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Tea Tree Oil Effect on Dimensional Change and Detail Reproduction of Addition Silicon Impression Material

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Abstract

Objective: Impression materials are thought to be the one of the primary sources of cross infection between patients and dentists. However, it was discovered that disinfection of the impression is not conducted routinely in ordinary dental treatment. Disinfection of addition silicon impression, whether by immersion or spray should not produce dimensional or detail errors. The purpose of this study was to examine the immersion of addition silicon impression material in tea tree oil and its influence on dimensional stability and detail reproduction of the addition silicon imprint material.

Materials and Methods: This study employed a total of 120 heavy- and light-body addition silicon impression material specimens. The specimens were randomly sorted and immersed into six groups. These test groups where four concentrations of TTO (0.25%, 0.5%, 0.75%, and 1%), and the other two groups were distilled water (negative control) and 2% glutaraldehyde (positive control). All specimens were immersed for 10 minutes in the testing solutions. Each of the six groups had 20 specimens separated into two subgroups.

Results: There were no statistically significant differences in linear dimensional changes and detail reproduction among all test groups.

Conclusion: The addition silicon impression material may be safely submerged in TTO for 10 minutes to disinfect it without impairing its dimensional correctness or detail replication of the impression.

Keywords: Addition silicon, Tea tree oil (TTO), Dimensional stability, Detail reproduction

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Introduction

Dental impressions infected with potentially harmful germs come into touch with the patient's blood and saliva [1,2]. This might lead to cross-infections among dentists, dental assistants, and laboratory technicians [3].

Impression materials are thought to be the primary cause of cross infection between patients and dentists.

An infection prevention program for dental impressions is necessary because a variety of viruses, fungi, and bacteria found in the oral environment have been associated to devastating and life-threatening disorders.[4] Disinfection of impressions is considered mandatory [5], and to reduce cross-contamination between patients and dental personnel in dental offices and laboratories, the American Dental Association (ADA) recommends disinfecting dental impressions as soon as they are removed from the patient's mouth [6].

Heat and chemicals are utilized to sterilize the various impression materials. The chemical procedure is the most often used method, which includes spraying or immersing a chemical disinfectant [6]. The immersion approach ensures that the disinfecting solution reaches all surfaces of the imprint material and tray [1].

An important consideration in disinfecting an impression material is the effect of the disinfectant on the properties of the impression material, particularly impression-like addition silicon, where the exact fit of the dental prosthesis significantly influences the outcome of prosthodontics work, which is dependent on the

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accurate recording of fine intraoral details. As a result, the basic requirement for many dental and maxillofacial rehabilitation treatments is to have a proper negative reproduction of the appropriate site that should not be affected by disinfection [1,2].

Addition silicones are available in four consistencies: low, medium, heavy, and putty [7]. The polymer (polymethyl-hydro siloxane) in the base paste of this impression class contains more than three and up to ten pendant or terminal hydrosilane groups per molecule. Filler is also included in the base [8].

Vinyl terminal groups, filler, and dimethyl siloxane polymer make up the accelerator (catalyst) and base paste. An additional component of the accelerator is a complicated chemical termed a Karstedt-type platinum catalyst, which is made of platinum and 1,3-divinyl tetramethyl disiloxan. The addition reaction, in contrast to the condensation type, rarely yields a low-molecular-weight byproduct; but, in the presence of -OH groups, a secondary reaction involving the generation of hydrogen gas may take place [9].

Chlorhexidine, hydrogen peroxide, alcohol, sodium hypochlorite, and glutaraldehyde are among the disinfectants that are most frequently used [10]. It is imperative to select a disinfectant with strong antibacterial qualities that does not compromise the impression's surface features or dimensional stability, as there is no one disinfectant that works for all impression materials [11].

Glutaraldehyde is an oily, colorless liquid with an overpowering odor. In addition, the lipid surfactant layer disintegrates and damages the airway epithelium, capillaries in the pulmonary system, and alveolar septum. Atelectasis, interstitial inflammation, and the emergence of hyaline membrane are other pathogenic indicators [11].

