AN IN VITRO STUDY TO EVALUATE THE TEAR STRENGTH OF AUTOCLAVABLE PVS, SMART WETTING PVS AND CONDENSATION SILICONE AND COMPARE THEM UPON AUTOCLAVING AND DISINFECTION.

Dental Science

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ABSTRACT

Aim: The tear strength of three different types of elastomeric impression materials was measured after disinfection and sterilization.

Material and Method: Dumb-bell shaped Tear strength specimens were prepared according to ISO 34-1 standardization. Ninety samples were prepared followed by disinfection and sterilization and tested with trouser piece method on Instron universal testing machine at a speed of 10 mm/min. One-way ANOVA, followed by Tukey post hoc test was used for statistical analysis.

Results: No significant difference was found when AFFINIS, SPEEDEX and AQUASIL were compared individually. When materials were compared with each other significant difference was present, highest AQUASIL while SPEEDEX and AFFINIS almost alike.

Conclusion: It was concluded that tear strength of AQUASIL was the highest. Disinfection and autoclaving had no significant influence on the three materials and showed adequate tear strength.

KEYWORDS

Tear strength, Disinfection, Sterilization, polyvinyl siloxane

INTRODUCTION

The basic need for a dental procedure to end or begin is making a good impression with a good impression material. Impression materials are used for the reproduction of intraoral hard and soft tissues for the formation of final prosthesis. Fabricating a precisely fitting prosthesis fully depends on an accurate impression making. These impressions are used to create gypsum models for designing and fabricating removable and fixed prostheses. Hence, to accomplish this preciseness dentists rely on impression materials on daily basis. The evolution of impression materials has received attention due to their better and evolved physical properties and ease in handling of the materials.¹

Impression making is mandatory for all dental procedure in one way or the other but it is basically an assembly of pathogens, so impressions must be autoclaved or disinfected before they are being stored and then send to the laboratory. HIV, Herpes and Hepatitis are some of the communicable viruses causing threat for dental and laboratory professionals. This cross-contamination must be stopped and proper infection control and sterilization techniques must be employed in our daily practices formed by various organizations like ADA (American Dental Association), CDC (Centers for Disease Control) and British Dental Association Advisory Service and Occupational Safety and Health Administration (OSHA).²

It is well familiar that disinfection is a kill microorganism and not the spores. So obviously sterilization is more effective in controlling cross contamination than chemical disinfection.³ As good a procedure is sterilization, but materials change their physical properties upon autoclaving due to lack of high temperature threshold.⁴

Polyvinyl siloxanes are reported to have ideal elastic properties, because many studies have been conducted so far to prove that they have good elastic recovery and resistance to deformation.⁵ Tear strength is a very important parameter which represents that the poured impressions can be retrieved from the cast without fracturing the model and also without distorting the impression, so that the same impression can be used more than once.⁶

Polyvinyl siloxane is the impression material which can withstand the sterilization procedure and yet can produce an accurate cast. Steam autoclaving is the most commonly used technique for sterilization which followed by most of the hospitals and the dental clinics. A survey revealed that 50% of the dentists used steam autoclaving for their impressions.^{7,8}

Nowadays, autoclavable impression materials are prevalent in market, and they show no change in their dimensional stability due to resistance to distortion even in high temperature environment during sterilization procedure.

The latest advancement added to the bag of elastomeric impression materials classification with quadrafunctional hydrophilic property are an excellent blend of a cross-linked polymer plus a surface active element. These materials have wettability equivalent to polyether impression materials. This exceptional improvement of PVS helps to achieve brilliant surface details even in moist environment. These quadrafunctionally modified PVS compromises of very high tear strength property showed by no other impression material until now.⁹

Taking into account all the evidences collected, we designed a study to compare the tear strength of three elastomeric impression materials upon autoclaving and chemical disinfection. The goal of the present dissertation is to accomplish the effect of disinfection and steam autoclaving on the tear strength of three different elastomeric impression materials. The Null Hypothesis was that, there will be no effect on tear strength of the materials when they are chemically disinfected and steam autoclaved.

