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Comparative Evaluation of Dimensional Accuracy of Autoclavable Polyvinyl Siloxane Impression Material Using Different Methods of Sterilization: An in-Vitro Study

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Abstract:-
Background: Impression making is one of the most common procedures that are performed by dentists in day-to-day practice. These impressions can act as vehicles of transmission and carry various types of microorganisms, and with the advent of pandemic like COVID 19 and its striking variants in future, an attempt was made to compare and evaluate the dimensional accuracy of recently introduced autoclavable polyvinyl siloxane impression material upon chemical disinfection and steam autoclaving.

Materials and methods: A comparative in- vitro study was conducted in which three groups were made for testing dimensional accuracy. The sample size for the study was kept 45 (15 samples in each group), test samples were made by making impression using two-step double-mix technique on the prepared three-unit bridge on the typhodont model. Statistical analysis was done using one way analysis of variance (ANOVA), independent t-test, the Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables.

Results: The mean linear distance between the two margins was as follows: Bucally: 1.7064 (Group I), 1.6850 (Group II) and 1.7039 (Group III), with mrv of 1.71 (master cast). Mesio-distally: 0.6224 (Group I), 0.6197 (Group II) and 0.6182 (Group III), mrv of 0.621(master cast). Lingually: 1.4661 (Group I), 1.4677 (Group II) and 1.4582 (Group III), with mrv of 1.470 (master cast). The difference between the calculated value and master model value was statistically significant in each group. Conclusion Within the limitations of this study, the use of this impression material may have future scope in the area of eliminating the cross infection in dental clinics and to have improved in the accuracy of the prosthesis. To improve the scope further in-vivo and in-vitro studies are required to evaluate the physical properties of this material as adequate so that it can be widely accepted in clinical practice.

Keywords:- *autoclavable polyvinyl siloxane impression material, dimensional accuracy, sterilization, disinfection, impression making.*

I. INTRODUCTION

Impression making is the most common step that is performed by dentists in day-to-day practice.These impressions can function as vehicles of transmission and carry different types of microbes. The dental profession has been studied as a model for occupation risk for human immune deficiency virus (HIV) infection because their risk of infection is very high. Infections may be transmitted in the dental office and laboratory through direct contact with blood, saliva, and other secretions of oral cavity, indirect contact with clinical equipment, or environmental surfaces, and in contact with aerosol when using air/water sprays or high speed or ultrasonic equipment. (1)

The primary possible routes of infection transmission from the patient to dental clinician is through contaminated impressions, casts and prosthesis. With the advent of pandemic COVID –19 and its unanticipated variants in future, it has become an absolute mandate to disinfect the impressions before pouring them or sending them to the laboratory. The American Dental Association (ADA) recommends immediate disinfection of dental impressions immediately after removing from the patient's mouth to prevent cross-infection between the patients and dental staff in dental offices and laboratories. The most commonly used method for sterilisation of dental impressions in clinics and hospitals is the chemical method, carried out by immersion in or spraying with a disinfectant. The most commonly used chemical disinfectant sareglutaraldehyde and sodium hypochlorite. This procedure is effective against organisms in vegetative forms but not bacterial spores. However, these procedures may guarantee only disinfection and not sterilization.

Physical disinfection methods act by increasing temperature and include autoclave, microwave irradiation, and UV light disinfection. The steam autoclave sterilization is stated to be efficient in controlling the cross-infection and contamination by dreaded microorganisms. When disinfecting impressions, its antibacterial efficiency and its effect on the dimensional stability of impression materials are important.(2)

Sterilization of impressions by standard method may also affect the physicalproperties of the impression materials.Water imbibingmaterials do not confer themselves to prolonged immersion,nor can be sterilized by autoclaving and other high temperature methods, since their physical properties andlinear dimensions can be affected by such procedures.(2)

Dental impression is a negative record of orofacial structures. Accuracy of impression is dependent on dimensional stability of impression material, and influenced by a number of factors such as impression technique, impression tray and properties of the impression materials. An accurate impression is an important step in processing and final fitting of dental prosthesis.(3)

Autoclaving is regarded to be the mosteffective method of sterilization however, the accuracy of the polyvinyl siloxane elastomeric impression material after autoclaving have not been considerably studied.