Natural or herbal derivatives have long been used in dentistry and medicine, and because of their antibacterial activity, biocompatibility, lack of germ resistance, antioxidant, anti-inflammatory, easy availability, and affordable qualities, they are becoming even more well-liked [12].

Tea tree oil (TTO) is generated from Melaleuca alternifolia, a native Australian plant, whose leaves could be steam-distilled to yield oil as shown in Figure 1. TTO is composed of a mixture of compounds, primarily alcohols of monoterpene and sesquiterpene hydrocarbons. Numerous investigations revealed that TTO possessed antiseptic, antibacterial [11], anti-inflammatory, and antifungal qualities, especially those that were anti-Candida [13]. Additionally, phytoconstituents were compounds present in natural agents with a particular target impact for the treatment and prevention of diseases connected to biofilms [14]. M. alternifolia is the source of α-terpineol [15]. Against Candida albicans, these phytoconstituents demonstrated antifungal action [16].

Figure 1. Tea tree oil shrub (Melaleuca alternifolia).

Because of tea tree oil valuable properties like antibacterial, antifungal and antiviral activities and its availability and biocompatibility, and since there is no previous study on the effect of TTO on dental impression material, this study was conducted to evaluate the effect on linear dimensional change and detail reproduction of addition silicon impression material after immersion in solutions with different TTO concentrations.

The null hypothesis predicted that the properties of the additional

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silicon impression material would not be significantly impacted, whereas the alternative hypothesis proposed that the properties of the additional silicon

impression material will be significantly impacted by the immersion of silicon impression material in tea tree oil solutions.

Material and Methods

Addition silicone impression specimens were prepared, according to the ISO 4823:2015 standard for evaluating elastomeric impression materials.

The test specimens and procedures were prepared at 23 ± 2 ºC and with a relative humidity of 50% ± 10%. The equipment was conditioned at this temperature and humidity for at least 10 hours before testing [17].

The testing solutions, distilled water, TTO concentrations (0.25%, 0.50%, 0.75%, and 1%) and 2% glutaraldehyde were also prepared under the same conditions.

In a moisture-resistant container, the addition silicon impression was conditioned at a temperature of 23 ± 2 ºC.

According to the ADA specification No. 19 standard for evaluating

elastomeric impression materials, an equipment was created, and 3D printed with the software package 3D max 2022.
The equipment is made up of four pieces. The first is a ruled test block that has five v-shaped lines engraved into it. Three vertical lines (A 50 μm, B 20 μm, and C 75 μm) and two horizontal lines (D1 and D2) have a depth of 75 μm. The length of the vertical lines between D1 and D2 is 25 mm, which is utilized to calculate the linear dimensional change. The second component is a ring mold that serves as a mold for a dental impression, while the third component is a riser as shown in Figures 2 and 3.

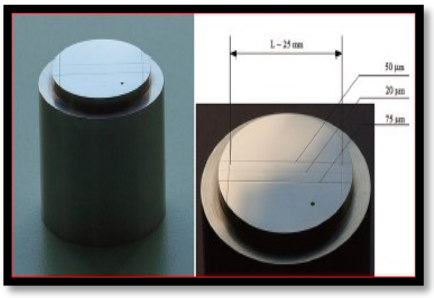

Figure 2. Testing block.

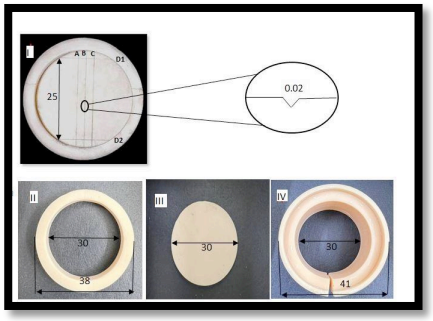

Figure 3. Testing apparatus.

Measures

Addition silicon impression material (3M, USA) was prepared according to ADA specification No. 19 [17] and used as the test impression material. Before impression making, The test block was immersed in a water bath at 35°C for 15 minutes to ensure that the block temperature standardizes to intra-oral temperature as the ADA standards recommend. The ring was cleaned with solvent alcohol (Hema Pharmaceuticals, Tamil, India) and dried after soaking in cotton (Jayamari Enterprises, Tamil, India). The ring was placed on the test block after lubricating with petroleum jelly (Bharat Pharmaceuticals, Tamil, India).