MATERIAL AND METHODS

S. No	Material	Manufacturer	Batch
1.	AFFINIS, (light body consistency) addition cured PVS impression material.	AFFINIS, Coltene/ Whaledent Pvt. Ltd., 9450 Alstalten, Switzerland	H80440
2.	SPEEDEX, (light body consistency) condensation cured silicone impression material.	SPEEDEX , Coltene/ Whaledent Pvt. Ltd., 9450 Alstalten, Switzerland	H44:41
3.	AQUASIL, (light body consistency) addition cured PVS impression material.	AQUASIL ((Dentsply (Australia) Pty Ltd)	IN2139356
4.	SURFASEPT S.A, (aldehyde free disinfectant solution, containing isopropyl alcohol-70% w/w and chlorhexidine gluconate-2.5% w/w	SURFASEPT S.A (Septodont Healthcare India PVT. LTD.	

Tear strength of AFFINIS, SPEEDEX and AQUASIL was measured by treatment of these materials with the help of immersion disinfection and steam autoclaving (Figure 1)

Figure 1- Three elastomeric impression materials used for tear strength measurement

An aluminium metal die was created which was made of two parts, upper member and a lower member. The lower member was cut into a recess of dimensions of A- 10 cm, B- 4 cm, C- 3 cm, D- 3 cm. It also consisted of two holes which acted as vertical stops and also help guide the upper member to seat on the lower member. Escape holes were generated for free flow of excess material, so that a constant thickness of the specimens can be achieved. (Fig 2 a)

Figure 2 (a)- Aluminium metal die cut into a recess of dimensions of A- 10 cm, B- 4 cm, C- 3 cm, D- 3 cm

The dumb-bell shaped specimens with a nick at one end were fabricated to measure tear strength according to ISO 34-1 standardization. This specimen is preferred for 'trouser- piece' method for the easy grip in the claps of Instron Universal Testing machine, and a nick is created at one end of the specimen so as to confirm parallel tear propagation along the length of the specimen.¹⁰

Hence, 30 specimens were prepared from each elastomeric impression material for measuring the tear strength. Firstly, impression material was loaded on recess of lower member and then it was covered with upper member of the metal die. The excess material flooded out of escape vents and a 1 mm thick specimen was formed (Fig 3,4).

Figure 3- loading the elastomeric impression material over the recess of metal die

Figure 4- retrieved specimen after setting of elastomeric impression material

A whole of 90 samples were fabricated, out of which each elastomeric impression material consist of 30 samples. These samples were than distributed into three groups the control group, the disinfection group and the sterilization group. These groups were again sub-divided into 3 groups of AFFINIS, SPEEDEX and AQUASIL. (Fig 5)

Figure 5- Prepared specimens for measuring tear strength

The sterilization group specimens were set to undergo a standard autoclave cycle of 134°C for 30 minutes which included a complete treatment i.e. autoclaving and drying of specimen. After the sterilization cycle all the samples were collected and sealed in a zip lock bag. The samples were stored for 24 hour time period before sending them to lab for testing. This was done to mimic the time between shipping of impression from the clinic to the dental lab (Fig 6). Remaining samples were immersed in a chemical disinfectant for 10 minutes, as per manufacturer's instructions and then washed under tap water (Fig 7).

Figure 6- Sterilization of specimen undergo at standard autoclave cycle of 134°C for 30 minutes

Figure 7- Immersion disinfection with chemical disinfectant

The tear strength measurement was done with the help "trouser-piece" method. In this technique the opposing sides of nick were clamped into the claws of the Instron universal testing machine which was adjusted to move at a constant speed rate of 10 mm per minute. Hence, a tear was initiated by moving these clamps in opposite direction. The maximum standardized force used to initiate a tear was measured and maintained electronically (Fig 8). Therefore, the tear strength was measured by the force required to start the tear divided by the specimen thickness.

$$\text{Tear strength} = \frac{\text{Force (Newton)}}{\text{Thickness (Millimete r)}}$$

Figure 8- Tear strength specimen mounted over Instron Universal testing machine

Statistical analysis was done by entering data in Microsoft Office Excel and Mini Tab Version 18 (Headquartered in State College, Pa., Minitab, LLC. operates offices in Phoenix, Arizona, Chicago). One-way analysis of variance (ANOVA) and Tukey Method was used to test for statistically significant differences i.e. p value of <0.05 within the groups and also across the groups.