The purpose of this study is to compare and evaluatethe dimensional accuracy of newly introduced autoclavable polyvinyl siloxane impression materialusing chemical method and steam autoclaving at two different temperatures.

With the introduction of new materials and technologies to deal with hygiene and infection control, a polyvinyl siloxane impression material has been developed having potential of steam autoclaving.Dimensionally stable autoclavable impressions will be efficient in managing the cross-infection and contamination caused by patient's saliva and other oral secretions.(4)

For a dentist it is very important to select an acceptable impression technique using suitable materials to get a model as accurate as possible. Therefore, it is important to understand the properties of various impression materials and their effect when used with different impression techniques. There are several impression techniques developed to produce impressions as accurate as possible.(5)

Autoclavable polyvinyl siloxane impression material allows steam autoclaving upto 134 degreecelcius.

II. METHODOLOGY

A cross-sectional, comparative, in-vitro study was conducted at the Department of Prosthodontics, Government College of Dentistry, Indore(2021-2022).Three groups were formed for testing different sterilization methods. A total no. of 45 samples were prepared as 15 for each group.

- Group (I): Impressions to bed is infected by immersing in 2% glutaraldehyde (control group).
- Group (II): Impressions to be autoclaved at 121 degree Celsius.
- Group (III): Impressions to be autoclaved at 134degreeCelsius.

A. Method of data collection

Tooth preparation for 3-unit bridge was done on fourth quadrant of mandibular typhodont. Impressions were made on this preparation using Coltene Affin is autoclavable poly vinylsiloxane impression material, using two step-double mix technique.

B. Testing procedure

➤ *Treatment of samples*

15 impressions of group (I)i.e., control group were immerse din 2% glutaraldehyde solutionfor10 minutes. Immersion is the most reliable method because all surfaces of the impression and tray will come into contact with the disinfectant solution.Impressions of group (II) were autoclaved at 121 degrees Celsius for 15 minutesat110kPa. Impressions of group (III) were autoclaved at 134 degrees Celsius for 3 minutes at 210kPa. After 24 hours, all impressions were sprayed with Debubblizer and poured using type IV die stone.

C. Measurement procedure

Scanning for all the 45 casts was done at DIGI DENT LAB, Indore using extra oral scanner (Identicablue). After scanning the STL files were sent for 3D Printing. 3D Printing was doneat ADVANCED MANUFACTURING AND DESIGN. Nylon 6 resin material was used for 3D printing. All the 45 3D printed models were then compared with the master model for change in the linear dimensional accuracy of the autoclavable poly vinylsiloxane impression material using CMM (Coordinated measuring machine), which was done at ZENITH INDUSTRIAL AUTOMATION AND BENCHMARKING SOLUTIONS LLP.

III. RESULT

To calculate dimensional accuracy following recordings were done

- Measurements on the Reference model
- Measurements of the linear dimensional changes in group (I)
- Measurements of the linear dimensional changes in group (II)
- Measurements of the linear dimensional changes in group (III)

	D	LINEAR DISPLACEMENT
	D1 (A1-A2)	MEASUREMENT OF LINEAR DISTANCE BETWEEN THE TWO MARGINS BUCALLY
	D2 (B1-B2)	MEASUREMENT OF LINEAR DISTANCE BETWEEN THE TWO MARGINS MESIO-DISTALLY
	D3 (C1-C2)	MEASUREMENT OF LINEAR DISTANCE BETWEEN THE TWO MARGINS LINGUALLY
	δ (DIFFERENCE)	(LINEAR DISPLACEMENT OF MASTER MODEL) – (LINEAR DISPLACEMENT OF 3D PRINTED MODEL)
	δ1	(D1 MEASURED ON MASTER MODEL) – (D1 MEASURED ON 3D PRINTED MODEL)
	δ2	(D2 MEASURED ON MASTER MODEL) – (D2 MEASURED ON 3D PRINTED MODEL)
	δ3	(D3 MEASURED ON MASTER MODEL) – (D3 MEASURED ON 3D PRINTED MODEL)

The data for the current study was entered in the Microsoft Excel 2007 and examined using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation. The level of the significance for the present study was fixed at 5%.The intergroup comparison for the difference of mean scores between independent groups was done using the One Way ANOVA and independent t test.