Impressions were made in two steps, using a putty wash technique. First, the square sheet of plastic wrap was placed over the impression surface of the test

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block, and then the impression ring was placed over the test block, mixing addition silicon putty by hand until gets mixture that has no streaks in it. When the putty was thoroughly mixed, it was placed over the impression ring, put the glass slab over it to produce a flat impression surface, and waited until it was completely set (3 to 5 minutes). Then the impression mold with addition silicon putty was removed, and then the square sheet of plastic wrap was replaced with addition silicon light body mixed with an auto-mixing gun (China) [18], as shown in Figure 4.

The ring was filled with putty and light body addition silicon impression material to achieve a three mm thickness. A glass slab (Star Labs, Star, India) was placed over the mold.

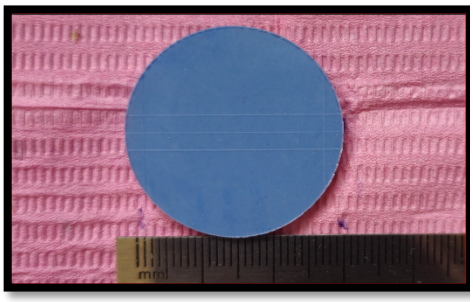

Figure 4. Addition silicon impression specimen image after transferred from camera to personal computer.

Specimen grouping

A total number of 120 impression specimens, which were divided into six test groups of 20 specimens each were used. The testing groups were:
Group 1: 20 addition silicon specimens were immersed for 10 minutes in 0.25% TTO.

Group 2: 20 addition silicon specimens were immersed for 10 minutes in 0.5% TTO.

Group 3: 20 addition silicon specimens were immersed for 10 minutes in 0.75% TTO.

Group 4: 20 addition silicon specimens were immersed for 10 minutes in 1% TTO.

Group 5: 20 addition silicon specimens were immersed for 10 minutes in distilled water (negative control).

Group 6: 20 addition silicon specimens were immersed for 10 minutes in 2% glutaraldehyde as advised by the ADA (positive control).

Preparation of TTO solutions

Tea Tree pure Essential Oil (Now Foods, Bloomingdale, IL 60108, USA), as shown in Figure 5, solution (TTO) was prepared by combining it (according to the specimen groups) with 1% Tween 80 as an emulsifier using a magnetic stirrer and distilled water.

Figure 5. Organic essential tea tree oil (Melaleuca alternifolia).

TTO solution was prepared in the Chemistry Lab, Department of Dentistry, University of Karbala. Tea tree oil, Tween 80® and distilled water were used to prepare the solution. A 1:1 ratio of tea tree and tween 80 was used, and a series of tea tree concentrations (0.25%, 0.5%, 0.75%, and 1%) was prepared using magnetic stirrer device under 300 round per minute (rpm) (Stuart- Hotplate & Stirrers) at room temperature (28 ±5 ºC). At first, tween 80 surfactant was added to the container and then tea tree oil was added and let them steer for a couple of minutes in a 100 ml glass container. Distilled water was added drop by

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drop until 100ml volume was reached, and then let to be stirred for about 10 minutes. Prepared tea tree oil solutions were stored at room temperature (28 ±5 ºC).

Specimens were conditioned in a water bath at 35°C for 10 minutes to mimic mouth temperature during impression taking. Samples were immersed in the prepared glass containers of each group for 10 minutes, then removed and rinsed by distilled water and stored at room temperature. After 24 hours, these specimens were tested for detail reproduction and linear dimensional change.

Linear dimensional change evaluation

Digital imaging was recommended by Oliveira et al. (2021) [19]. This approach did not significantly differ from measurements taken under a microscope, which was a common method used in research. There are benefits of using software to measure distance instead of a microscope, which include lower operating costs, the flexibility to store the photos for the measurements whenever the operator wants, and shorter average measurement times. This approach was used in this investigation to calculate the distance on the specimen between D1 and D2.