Tear Strength Table

Table 1: Descriptive Statistics of Tear Strength of AFFINIS (MPa)				
Group	N	Mean	Std. Deviation	'p' Value
1A	10	0.2315	0.0946	>.05
2A	10	0.2831	0.1115	
3A	10	0.3212	0.0968	
Table 2: Descriptive Statistics of Tear Strength of SPEEDEX (MPa)				
Group	N	Mean	Std. Deviation	'p' Value
1B	10	0.3288	0.1204	> .05
2B	10	0.2768	0.2063	
3B	10	0.2950	0.1243	
Table 3: Descriptive Statistics of Tear Strength of AQUASIL (MPa)				
Group	N	Mean	Std. Deviation	'p' Value
1C	10	0.4466	0.0903	> .05
2C	10	0.5527	0.1967	
3C	10	0.4566	0.2401	
Table 4: Descriptive Statistics of Tear Strength of AFFINIS, SPEEDEX and AQUASIL (MPa)				
Group	N	Mean	Std. Deviation	'p' Value
1A	10	0.2315	0.0946	<.05
1B	10	0.3288	0.1204	
1C	10	0.4466	0.0903	
Table 5: Tukey Pairwise Comparisons Grouping Information Using the Tukey Method and 95% Confidence				
Factor	N	Mean	Grouping	
1A	10	0.2315	*	
1B	10	0.3288		
1C	10	0.4466		
Table 6: Descriptive Statistics of Tear Strength of AFFINIS, SPEEDEX and AQUASIL upon Disinfection (MPa)				
Group	N	Mean	Std. Deviation	'p' Value
2A	10	0.2831	0.1115	<.05
2B	10	0.2768	0.2063	
2C	10	0.5527	0.1967	
Table 7: Tukey Pairwise Comparisons Grouping Information Using the Tukey Method and 95% Confidence				
Factor	N	Mean	Grouping	
2A	10	0.2831		
2B	10	0.2768		
2C	10	0.5527		
3C	10	0.4566	*	

Table 8: Descriptive Statistics of Tear Strength of AFFINIS, SPEEDEX and AQUASIL upon Sterilization (MPa)

Group	N	Mean	Std. Deviation	'p' Value
3A	10	0.3212	0.0968	<.05
3B	10	0.2950	0.1243	
3C	10	0.4566	0.2401	

Table 9: Tukey Pairwise Comparisons Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping	
3A	10	0.3212		
3B	10	0.2950		

RESULT

When Tear strength of AFFINIS, SPEEDEX and AQUASIL upon disinfection, sterilization and untreated specimens was compared individually:

The mean tear strength values of all three test specimens of three different impression materials are shown in table 1, 2, 3 and Graph I, II, III. There was no significant difference found in mean values of all the three groups of AFFINIS, SPEEDEX and AQUASIL impression materials, whether they are disinfected or sterilized on using One Way ANOVA and Tukey test.

When Tear strength of control groups of AFFINIS, SPEEDEX and AQUASIL compared among each other:-

Table 4, 5 and graph IV revealed a significant difference in the mean values of tear strength, when the untreated specimens of AFFINIS, SPEEDEX and AQUASIL were compared among each other using One Way ANOVA test and Tukey test. It was discovered that AQUASIL had highest tear strength among the three followed by SPEEDEX and AFFINIS.

Effect of disinfection on the Tear strength of AFFINIS, SPEEDEX and AQUASIL when the specimens were compared among each other:-

Table 6, 7 and graph V shows mean tear strength values of AFFINIS, SPEEDEX and AQUASIL upon disinfection. The three disinfected test material specimen were compared using One Way ANOVA test and Tukey test and found that there was a significant difference found in the mean values of the three impression materials. It was evaluated that AQUASIL showed highest tear strength while AFFINIS and SPEEDEX showed equal tear strength mean values.

Effect of sterilization on the Tear strength of AFFINIS, SPEEDEX and AQUASIL specimens, when they were compared among each other:-

Table 8, 9 and graph VI shows a significant difference in the mean values of tear strength of AFFINIS, SPEEDEX and AQUASIL. One Way ANOVA test and Tukey Test found that AQUASIL had highest tear strength followed by AFFINIS and then SPEEDEX.