The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the uniformity of the variables. The data were found to be uniform and normally distributed. Mean and standard deviation (SD) were calculated for each variable.

Independent t-Test can be used to determine if two sets of data are significantly different from each other, and is most commonly applied when the test statistic would follow a normal distribution. The independent t-test samples are used when two separate sets of independent and identically distributed samples are obtained, one from each of the two samples being compared.

Measurement of the linear displacement		Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value
D1	Group I	1.7064	.00283	.00073	1.70	1.71	0.001 (Sig)
	Group II	1.6850	.00483	.00125	1.68	1.69	
	Group III	1.7039	.00584	.00151	1.69	1.71	
D2	Group I	.6224	.00121	.00031	.62	.62	0.001 (Sig)
	Group II	.6197	.00135	.00035	.62	.62	
	Group III	.6182	.00174	.00045	.62	.62	
D3	Group I	1.4661	.00353	.00091	1.46	1.47	0.001 (Sig)
	Group II	1.4677	.00179	.00046	1.46	1.47	
	Group III	1.4582	.00664	.00172	1.45	1.47	

Table 1: Intergroup Comparison of Linear Displacement

Measurement of the linear displacement		Mean	SD	Std Error	Mean Diff	P value
D1	Group I	1.7064	.00283	.00073	0.021	0.001 (Sig)
	Group II	1.6850	.00483	.00125		
D2	Group I	.6224	.00121	.00031	0.002	0.001 (Sig)
	Group II	.6197	.00135	.00035		
D3	Group I	1.4661	.00353	.00091	0.001	0.322 (Non-Sig)
	Group II	1.4677	.00179	.00046		

Table 2: Intergroup Comparison of Linear Displacement in Group I and Group II

Measurement of the linear displacement		Mean	SD	Std Error	Mean Diff	P value
D1	Group II	1.6850	.00483	.00125	0.018	0.001 (Sig)
	Group III	1.7039	.00584	.00151		
D2	Group II	.6197	.00135	.00035	0.002	0.001 (Sig)
	Group III	.6182	.00174	.00045		
D3	Group II	1.4677	.00179	.00046	0.009	0.001 (Sig)
	Group III	1.4582	.00664	.00172		

Table 3: Intergroup Comparison of Linear Displacement in Group II And Group III

Measurement of the linear displacement		Mean	SD	Std Error	Mean Diff	P value
D1	Group I	1.7064	.00283	.00073	0.001	0.154 (Non-Sig)
	Group III	1.7039	.00584	.00151		
D2	Group I	.6224	.00121	.00031	0.004	0.001 (Sig)
	Group III	.6182	.00174	.00045		
D3	Group I	1.4661	.00353	.00091	0.007	0.001 (Sig)
	Group III	1.4582	.00664	.00172		

Table 4: Intergroup Comparison Of Linear Displacement In Group I And Group III

Measurement of the linear displacement		Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value
D1	Group I	.0071	.00362	.00094	.00	.01	0.001 (Sig)
	Group II	.0254	.00512	.00132	.02	.03	
	Group III	.0085	.00522	.00135	.00	.02	
D2	Group I	-.0004	.00135	.00035	.00	.00	0.001 (Sig)
	Group II	.0022	.00125	.00032	.00	.00	
	Group III	.0035	.00170	.00044	.00	.01	
D3	Group I	.0061	.00420	.00108	.00	.01	0.001 (Sig)
	Group II	.0027	.00205	.00053	.00	.01	
	Group III	.0120	.00679	.00175	.00	.02	

Table 5: Intergroup Comparison of Linear Displacement

Measurement of the linear displacement		Mean	SD	Std Error	Mean Diff	P value
D1	Group I	.0071	.00362	.00094	0.018	0.001 (Sig)
	Group II	.0254	.00512	.00132		
D2	Group I	-.0004	.00135	.00035	0.002	0.001 (Sig)
	Group II	.0022	.00125	.00032		
D3	Group I	.0061	.00420	.00108	0.003	0.001 (Sig)
	Group II	.0027	.00205	.00053		

