60	53.14	119.20	37.57	46.86	-19.2	62.43
		76.49	84	42.09	23.51	16	57.91
		62.80	82.86	45.86	37.2	17.14	54.14
		46.86	109.40	41.34	53.14	-9.4	58.66
		28.37	94	33.80	71.63	6	66.2
		131.03	105.17	38.49	-31.03	-5.17	61.51
		35.66	109.94	55.66	64.34	-9.94	44.34
		40.09	80.43	53.51	59.91	19.57	46.49
		122.86	73	32.09	-22.86	27	67.91
		34.83	93.43	40.97	65.17	6.57	59.03
Average (%)					36.9	4.86	57.86
PVS							
	61 to 90	119.37	53.43	99.69	-19.37	46.57	0.31
		67.63	34	73.80	32.37	66	26.2
		113.54	35.46	101.97	-13.54	64.54	-1.97
		128.51	43.80	88.51	-28.51	56.2	11.49
		129.97	34	90.80	-29.97	66	9.2
		116.57	44.91	99.03	-16.57	55.09	0.97
		137.57	39.06	101.03	-37.57	60.94	-1.03
		90.23	31.09	98.77	9.77	68.91	1.23
		130.60	33.20	122.06	-30.6	66.8	-22.06
		92	39.83	113.69	8	60.17	-13.69
Average (%)					-12.6	61.12	1.07

Table 3: Descriptive statistics of Elastic Recovery of Identium, Polyether, Addition Silicone(%) of control group

Group	N	Mean	SD	One Way ANOVA		Posthoc Tukey Test		
				F value	P value	Identium vs Polyether diffrence.(p value)	Identium vs PVS diff.(p value)	Polyether vs PVS difference (p value)
Identium	10	42.68	42.68±10	9.304*	0.002	5.78 (0.867)	55.29 (<0.001)	49.5 (<0.001)
Polyether	10	36.9	36.9±36.3					
PVS	10	-12.6	-12.6±22.39					

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Table 4: Descriptive statistics of Elastic Recovery of Identium, Polyether, Addition Silicone on Disinfection group								
Identium	10	51.77	51.77±9.8	54.49	<0.001	46.91(<0.001)	-9.36 (0.039)	-56.27(<0.001)
Polyether	10	4.86	4.86±15.23					
PVS	10	61.12	61.12±6.88					
Table 5: Descriptive statistics of Elastic Recovery of Identium, Polyether, PVS of Autoclaving group								
Identium	10	51.99	51.99±11.75	78.669	<0.001	-5.87 (0.385)	50.93 (<0.001)	56.8 (<0.001)
Polyether	10	57.86	57.86±7.69					
PVS	10	1.07	1.07±13.22					

Table 6: Descriptive statistics of Elastic Recovery of IDENTIUM Group								
GROUP	N	Mean	SD	One Way ANOVA		POSTHOC TUKEY TEST		
				F value	P value	Control vs Disinfection difference (p value)	Control vs Autoclaving difference (pvalue)	Disinfection vs Autoclaving difference (p value)
Control	10	42.68	42.68±10	2.531	0.098	-9.08 (0.151)	-9.31 (0.139)	-0.23 (0.999)
Disinfection	10	51.76	51.77±9.8					
Autoclave	10	51.99	51.99±11.75					
Table 7: Descriptive statistics of Elastic Recovery of POLYETHER Group								
Control	10	36.79	36.79±36.54	46.518*	<0.001	32.05 (0.012)	-20.96 (0.126)	-53.01 (<0.001)
Disinfection	10	4.86	4.86±15.23					
Autoclave	10	57.86	57.86±7.69					
Table 8: Descriptive statistics of Elastic Recovery of ADDITION SILCONE Group								
Control	10	-12.6	-12.6±22.39	10.817*	<0.001	-73.72(<0.001)	-13.67 (0.14)	-13.67 (0.14)
Disinfection	10	61.12	61.12±6.88					
Autoclave	10	1.07	1.07±13.22					

