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RESEARCH ARTICLE
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A COMPARATIVE EVALUATION OF SURFACE ROUGHNESS AND DIMENSIONAL STABILITY OF DENTAL PLASTER, DENTAL STONE AND DIE STONE AFTER DISINFECTING THEM WITH 2.45% GLUTARALDEHYDE BY SPRAY AND INCORPORATION TECHNIQUE

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Abstract-

Introduction- Infection control attitudes at dental clinics and dental labs are changing as a result of the increased understanding of the hazards of cross-contamination with hepatitis B virus (HBV) and human immunodeficiency virus (HIV).

Objective-To examine how well dental stone, die stone, and plaster of Paris models cleaned using the spray approach and included with Glutaraldehyde reproduce surface detail and dimensional stability in their experiments.

Methodology- In-vitro experimental study was conducted in the Department of Prosthodontics and Crown And Bridge, Teerthanker Mahaveer Dental College And Research Centre, TMU, Moradabad to evaluate and compare the effect of glutaraldehyde on the dimensional stability and surface roughness of die stone, dental stone and dental plaster. Sample size was 100, contact profilometer was used to measure the surface roughness and Vision Inspecting system was used to measure the dimensional stability of the samples.

Results- The significant difference in plaster between the three groups was observed between Control and Incorporation groups (S.R high in Incorporation group) spray and Incorporation groups (S.R high in Incorporation group), for Dental Plaster and stone, there is no significant difference in dimension between the three techniques. For die stone alone, a significant difference was observed.

Conclusion- in our study found that surface roughness of dental plaster and die stone was higher and dimensional stability of die stone was lower after it was disinfected with glutaraldehyde, however

spray disinfection has no ill effect on physical properties of gypsum products, further studies and more researches are required to improve the effectiveness of spray disinfection.

Keywords- Infection Control, Surface Roughness, Dimensional Stability, Dental Plaster, Dental Stone, Die Stone, Glutaraldehyde, Spray, Incorporation Technique

INTRODUCTION

Infection control attitudes at dental clinics and dental labs are changing as a result of the cross-contamination with the hepatitis B virus (HBV), the human immunodeficiency virus (HIV), and Covid pandemic (corona virus). A contaminated imprint, model, or prosthesis may transmit disease from a patient to a dental worker, posing the greatest risk. For dental models, gypsum products are a common choice of materials. Dental casts are often exchanged between the dental laboratory and the dental practice. More rigid disease control measures have been created because of the chance of these models being sullied with irresistible human illnesses including Mycobacterium tuberculosis, HIV, and HBV researchers have shown that microbes and infections might be moved from patients to gypsum models during the prosthesis-production process using tainted engravings or chomp squares and preliminary bases[1]. When in doubt, impressions have been washed with running water and set in a sufficient sanitization answer for manage what is going on (ADA Council on Scientific Affairs and Council on Dental Practice, 1996).

In 1978 an aerosol spray containing chlorhexidine solutions was recommended to disinfect imprints of teeth. Impressions treated with a 0.02 percent chlorhexidine spray exhibited bacterial development after 24 hours, but impressions treated with 0.5% chlorhexidine remained clean after one week of microbiological testing[2]. In 1988, the American Dental Association (ADA) proposed that all impressions and the subsequent dental projects be washed with water, splashed with an ADA-acknowledged sanitizer, and given the suggested contact time for sanitization by makers for impressions[3].

To forestall cross-tainting, dental projects ought to be poured against a cleaned impression or the actual cast ought to be sanitized[4], as suggested by the ADA and the CDC (ADA Council on Scientific Affairs and Council on Dental Practice, 1996. Iodophor and phenol are two more regularly used disinfectants in addition to sodium hypochlorite and glutaraldehyde[5]. Infectious microorganisms and the length of time they are exposed to a disinfectant are both factors that influence the disinfectant's capacity to kill pathogens[6]. Impression disinfection methods have a wide range of concentration, kind, and immersion duration recommendations in the literature. Bacterial growth may be inhibited by submerging impressions for one minute in a solution of chlorhexidine 0.5 percent solution and 70% alcohol[2].