DISCUSSION

A good impression is a basic requisite to initiate or finish a dental procedure. Whether it be a diagnostic impression which is used to decide the treatment plan for a patient, or a preliminary and final impression for fabrication of fixed or removable prosthesis, each and every step is significant. But these impressions have been proved highly infectious and are loaded with millions of pathogens. These impressions are prime cause for transmission of the pathogens from clinician to the dental laboratory professionals. Nowadays elastomeric impression materials have evolved to such an extent that they can be disinfected as well as sterilized without losing their physical properties.

In 1998 **Mandikos** stated that the impression materials of lower viscosity showed more changes due to low filler content and difference in the molecular weights of polysiloxanes already present. Hence, this study revealed that impression materials with lower viscosity did not show adverse effect on materials dimensional stability¹¹

Earlier in 2007 **Ahmad** experimented to see the change in dimensional stability of addition silicones. The material was immersed in aldehyde free disinfectant for 10 minutes. It was observed that addition cured silicone showed no change in dimensional stability during the disinfection procedure.¹²

Recently, autoclavable and Quadra-functionally modified elastomeric impression materials were launched in market. The composition and the mode of action of autoclavable impression material was not revealed by the manufacturers due to company policy, but they claimed that the impression material can withstand high temperatures such as 134°C for 18-20 minutes, without any change in physical properties of the impression material.⁴

On the other hand, the Quadra functionally modified impression materials showed hydrophilic property which was due to its immense cross-linked polymerized structure with a surface active agent. The polymer chains are accountable for excellent tear strength due to its cross-linked configuration. The surfactant is responsible for excellent wettability which is equivalent to polyether elastomeric impression material. Hence, they are proved to be a perfect combination of polyether due to excellent wettability and PVS due to good dimensional accuracy and high resistance to deformation. Most importantly they have proven to show highest tear strength even after disinfection and sterilization.⁹

Polyvinyl siloxanes distort at a much slower rate and tear at a point of less permanent deformation when compared to other elastomeric impression materials. Ideal tear strength range from 1.5–4.3 KN/m² for silicone impression materials range from.⁶ Tear strength is a very essential aspect for defining the quality of an impression material. The more resilient impression rubber will ensure higher success rate which will in turn lead to a better impression in one go with reduced patients discomfort and ability to pour an impression more than once.^{13,14}

The impressions made must resist tear upon force application during removal of impression intra-orally or retrieval from the gypsum model. The tear prone areas gingival crevices and interproximal areas where fragments of impression materials get stuck which affects the precision of the final prosthesis also inflammatory reactions intraorally.¹⁵ Impression material are shown penetrate a crevice upto 0.05 mm in vitro. In this study, imm thick specimens were fabricated in order to simulate the tear process of a light body materials, as these materials tend to get a tear at thin portions of inter-proximal and crevicular regions.^{16,17}

On analyzing the tear strength of each individual impression material using One Way ANOVA and Tukey test there was no significant difference found in mean values of AFFINIS, SPEEDEX and AQUASIL impression materials upon disinfection and steam autoclaving. Tear strength of AFFINIS, SPEEDEX and AQUASIL upon disinfection were compared, and found that there was significant increase in tear strength of AQUASIL when compared to AFFINIS and SPEEDEX. However, tear strength of AFFINIS and SPEEDEX upon disinfection were alike. On analyzing the tear strength of the three impression materials upon steam autoclaving a significant difference in mean values of tear strength of AFFINIS, SPEEDEX and AQUASIL was found. AQUASIL shows highest tear strength followed by AFFINIS and then SPEEDEX.

This study illustrates that the three elastomeric impression materials experimented can tolerate higher temperature of sterilization without any significant effect on their tear strength. Hence, these impression materials can be used upon disinfection and sterilization by clinicians in their daily practices without the risk of change their physical properties.

CONCLUSION

Within the boundaries of this in vitro study, the conclusions were:

1. AQUASIL showed highest tear strength upon comparison with AFFINIS and SPEEDEX, when the three elastomeric impression materials were untreated.
2. Tear strength of AQUASIL impression materials was highest followed by AFFINIS and SPEEDEX upon chemical disinfection.
3. AQUASIL also showed highest tear strength followed by AFFINIS and SPEEDEX upon steam autoclaving.
4. Individually, disinfection and autoclaving did not have a significant effect on tear strength of all the three materials.

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