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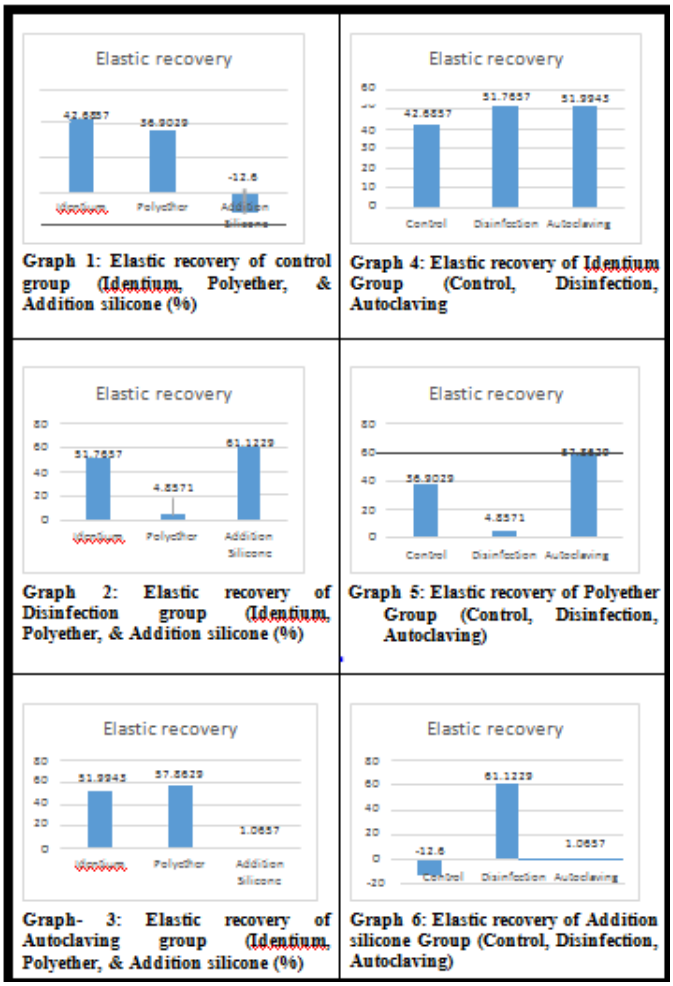

Graph 1: Elastic recovery of control group (Identium, Polyether, & Addition silicone (%)

Graph 4: Elastic recovery of Identium Group (Control, Disinfection, Autoclaving

Graph 2: Elastic recovery of Disinfection group (Identium, Polyether, & Addition silicone (%)

Graph 5: Elastic recovery of Polyether Group (Control, Disinfection, Autoclaving)

Graph- 3: Elastic recovery of Autoclaving group (Identium, Polyether, & Addition silicone (%)

Graph 6: Elastic recovery of Addition silicone Group (Control, Disinfection, Autoclaving)

Discussion

The increasing risk of cross infection through dental impressions has been a topic of interest from many years.[6] Various microorganisms such as alpha-hemolytic streptococci, Candida albicans, E-coli, Enterococci feacalis, Staphylococci aureus, Staphylococci albus can transmit through impressions. Therefore a standard infection control protocol such as disinfection and sterilization of impressions is recommended to protect the clinicians and laboratory technicians from infectious diseases [3,9].

The mechanical properties of elastomeric impression materials should remain unchanged even after disinfection and autoclaving. Rios et al (1996) did not detect any dimensional changes in polyethers and addition silicone disinfected by immersion in chlorine compounds, 2% neutral glutaraldehyde, 3.5% neutral glutaraldehyde.[16] A study were conducted by Gothwani et al [3] (2019) on the elastic recovery of Elastomeric impression where Affinix showed least elastic recovery compared to Speedex and Aquasil when untreated. Upon chemical disinfection, elastic recovery of AFFINIS displayed the best results & on steam autoclaving, Affinix showed a remarkable improvement in elastic recovery. Another study was conducted by Khan et al (2015) where he concluded that autoclave sterilization of vinylsiloxane ether can be suggested without any adverse effects on dimensional stability and accuracy.[27].