To avoid cross-contamination, disinfectants might be added to gypsum when it is mixed with the casting material. Some producers have sought to add disinfectants to the dental stone powder in an effort to make the practice more accessible. Some of these disinfectants include sodium hypochlorite, glutaraldehyde, calcium hypochlorite, phenol, and iodophor, among others[8]. However, phenol had no antibacterial effect whatsoever, and iodophor was only effective after 24 hours of exposure. In 1955 research found that two percent glutaraldehyde and povidone-iodine were the most effective disinfectants after one hour, whereas sodium hypochlorite was only effective after 24 hours.[7] While povidone-iodine lowered the compressive strength of castings, glutaraldehyde was shown to be less damaging for their physical properties[8]. It seems that including a disinfectant into the dental stone powder, or substituting disinfectant solution for water when mixing the gypsum, may reduce the organism level in the resultant cast. Cleaning dental stone before casting reduces its tensile and compressive strength, as well as its ability to reproduce fine surface details, which are both undesirable outcomes.[9]

This study was conducted to determine the surface roughness and dimensional stability of dental stone, die stone, and dental plaster models disinfected using the spray method and incorporation method with 2.45% Glutaraldehyde.

Methodology

Maxillary Jaw model (Nissin dental products INC., Japan) was taken with all the teeth present and secured with screws. Two different anatomical reference point were taken on the canine tips of left and right maxillary canine and on the central fossa of the right and left maxillary 1st molar. PVS Putty and light body (Photosil- Dental products of india,Mumbai) single phase impression was made of the Maxillary jaw model. Impression was kept in a zip lock bag for 1 hour and was later poured in gypsum products (Kalabhai Dental Pvt.) (fig-1), according to the water powder ratio of the respective gypsum product using Measuring Cylinder and Weighing Machine (fig-2). Each impression was used to pour only 2 casts. Obtained casts were divided into following groups with 8 specimen in each group.

Figure 1- Samples stored in zip lock bag after disinfection prior to material testing

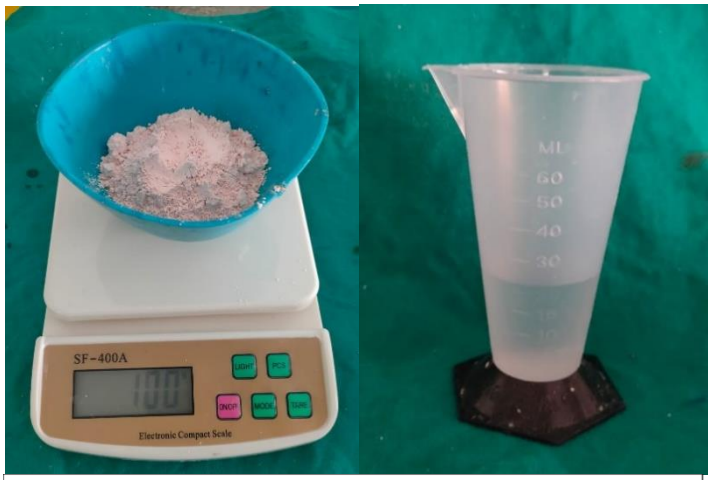

Figure 2-

a: measurement of water powder ratio prior to mixing (Measuring Powder)

b: measurement of water powder ratio prior to mixing (Measuring Water/Disinfectant)

Spray Group -The maxillary cast was made by mixing Type II, III and IV gypsum products with water, according to its water to powder ratio, after the final set the cast was removed from the impression and 2.45% of glutaraldehyde (Glutradex- Microgen hygiene Pvt.) was sprayed over the entire cast (fig-3). It was allowed to dry for 10-15 mins at room temperature.

Figure 3- 2.45% Glutaraldehyde prepared spray bottle

Incorporation Group - water was replaced with 2.45% glutaraldehyde (Glutradex- Microgen hygiene Pvt.). The maxillary cast was made by mixing Type II, III and IV gypsum products with 2.45% Glutaraldehyde, according to its water to powder.

