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Dimensional Stability and Accuracy of Silicone Impression Materials after Ozone Water Disinfection: An In Vitro Study

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ABSTRACT

Objectives: This study evaluated the effect of ozone water disinfection on dimensional stability and accuracy of silicone impression materials.

Materials and Methods: According to ISO-4823, a stainless-steel die was fabricated for this in vitro study. Three horizontal parallel lines, namely x, y, and z (25, 50, and 75µm in width and 25mm in length) running perpendicular to two vertical lines, namely D1 and D2 (0.075±0.008mm wide), were created on the superior surface of the die. Group A served as the control group with no disinfection. Disinfection was performed with 2% glutaraldehyde in group B, 5.25% sodium hypochlorite in group C, and ozone water in group D for 10 minutes. Totally, 60 samples were fabricated. The silicone impression samples were allowed to polymerize in a thermostatically controlled water bath at 35±1ºC for 10 minutes. The dimensional stability and accuracy of the silicone impression samples were evaluated by using a video measuring microscope and an optical microscope. Data were analyzed by two-way ANOVA followed by post-hoc analysis with the Scheffe test (alpha=0.05).

Results: The highest dimensional stability (25.01mm) and accuracy (25.02µm) were seen in addition silicone putty and light body impression with ozone water disinfection, and the lowest parameters were seen in condensation silicon putty and light body disinfected with 2% glutaraldehyde (24.87mm and 24.88 µm, respectively); this difference was statistically significant (P<0.001).

Conclusion: Ozone water disinfection caused minimal changes in dimensional stability and accuracy when compared to 2% glutaraldehyde and 5.25% sodium hypochlorite disinfection.

Keywords: Disinfection; Dental Impression Materials; Ozone; Water; Silicones

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INTRODUCTION

Dental impressions are made to fabricate a successful final dental restoration. Dental impression is a negative likeness of an oral structure used to produce a similar replica for the fabrication of dental prostheses [1].

Cross contamination is an important risk factor for dental professionals. Dental impressions can be infected with blood, saliva, and bacterial plaque, which increase the risk of transmission of bacteria and viruses, and communicable diseases like the human immunodeficiency virus, hepatitis-B virus, and tuberculosis from dental clinic to dental laboratory [2]. To prevent infection transmission, dental impressions should be either disinfected or sterilized in dental office [3,4].

Spraying dental impressions with disinfecting agents is the most common method of disinfection followed by disinfection through immersion [5,6]. The disinfection process is intended to eliminate the microorganisms from the surface of impressions without changing their dimensions or accuracy. Although washing the impressions under running water is the recommended practice, it does not completely remove the microorganisms from dental impressions [7,8].

The immersion method has been recognized as a more effective and reliable method than disinfection by spray, as it guarantees that the external surface of the impression and tray is completely exposed to the disinfecting solution [9]. Although various disinfectants have been advocated for disinfection, no single disinfectant has been considered suitable for all impression materials. Nonetheless, it is critical to select a disinfectant with maximum disinfecting efficacy and no adverse effect on the dimensional accuracy of dental impressions [10].

Recently, it was found that ozone water has biocompatible, wound healing, antimicrobial, and disinfecting properties [11]. Hence, this study was designed to evaluate the effect of disinfection with ozone water, 2% glutaraldehyde, and 5.25% sodium hypochlorite on the dimensional stability and accuracy of silicone impression materials. The null hypothesis of the study was that no significant difference would be found in the dimensional stability and accuracy of silicone impressions after their disinfection with ozone water, 2% glutaraldehyde, and 5.25% sodium hypochlorite.

MATERIALS AND METHODS

Master die fabrication:

A stainless-steel die was prepared according to ISO 4823 [12] with 31mm length, external and internal diameters of 38mm and 29.97mm, respectively, and internal height of 3mm. On the superior surface of the die, three horizontal parallel lines namely x, y, and z (with 25, 50, and 75µm width and 25mm length) running perpendicular to the two vertical lines namely D1 and D2 (0.075±0.008mm wide) were created for determination of dimensional changes. The distance between the x and z lines was 5mm (the lines had 2.5mm distance from each other) (Figs 1 and 2).