Table 6: Intergroup Comparison of Linear Displacement in Group I and Group II

Measurement of the linear displacement		Mean	SD	Std Error	Mean Diff	P value
D1	Group I	.0071	.00362	.00094	0.001	0.447 (Non-Sig)
	Group III	.0085	.00522	.00135		
D2	Group I	-.0004	.00135	.00035	0.003	0.001 (Sig)
	Group III	.0035	.00170	.00044		
D3	Group I	.0061	.00420	.00108	0.005	0.001 (Sig)
	Group III	.0120	.00679	.00175		

Table 7: Intergroup Comparison of Linear Displacement in Group I and Group III

Measurement of the linear displacement		Mean	SD	Std Error	Mean Diff	P value
D1	Group II	.0254	.00512	.00132	0.016	0.001 (Sig)
	Group III	.0085	.00522	.00135		
D2	Group II	.0022	.00125	.00032	0.001	0.024 (Sig)
	Group III	.0035	.00170	.00044		
D3	Group II	.0027	.00205	.00053	0.009	0.001 (Sig)
	Group III	.0120	.00679	.00175		

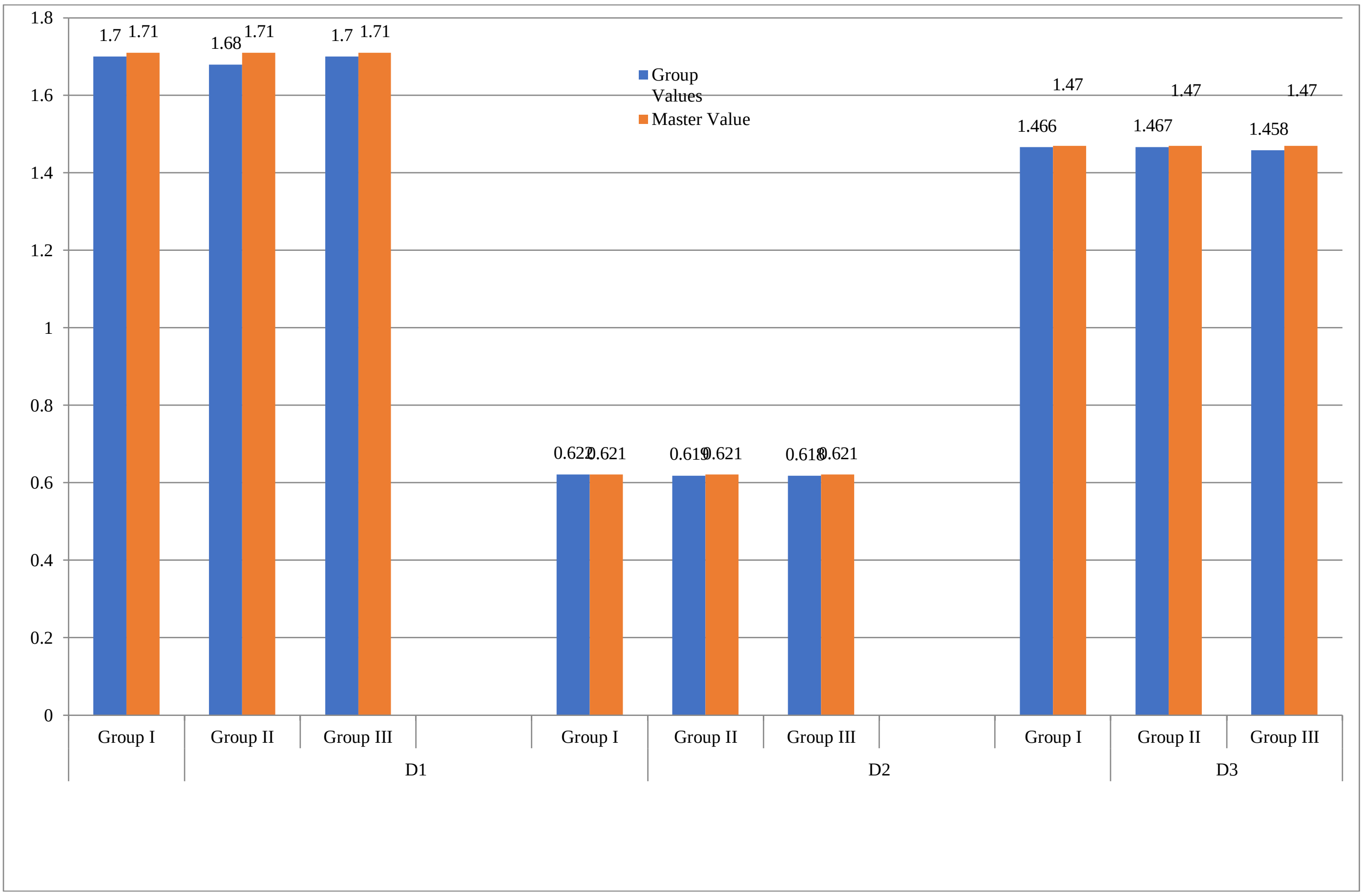
Table 8: Intergroup Comparison of Linear Displacement in Group II and Group III