Control Group –The maxillary cast will be made by mixing Type II, III and IV gypsum products with water, according to its water to powder ratio. These casts were not treated with any disinfectant. Contact Profilometer (Handysurf-Zeiss, India) was used to measure the surface roughness of the samples. Gypsum cast's base was trimmed to prevent any knocking of the cast and the profilometer's stylus was attached to the machine's main body and set on top of the cast.
In order to measure the surface height, Sylus profilometers physically move a probe along the surfac e to detect it. Mechanically, a feedback loop that tracks the force the sample exerts on the probe as i t moves over the surface scans the area in question. The arm is maintained with a particular torque a pplied to it, or the "setpoint," via a feedback system. The surface may then be rebuilt using the varia tions in the arm holder's Z position.[15,16,17,18](Fig-4)
In this Study Vision Inspecting system was used to measure the dimensional stability of the samples. Vision inspection systems, which are sometimes called "machine vision systems," enable the use of automated image-based inspection for a wide range of industrial and manufacturing tasks. 2D and 3D machine vision systems are not a new technology, but they are now commonly used for automated inspection, robot guidance, quality control and dimensional accuracy .[19,20,21] (fig-5)

Figure 4- Measuring surface roughness using contact profilometer

Figure 5- Measuring dimensional stability using vision inspecting system

STATISTICAL ANALYSIS-

Descriptive and Inferential statistics were analyzed by IBM SPSS version 20.0 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). The data was found to be normally distributed, therefore Parametric tests were used. Mean and SD were used to summarize the clinical parameters. One-way ANOVA was used for intergroup comparison of surface roughness and dimensions between three Controls, Spray and Incorporation technique. Tukey's post hoc test was used for multiple pairwise comparison between the groups where a significant P value was found in ANOVA comparison. Throughout the study a P value of <0.05 were considered as statistically significant difference.

The sample size was calculated using the nMaster 2.0 software. The power of the study was taken to be 80% and Confidence Interval (C.I.) of 95% was taken. The sample size calculation was done as per the article by Khalaf and Mohammed[10]. The sample size was calculated to be a minimum of 8 per group.

RESULT

A. Surface Roughness

Test one-way ANOVA for Dental Stone shows no significant difference in surface roughness between the three techniques (table-1). For Plaster and die stone alone, a significant difference was observed. Hence Tukey's Post hoc test for multiple pairwise comparison of surface roughness was done. (table-2) The significant difference in plaster between the three groups was observed between Control and Incorporation groups (Surface Roughness' (S.R) high in Incorporation group) Spray and Incorporation groups (S.R high in Incorporation group) The significant difference in Die stone between the three groups was observed between Control and Incorporation groups (S.R high in Incorporation group) Spray and Incorporation groups (S.R high in Incorporation group).

Table1. Intergroup comparison of surface roughness (Test: One-way ANOVA)

		Mean	Std. Deviation	95% Confidence Interval for Mean		P value
				Lower Bound	Upper Bound	
Plaster	Control	2.72	.08	2.65	2.79	0.001
	Spray	2.78	.08	2.71	2.85	
	Incorporation	3.73	.07	3.67	3.79	
Dental Stone	Control	1.90	.15	1.77	2.02	0.165
	Spray	1.98	.24	1.78	2.18	
	Incorporation	2.45	.99	1.62	3.28	
Die stone	Control	1.28	.06	1.23	1.34	0.001
	Spray	1.36	.10	1.27	1.45	
	Incorporation	2.28	.11	2.19	2.38	

*P value <0.05 is statistically significant

Table2-Tukey's Post hoc test for multiple pairwise comparison of surface roughness

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	P value
Plaster	Control	Spray	-.06	.303
		Incorporation	-1.01*	0.0001
	Spray	Control	.062	.303
		Incorporation	-.95*	0.0001
	Incorporation	Control	1.01*	0.0001
		Spray	.95*	0.0001
Die	Control	Spray	-.07	.288
		Incorporation	-1.00*	0.0001
	Spray	Control	.075	.288
		Incorporation	-.92*	0.0001
	Incorporation	Control	1.00*	0.0001
		Spray	.92*	0.0001

*P value <0.05 is statistically significant

B. Dimensional Stability

For Dental Plaster and stone, there is no significant difference in dimension between the three techniques after oneway ANOVA test. (Table-3) For die stone alone, a significant difference was observed hence Tukey's Post hoc test for multiple pairwise comparison for Die stone alone. (Table-4)