After capturing the test specimens by camera after disinfection, the line B between the line D1 and the line D2 was measured by using Image J 1.53k (National Institutes of Health, United States of America) (Oliveira et al., 2021), as shown in Figure 6. For each impression specimen, three measurements were taken at different times and according to World Health Organization (WHO) for interexaminer evaluation. We waited 30 minutes between the measurements, and the means of those readings were computed. Ten measurements of the test block were taken in total, with the mean length of test block being 25.002 mm. This value served as the initial (before treatment) measure for each specimen (L1) [20]. The following calculation was used to determine the linear dimensional change percentage for each specimen in accordance with ISO 4823:2015:

$$\Delta L = 100 \times [(L1 - L2)/L1]^{[21]},$$

where L1 represents the length of the line B as calculated on the test block, while L2 represents the length of the line B as calculated on the impression specimen after

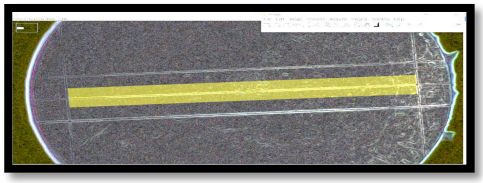

Figure 6. Evaluation of dimensional change of the addition silicon impression specimen by using the ImageJ software.

Detail reproduction evaluation

Elastomeric imprint materials used to make precision castings must meet the ISO 4823:2015 standard of replicating fine detail to a depth of 20 μm or less, which is an accurate and comparable process. In this investigation, an ISO 4823:2015 standard apparatus was employed to restrict the variances caused by uncontrollable circumstances, resulting in a more accurate and comparable assessment of the impression material's ability to recreate surface detail. The image was used to quantify linear dimensional change, where two observers viewed line B to determine the surface detail score using a ranking system developed by Owen. This system aimed to evaluate how well line B was replicated in the specimens. The specimens were ranked with four scores.

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- Score 1: The entire line is sharply and clearly replicated between the markings (D1 and D2).
- Score 2: The line is distinct for more than half of its length, with less than half being obscure.
- Score 3: The line is hidden for more than 50% of its length, obscure for less than half of its length, or completely visible but rough and imperfect.
- Score 4: Disparate in length and pitted, rough, or blemished.
  After disinfection, the 20 µm line between markings (D1 and D2) remained unaltered independent from the disinfectant type.

Statistical analysis

Individual linear dimensional change readings, as well as values for detail reproduction, were measured and then summarized. Means and standard deviations for every group were computed utilizing SPSS program (IBM SPSS version 21) as shown in Tables 1 and 2. The results were compared between the groups using one-way ANOVA and Kruskal-Wallis. P-values less than 0.05 were considered significant.

Results

Immersion of addition silicon impression material in different concentrations of tea tree oil for 10 minutes showed no changes in linear dimension and detail reproduction in comparison to controls.

The line with 20µm depth was sharply visible on the impression surface of the specimens following disinfection with TTO and 2% glutaraldehyde, and it showed that it was also identically sharply visible on the surfaces of all control addition silicon specimens.

Discussion

Because of the growing number of infectious diseases that pose a considerable risk not only to clinical workers but also to dental lab workers, impression disinfection is one of the most essential and frequently discussed topics. Healthcare providers are accountable for maintaining hygienic standards in health care facilities, such as disinfecting instruments, aids, and dental impressions. In addition to the fundamental antibacterial efficacy of the disinfectants, it is required to analyze their effect on the properties of dental impression materials. Ideal disinfectants for dental impressions should not only be effective against a wide range of germs and viruses, but they should also have no negative effects on the materials' qualities or structure. The null hypothesis for this study predicted that disinfectants have no influence upon the dimensional stability, accuracy, or quality of the impression material surfaces.

Data have shown that 67% of materials sent to dental laboratories are infected by various microorganisms [22]. Infectious agents are transferred from saliva and blood to the casts via dental impressions [23].

Among the various methods of sterilization and disinfection, chemical disinfection is the ideal choice for disinfecting dental impressions, because impressions cannot be disinfected by using heat [24].

There are basically three methods of chemical disinfection: a) spray disinfection, b) immersion disinfection, and c) mixing the disinfectant in the gypsum before

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pouring the model [24]. Immersion disinfection of impression is considered the best reliable method, because this method ensures that all the surfaces of the impression and tray will be in direct contact with the disinfectant solution [17]. For that reason, the immersion method was chosen for this study.