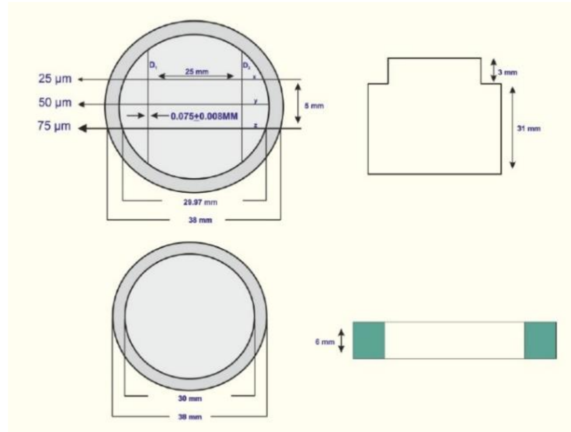

Fig 1: Schematic view of the master die

Fig 2: Stainless-steel die

A stainless-steel ring (with 6mm height, 30mm internal diameter and 38mm external diameter) was placed on the die and fitted to serve as a mold for the impression material (Fig 3).

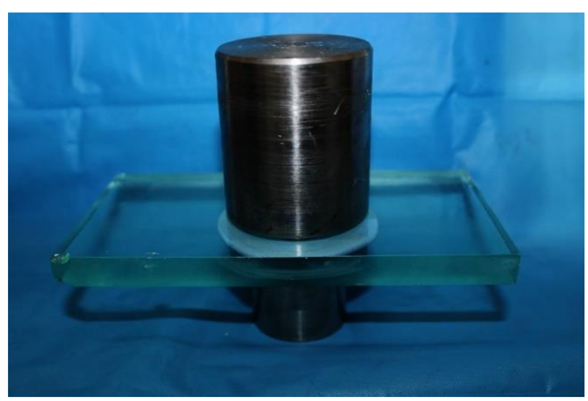

Fig 3: Impression making

In this study, addition silicone putty and light body (Aquasil; Dentsply De Trey, Konstanz, Germany), addition silicone medium body (Aquasil; Dentsply Caulk Milford, DE, USA), and condensation silicone putty and light body (Speedex; Coltene/Whaledent, Switzerland) were used.

Sample distribution:

A total of 60 silicone samples with 5 samples in each group were fabricated. The silicone samples were not disinfected in the control group. They were disinfected with 2% glutaraldehyde solution (Jalgaon Chemicals Pvt. Ltd., Jalgaon, India) in group B, 5.25% sodium hypochlorite solution (Glaxo SmithKline Pharmaceutical Pvt. Ltd., India) in group C, and ozone water (Stratus O3, MitoZen, WY, USA) in group D, each for 10 minutes.

Sample preparation:

Initially, the master die was cleaned with ethanol and allowed to dry. The master die was placed on the ruled block. Next, the silicone materials were mixed using single- and double-mix methods and loaded into a 50-mL cartridge syringe to pour the material into the master die. A glass slab was placed over the impression on which 1kg weight was applied to simulate hand pressure. The silicone samples were allowed to polymerize in a thermostatically controlled water bath at 35±1ºC and removed once the material was polymerized. Next, the silicone samples were cleaned for 30 seconds under running water.

Evaluation of dimensional stability and accuracy:

Dimensional stability and accuracy were assessed in x-y axis using a video measuring microscope (Kosaka Calibration lab, Chennai, Tamil Nadu, India) with a linear accuracy of ±5µm and an optical microscope (Nikon Eclipse Optical microscope, Tokyo, Japan), respectively. The measurements were made three times by one single examiner with one-minute intervals. The dimensional stability was calculated and compared between the control and disinfected groups by computing the distance between D1 and D2 of the x, y, and z lines (Fig 4), The dimensional accuracy of the impression materials was assessed by comparing the width of the x, y, and z horizontal lines of the test samples in each group (Fig 5).