Table 3-Intergroup comparison of Dimension

		Mean	Std. Deviation	95% Confidence Interval for Mean		P value
				Lower Bound	Upper Bound	
Plaster	Control	48.66	.15	48.53	48.80	0.20
	Spray	48.60	.25	48.39	48.81	
	Incorporation	48.41	.38	48.09	48.74	
Dental Stone	Control	48.67	.29	48.43	48.92	0.35
	Spray	48.57	.32	48.30	48.84	
	Incorporation	42.33	17.10	28.03	56.64	
Die stone	Control	48.68	.17	48.54	48.83	0.006
	Spray	48.65	.18	48.49	48.81	
	Incorporation	48.33	.24	48.12	48.53	

*P value <0.05 is statistically significant

Table 4 Tukey's Post hoc test for multiple pairwise comparison for Die stone alone

(I) Group	(J) Group	Mean Difference (I-J)	P value
Control	Spray	.030	.953
	Incorporation	.354*	.006
Spray	Control	-.03	.953
	Incorporation	.32*	.013
Incorporation	Control	-.35*	.006
	Spray	-.32*	.013

*P value <0.05 is statistically significant

There is no significant difference in dimension between Control and Spray technique group. There is a significant difference in dimension between
Control and Incorporation (Dimension Lower in Incorporation group)
Spray and Incorporation (Dimension Lower in Incorporation group)

DISCUSSION

In Prosthodontics, items might be infected with harmful bacteria and are moved between the dental clinic and laboratory especially dental cast. It has been suggested that special disinfection procedures should be performed to prevent cross contamination. The standard remedy for this issue has been to chemically disinfect either the impressions or the gypsum casts, according to the literature.

Mansfield SM et al[11] in their study concluded that incorporation of disinfectants into gypsum casts significantly reduced the number of viable bacteria at 24 hours. This technique, in combination with other standard infection-control practices, should eliminate or significantly reduce transmission of bacterial contaminants from the operatory to the laboratory, thus breaking the contamination cycle.[11]

In a study done by Lucas MG et al[12] they found that Glutaraldehyde and Chlorhexidine does least changes in physical properties of gypsum products.[12]

In this study, gypsum samples were disinfected using the spray technique, which is the most popular method of disinfecting gypsum casts, and the incorporation technique, which is the most efficient method of disinfect gypsum casts with 2.45% Glutaraldehyde. They were also inspected for surface roughness and dimensional stability were also inspected.

Ivanovski S et al [8] in their study found that there was no significant changes in physical properties of gypsum products when disinfected with glutaraldehyde.[8]

We in our study found similar result that for type III gypsum there was no significant difference in surface roughness between the two techniques (spray and incorporation) when compared with control. But on the other-hand for type II and type IV alone, a significant difference was observed after using ANOVA test. For more specificity.

Tukey's Post hoc test for multiple pairwise comparison of surface roughness was used to check the values of type II and type IV since a significant difference was observed in these two groups, Surface roughness was high in type II and type IV gypsum cast when they were disinfected using incorporation technique when compared with spray and control group.

The expansion of the gypsum mass during the hydration of calcium sulphate has been discussed[9]; depending on the composition of the gypsum and the calcination method, a linear expansion of 0.06 to 0.5% of the total volume is anticipated .[13,14]

Lucas MG et al [12] concluded in his study that linear dimensional stability of gypsum mixed with glutaraldehyde presented an expansion statistically similar to the control group[12], we found similar result For Dental Plaster and stone, there is no significant difference in dimension between the three techniques. For die stone alone, a significant difference was observed for more specificity (Tukey's Post hoc test for multiple pairwise comparison for Die stone alone was used) we found there was no significant difference in dimension between Control and Spray technique group. There was a significant difference in dimension between Control and Incorporation (Dimension Lower in Incorporation group) Spray and Incorporation (Dimension Lower in Incorporation group).

CONCLUSION

According to the literature and published articles Incorporation technique is the best way to disinfect gypsum cast and glutaraldehyde is the best disinfectant material to do so. However we in our study found that surface roughness of dental plaster and die stone was significantly higher and dimensional stability of die stone was lower after it was disinfected with glutaraldehyde. Spray disinfection has no ill effect on physical properties of gypsum products, further studies and more researches are required to improve the effectiveness of spray disinfection. However for making diagnostic cast incorporation technique might be used in patients with infection in unavoidable clinical circumstances.

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