comparison of linear displacement with average values		Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value
D	Group I	1.2650	.00130	.00033	1.26	1.27	0.001 (Sig)
	Group II	1.2575	.00144	.00037	1.26	1.26	
	Group III	1.2601	.00364	.00094	1.25	1.27	
						1.27	
δ	Group I	.0043	.00155	.00040	.00	.01	0.001 (Sig)
	Group II	.0101	.00149	.00038	.01	.01	
	Group III	.0080	.00388	.00100	.00	.01	

Table 9: Intergroup Comparison of Linear Displacement with Avg Value

comparison of linear displacement with reference values		Group Values	Master Value	P value	Significance
D1	Group I	1.70±0.001	1.71±0.001	0.001	Significant
	Group II	1.68±0.004	1.71±0.001	0.001	Significant
	Group III	1.70±0.005	1.71±0.001	0.001	Significant
D2	Group I	0.622±0.001	0.621±0.001	0.038	Significant
	Group II	0.619±0.001	0.621±0.001	0.001	Significant
	Group III	0.618±0.001	0.621±0.001	0.001	Significant
D3	Group I	1.466±0.003	1.470±0.003	0.008	Significant
	Group II	1.467±0.001	1.470±0.003	0.038	Significant
	Group III	1.458±0.006	1.470±0.003	0.001	Significant

Table 10: Intergroup Comparison of Linear Displacement with Reference Values



Graph 1: Bar graph showing comparison of mean linear distance between Group I, II and III with the reference model values

IV. DISCUSSION

The results of the present study were statistically analyzed and it was found that initial measurements of samples in all the 3 groups were statistically and significantly different. It might be due to the fact that it was not possible to make all 45 impressions at the same time and then randomize them into three groups. Also with time, the material is probably to show some changes in linear measurements. To control the film thickness of the light body impression material, a 2mm vacuum-adapted thermoplastic spacer sheet was used in the study to prevent it as an influencing factor. Impression making in the clinical situation will never give totally alike impression if an impression is repeated in the same patient, therefore, this difference may not be clinically significant.

For checking the dimensional accuracy, the linear distance was measured between abutment teeth, two distance were taken on buccal margin, two on mesial and distal side of the abutment teeth and two measurements were taken on lingual margins. The distances were then compared with the measurements of the master model.

The present study was undertaken to compare and evaluate the dimensional accuracy of Autoclavable polyvinyl siloxane impression material sterilized using three different methods i.e. disinfected using 2% glutaraldehyde solution and autoclaved at two different temperatures i.e. 121 and 134 degree Celsius. A study was planned to evaluate the dimensional accuracy of the newly introduced PVS impression material upon autoclaving and comparing it to the traditional means of chemical disinfection i.e. immersion in 2% glutaraldehyde solution.