Tween 80 was used with TTO as an emulsifier agent to create microemulsions that increase the activity of oil. Hence, it had no antibacterial characteristics. It might be utilized to make synthetic dilutable U-type microemulsion, while surfactants could improve membrane fluidity and cell permeability.

Chemical cleaning involves immersing in solutions with antibacterial, antifungal, and solvent characteristics. These solutions can be used alone or in conjunction with mechanic or ultrasonic cleaners [25].

Extracts possess advantages over produced products because of their non-toxic nature and antimicrobial tolerance [26].

Tea tree oil was chosen as a disinfectant for addition silicon impression in this study because it is a natural product that has antimicrobial properties and is available, has low cost, is biocompatible, and has no harmful effects on operator's skin or respiratory system.

Linear dimensional change test

One of the most essential aspects about impression materials is its dimensional stability, which influences the accuracy of impressions and castings.

The bulk of the dimensional shrinkage of the silicon impression material is caused by continuous polymerization during the first three minutes after removing the imprint from the mouth.

This study evaluated the linear dimensional change using a well-established method to test elastomeric impression *in vitro*, using standardized parameters by ISO:4823:2015 to test elastomer impression material *in vitro* [18].

Table 1. Descriptive statistics for linear dimensional change.

Test-groups	N	Mean	Std-Deviation	Std-Error	Minimum	Maximum
Control	10	1	0	0	1	1
0.25%TTO	10	1	0	0	1	1
0.5%TTO	10	1	0	0	1	1
0.75%TTO	10	1	0	0	1	1
1%TTO	10	1	0	0	1	1
2%Glutraldehyde	10	1	0	0	1	1

Despite the non-significant result regarding impression dimensional change, the specimens immersed in TTO tended to be more dimensionally stable than the control ones. This may be attributed to the fact that the size of the impression material changes because of the disinfection treatment. This can be caused by a chemical interaction

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between the setting substance and the disinfectant [27].

This change in size effect might also be attributed to the impression material's continuous polymerization or the evaporation of its volatile components [28,29].

Detailed reproduction test

Detailed reproduction ISO 4823:2015 [18] specifies that elastomeric impression materials employed in precision castings shall replicate fine detail to 20 µm or less, ensuring an accurate and comparable approach. In this investigation, an ISO 4823:2015 standard apparatus was used to limit the variations associated with uncontrolled factors; hence, the capacity of the imprint material to replicate surface detail was evaluated in a more exact and comparable manner. All specimens in all six groups maintained the crisp and distinct 20 µm line.

The null hypothesis was accepted because of the outcomes of this investigation, which showed that impression specimens immersion in TTO offered detailed reproduction equivalent to the control specimens.

This work was also consistent with Vrbova et al.'s [30] investigation, which employed the use of scan electron microscopy (SEM), light microscopy, and micro computed tomography to examine dimensional changes. It was observed that the elastomeric impression materials are very resistant to disinfectants. Each reproduced a 20 µm line [30].

Conclusion

Within the parameters of this study, it was shown that addition silicone impression material can be safely disinfected by immersion in TTO for ten minutes without affecting the details of the reproduction and dimensional accuracy of the impressions.

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Table 2. Descriptive statistics for detail reproduction.						
Test groups	**N**	**Mean**	**Std-Deviation**	**Std-Error**	**Minimum**	**Maximum**
Control	**10**	**-0.5754**	**0.4168**	**0.1318**	**-1.379**	**-0.023**
0.25%TTO	**10**	**-0.5622**	**0.2699**	**0.08534**	**-0.895**	**-0.055**
0.5%TTO	**10**	**-0.5348**	**0.3405**	**0.1077**	**-0.995**	**0.107**
0.75%TTO	**10**	**-0.5344**	**0.4439**	**0.1404**	**-1.351**	**0.207**
1%TTO	**10**	**-0.4966**	**0.04957**	**0.01568**	**-0.595**	**-0.439**
2%Glutraldehyde	**10**	**-0.5007**	**0.05807**	**0.01836**	**-0.595**	**-0.435**