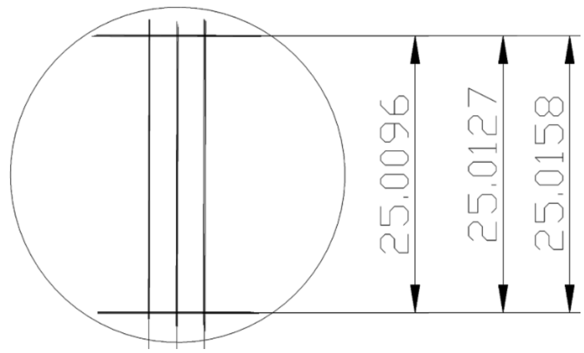

Fig 4: Video measuring microscope image to assess the dimensional stability

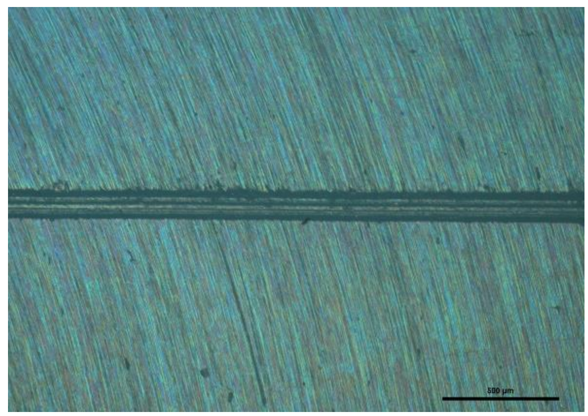

Fig 5: Optical microscope image to measure accuracy

Statistical analysis:

The sample size was calculated with a power analysis with 95% confidence interval. Two-way ANOVA (general linear model) was used to analyze the effects of group, material, and their interaction on dimensional stability and accuracy, followed by pairwise comparisons with the post hoc Scheffe test. SPSS version 26.0 (IBM SPSS Statistics for Windows; IBM Corp., Armonk, NY, USA) was used for data analysis at P<0.05 level of significance.

RESULTS

Comparison of dimensional stability and surface accuracy between group A, group B, group C and group D were analyzed using two-way ANOVA and multiple pairwise comparison was done using Post Hoc with Scheffe´s test.

There was insignificant difference found in dimensional stability for x line (25mm) among the groups (p=0.192) but the comparison between impression materials and disinfectant solution groups showed the significant P<0.05. Hence it was considered as statistically significant when comparing the dimensional stability among impression materials and disinfection solution (Table 1). Post hoc with Scheffe´s test was applied to compare the dimensional stability of multiple groups where the significant P value was <0.001. Hence the dimensional stability changes were significant among the impression materials (Table 2).

Comparison of surface accuracy between groups were analyzed using two-way ANOVA which showed insignificant difference in dimensional accuracy for x line (25μm) among the groups (p=0.166) but the comparison between impression materials and disinfectant solution groups showed the significant P value <0.05. Hence it was considered as statistically significant when comparing the dimensional stability among impression materials and disinfection solution (Table 3).

DISCUSSION

Disinfection of impressions is a recommended procedure in all dental offices and laboratories. Spraying 1:10 dilution of 5.25% sodium hypochlorite for 10 minutes has been recommended by the American Dental Association for disinfection of impressions [13]. Also, according to the American Dental Association, the impression materials should be immersed in disinfecting solutions for less than 30 minutes to avoid changes in their dimensional accuracy, stability, and surface quality [13].

Sodium hypochlorite is the recommended disinfectant for alginate materials [14]. Also, it has been advocated by the United States Environmental Protection Agency as a non-irritating and effective disinfectant against a wide spectrum of microorganisms [15]; while, glutaraldehyde has the same activity and can eliminate viruses, fungi, and Mycobacterium [15]. A previous study reported that both *Streptococcus sanguinis* and Poliovirus can be inactivated by immersion of alginate materials in 0.1% hypochlorite for 7.5 minutes [16]. The results of an earlier study [17] showed that there were insignificant linear changes in condensation silicone impression materials after disinfection with 1% sodium hypochlorite and 2% glutaraldehyde.

Ozone water has been widely used in dentistry for treatment of incipient caries and periodontal pockets, root canal treatment, enhancement of wound healing in patients with ulcerations and herpetic lesions, treatment of tooth discolorations and peri-implantitis, denture cleaning, and tooth brush decontamination [18]. The oxidative power of ozone destructs the cell wall and cytoplasmic membrane of the bacteria and fungi [19].