In the present study, in subgroup-A (control group) group-1 (vinylsiloxane ether) showed highest elastic recovery of 42.69%, followed by group- 2 (polyether) 36.9% and then group-3 (addition silicone) showed -12.6%. These result were in accordance with the study of Pandey et al (2019)[45] who concluded that a newer vinylsiloxane ether showed good elastic recovery, preferred in undercut areas & impressions can removed without tear and distortion.

In subgroup-B (disinfection group) group-1 (vinylsiloxane ether) displayed elastic recovery of 51.76%, then group-3 (addition silicone) displayed elastic recovery of 61.12%, whereas greatest dimensional changes seen in group-2 (polyether) i.e 4.86%. This result were in accordance with Nassar U et al [28] 2017 & Sirisha G et al [29] (2019) who concluded that PVS impressions showed dimensional change of -0.0270mm, Polyether impressions showed 0.0680 mm, whereas Vinyl polysiloxane ether showed 0.0350mm. The results indicated that addition silicone impressions showed excellent recovery followed by vinylsiloxane ether and then polyether. The possible reason is due to the chemical structures containing functional group in

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polyether interact with water molecules and expansion occurs. Thus, the elastic recovery of polyether impression materials get decreased. The impressions of VSE also showed expansion on disinfection this might be due to hydrophilic nature of polyether (PE) compound of vinylsiloxane ether (VSE) might absorbed water from the surrounding environment and led to expansion[21].

In subgroup-C (autoclaving group) there is slight increase in the elastic recovery of group-1 (vinylsiloxane ether,) i.e.,51.99%, group-2 (polyether) showed elastic recovery i.e 57.86%, where greatest dimensional changes seen in group-3 (addition silicone) of 1.07 %. This might be due to the loss of chemical constituents from the elastomers and shrinkage occurs when subjected to high temperature of autoclave[27]. This study were accordance with study done by Ramakrishnaiah et al, (2012)[44] showed that polyvinyl siloxane showed a contraction after autoclave sterilization due to the loss of chemical constituents from the elastomers. A study by Khan et al (2015)[27] in his study concluded that autoclave sterilization of vinylsiloxane ether can be suggested without affecting dimensional stability. Hence autoclave sterilization of vinylsiloxanether can be suggested without having any adverse effects on dimensional stability and accuracy[27]. The present study showed that there is statistical significant difference occurred between the groups and showed variations in elastic recovery therefore the null hypothesis were rejected. The Limitations of the present study such as the specimens of elastomeric impression materials were tested with only immersion in glutaraldehyde disinfectant and not tested with other type of disinfectant solutions. Another limitation that the specimens were not tested for longer duration for 2 days and 1week. Another limitation that the only one property (elastic recovery) of elastomeric impression materials were studied, properties like wettability, tear strength were not studied.

Conclusion

Within the limitations of this in vitro study, the following conclusions were drawn. In control group, Vinylpolysiloxane ether (Identium) showed the excellent elastic recovery compared to addition silicon and polyether. In chemical disinfection group, addition silicone (Zhermack hydrorise) showed better elastic recovery followed by vinylpolysiloxane ether (Identium) whereas polyether (3M, Impregum) showed least elastic recovery. In steam autoclaving group, polyether (3M, Impregum) showed better elastic recovery followed by vinylpolysiloxane ether (Identium) where addition silicone (Zhermack hydrorise) showed least elastic recovery. Comparatively, all over vinylsiloxane ether, (Identium) proves better material and showed good elastic recovery after chemical disinfection and autoclaving. Hence, these newer elastomeric impression materials can be disinfected & safely autoclaved with good elastic recovery from a clinical point of view.

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