Reddy et al. in a study introduced samples to long cycle autoclaving (134°C for 18 min) and poured type IV stone casts. They suggested autoclavable PVS material for making short-span multiunit restorations rather than when planning for a complete arch fullrestorations. In comparison to the above study, interestingly from our testing, it was noted that after 24 h the autoclaved samples showed a mean length change (shrinkage) of 291 µm but this could be due to initial distinction in mean length.(2)

Tjan asserted that in an autoclaved PVS impression, a variation of approximately 50 µm was appreciable. So, if we overlook the change of length, which may have taken place due to the limitations of this study, the impression with the group I is the most satisfactory for preparing final prosthetic restorations over the casts poured at 24 h of autoclaving.(6)

Surendra et al. analyzed the effect of autoclaving on the dimensional accuracy of a PVS (Affinis) impression material showed that there was higher mean dimensional change immediately after autoclaving when compared to the other two timedurations, that is, before autoclaving and 24 h after autoclaving.(7)

Bergman et al. Group II and III impressions were poured 24 hours after steam autoclaving. It may not be desirable to pour Affinis impressions without autoclaving. This material is best autoclaved and poured after 24 hours to obtain compensatory expansion.

Jeon et al. For dimensional analysis all the 45 stone models of all the three groups were scanned using Lab scanner and the scanned file were then sent for 3D printing. (8)

Marta et al.3D printing was done as 3D printed dental models could be a good replacement for stone models as diagnostic tools and as a part of medical records.

Izadi et al.3D printed models were then checked with the master model for any dimensional changes using CMM (Coordinated measuring machine).(9)

In discussion, the results of this In- vitro study reveals that Impressions of group (I) have noticeably less linear dimensional change, The results of group (I) revealed that autoclavable PVS was dimensionally stable after disinfection with 2% glutaraldehyde solution for 10 minutes. Impressions of group (II) show more linear dimensional changes, and group (III) impressions show less changes in dimension as compared to group (II). The most acceptable values have been seen in glutaraldehyde group (I). Further in-vivo and in-vitro studies are required to prove the physical properties of this material as adequate so that it can be widely accepted in clinical practice. Sterilization, compared with disinfection, is a preferable technique for infection control. Polyvinylsiloxane impression materials are the only materials currently available that may tolerate the procedures necessary for sterilization and still produce accurate casts. This study subjects an Autoclavable polyvinylsiloxane impression material. Sterilization is done using a Runyes type B autoclave. The aim of this study is to evaluate the effect of steam autoclave sterilization due to the influence of Covid-19 on the accuracy of the impression materials. Sterilization is best accomplished using a steam autoclave sterilization, which takes shorter period and is more dependable than chemical disinfection. Though disinfecting impressions is common practice, steam sterilization of the elastomer impression materials is an efficient means of sterilization, which destroys bacteria, fungi etc. better than chemical disinfection. It also eliminates the potential for microbial cross-contamination during the transport and processing of dental impressions. It was concluded that linear dimensional changes in the impression material tested after disinfecting and autoclaving are all within the ranges, and hence this impression material may be acceptable clinically for fabricating short-span fixed dental prosthesis (FPDs), and hence the null hypothesis was accepted. Further in-vivo and in-vitro studies are required to evaluate the physical properties of this material as adequate so that it can be widely accepted in clinical practice.

V. CLINICAL INFERENCE

Dental Impression carries different types of microorganisms in clinics and in dental laboratories,as it comes in contact with saliva and blood in the oral cavity hence it is mandatory to disinfect the impression material in routine basis to avoid cross infection. But in diseases like HIV and COVID 19 only disinfecting the impression is not enough, it is required to be autoclaved to circumvent any transmission of infection. After disinfection and autoclaving the material should be accurate and stable. Newly introduced autoclavable polyvinyl siloxane impression material have capability to be autoclaved at 134 degree Celsius, hence to avoid cross infection and to have good accuracy, this material can be used in clinics.

VI. CONCLUSION

Within the limitation of this study, Autoclavable polyvinyl siloxane impression material may have future scope in terms of eliminating cross infections. Statistical analysis was done for the samples obtained and following conclusions were drawn:

- Linear dimensional changes in the impression material tested after disinfecting and autoclaving are all within the approved ranges
- Autoclavable polyvinyl siloxaneimpression material may be acceptable clinically for constructing short-span fixed dental prosthesis (FPDs).
- Autoclavable polyvinyl siloxane material can be disinfected with 2% glutaraldehyde for 10 mins.
- Pouring impressions made by autoclavable polyvinyl siloxane impression material, autoclaving must be delayed for at least 24 hours to take advantage of the rebound phenomenon showed by this material.
- As the material is autoclavable, it limits the infection transmission like COVID-19, HIV etc.

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