Table 1: Two-way ANOVA for dimensional stability of silicon impressions after disinfection with various disinfectant agents at x line (25mm)

Source	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	0.20[a]	11	0.01	37.42	-
Intercept	37367.03	1	37367.03	75732879.21	-
Disinfecting solution	0.00	3	0.00	1.64	0.192
Impression material	0.19	2	0.09	196.50	0.001
Disinfecting solution×Impression material	0.00	6	0.00	2.98	0.021
Error	0.02	48	0.00		-
Total	37367.26	60			-
Corrected Total	0.22	59			-

[a] R Squared = 0.896 (Adjusted R Squared = 0.872).

Table 2: Pairwise comparison of dimensional stability of impression materials using post hoc Scheffe test

Material		p
Addition silicone putty and light body	Addition silicone medium body	<0.001
	Condensation silicone putty and light body	<0.001
Addition silicone medium body	Condensation silicone putty and light body	<0.001

Table 3: Two-way ANOVA for dimensional accuracy of silicon impressions after disinfection with various disinfectant agents at x line (25µm)

Source	Type III Sum of Squares	df	Mean Square	F	p
Corrected Model	0.57[a]	11	0.05	2.43	-
Intercept	37558.52	1	37558.52	1737011.11	-
Disinfecting solution	0.11	3	0.03	1.76	0.166
Impression material	0.07	2	0.03	1.78	0.180
Disinfecting solution * Impression material	0.38	6	0.06	2.98	0.015
Error	1.03	48	0.02		-
Total	37560.14	60			-
Corrected Total	1.61	59			-

[a] R Squared = 0.358 (Adjusted R Squared = 0.211).

Another study showed that ozone had little influence on oxidation of dental alloys like Au, Cu, Ag, and Pd, and no significant changes were detected after treatment of Co-Cr and Au-Ag-Pt alloys with ozone [20]. Also, ozone reduced the *Candida albicans* count by 1:10 on removable dentures after 30 minutes, and by 1:103 after 60 minutes of treatment [21]. Ozone caused inactivation of Escherichia coli T1 phage resistant strain within 30-40 minutes [22]. Another study reported a significant reduction in selected Gram-positive and Gram-negative bacteria after 3 minutes of ozone exposure using an automated prototype device, and suggested low-flow high-ozone concentration disinfection of dental impressions [23].

Silicone materials have shown dimensional changes within the clinically acceptable range, and were found to be the most stable material in all disinfection methods in a previous study [24]. The use of stock and custom trays did not affect the hardness of dental implant impressions [25]. Also, another study reported that ozone water disinfection caused the least surface changes in dental impressions when compared to 5.25% sodium hypochlorite disinfection and 2% glutaraldehyde [26]. Hence, this study was conducted to evaluate the dimensional stability and accuracy of addition and condensation silicone impression materials following disinfection by immersion in 2% glutaraldehyde, 5.25% sodium hypochlorite, and ozone water. The measurements were made using a Nikon Eclipse optical microscope with 1µm (0.001mm) accuracy.

In group comparisons, a significant difference was found among the three disinfection methods for silicone impression material for dimensional stability at 25mm distance and dimensional accuracy at x line (25µm). Hence, the null hypothesis was rejected. The results showed that the impression materials and disinfection protocols had significant differences in accuracy of surface details < 25 µm which indicates that silicone impression materials and the disinfectant solutions can be used in the clinical setting since the changes were within the clinically acceptable range.

A previous study reported mild dimensional changes after disinfection that did not exceed the American Dental Association criteria [13]. Also, ozone water produced the least changes in dimensions and accuracy (25µm or less) of silicon impressions followed by 5.25% sodium hypochlorite and 2% glutaraldehyde.

The limitations of this study included manual mixing of the base and catalyst of the materials. Also, in vitro results should be verified in future clinical studies.

CONCLUSION

Within the limitations of this in vitro study, the results showed that ozone water caused minimal changes in dimensions and accuracy of silicone impressions compared to 5.25% sodium hypochlorite and 2% glutaraldehyde. Hence, ozone water can be utilized as an alternative disinfectant for disinfection of silicone impression materials in clinical practice.

CONFLICT OF INTEREST STATEMENT

None declared.

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