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Effect of Disinfection with Hypochlorous Acid on Wettability and Surface Roughness of Polyether Impression Material

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ABSTRACT

Dental impression can be contaminated through contact with patient's saliva, blood, or plaque and cross-contamination is avoided by disinfecting impression materials. Nevertheless, the disinfectants may affect the wettability and surface roughness qualities. This study aimed to investigate how the wettability and surface roughness of polyether impression material changed after being immersed in two disinfectants (2% glutaraldehyde for 10 min and 200 ppm hypochlorous acid for 15 min.). 60 polyether dental impression material specimens (Monophase Impregum, 3MESPE, Germany) were randomly categoried into three test groups of ten specimens for each test. A ring mold with a diameter of 30 mm and a thickness of 6 mm was used to prepare the specimens. The specimens were submerged in two disinfection solutions: 2% glutaraldehyde and 200 ppm hypochlorous acid. The control group did not get any disinfection. The wettability of the specimens was determined by measuring the contact angle with a Goniometer, while surface roughness was determined using a digital Profilometer. The data were submitted to a 5% variance significance analysis threshold. The results of this study show that wettability and surface roughness of polyether impression material indicate a non-significant difference as compared with the control group (P>0.05). Within the study's limits, 2% glutaraldehyde showed safe for 10 minutes of immersion disinfection, whereas immersion in 200 ppm hypochlorous acid for 15 minutes shows promise as an efficient disinfectant without compromising the polyether's wettability or surface roughness.

GRAPHICAL ABSTRACT

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Introduction

Dental impressions are used to precisely record and duplicate the shape of teeth as well as the connection of teeth to the other oral structures in the mouth of the patient [1]. When dental impressions come into contact with the oral tissue with blood, saliva, or plaque, they are almost probably contaminated with potentially dangerous germs. Dentists, dental assistants, and laboratory employees might be exposed to the infectious diseases due to this, which could lead to cross-contamination [2]. Disinfection procedures such as spraying and immersion of imprint material are widely used [3]. On the other hand, the immersion approach is recommended by the American Dental Association (ADA) because it permits the direct contact with disinfection solutions on all surfaces of the impression [4]. Although immersion disinfection minimizes the danger of cross-infection, changes in the dimensions of impression materials and a detrimental influence on the quality of the resultant cast have been often recorded [5, 6]. Therefore, there is a possibility that the dimensions of the dental cast prosthesis may vary, which will eventually have an effect on how well the final restoration will fit [7].

Daily dental practice often involves washing impression materials with tap water, as the Advisory British Dental Association Service recommended. However, although this may eliminate some of the bacteria attached to the surface of a dental impression, a considerable proportion still remains. Despite the presence of halogenated chemicals in the tap water of certain nations, the Advisory British Dental Association Service advises using tap water to rinse impression materials in routine dental treatment [8]. Over 90% of bacteria on the impression's surface are killed by this method [9]. However, a sizable fraction of the bacteria would survive. In light of the recent advice, disinfection solutions are encouraged [10]. Different perspectives on the optimal disinfection process lead it to be challenged to make a well-informed decision [11].

Sodium hypochlorite, chlorhexidine, alcohol, glutaraldehyde, and hydrogen peroxide are only some of the most widely used disinfectants [12]. Since there is no "one size fits all" disinfection for impression materials, it is crucial to choose a disinfecting chemical that has the strong antibacterial properties without altering the surface qualities of the imprint or dimensional stability [13].

Likewise, knowing that the market had a wide range of branded impression materials (reversible and irreversible hydrocolloids, polyethers, polysulphides, and silicones) and gypsum-based castings made it possible to use many different combinations of impression materials and disinfection. A disinfectant has to do two things: kill bacteria well and not change the size of the impression material or the gypsum model that comes out of it. This is important if you want a finished appliance with a proper function and fits well. Different opinions exist on whether the disinfecting technique makes the impression worse or changes it [14].

The elastomeric impression materials are widely used because of their various benefits. The most popular examples of such substances are polyvinyl siloxane and polyether. They constantly contact human spit and blood, transferring microorganisms to the stone cast [15]. The polyether substance is hydrophilic. The disinfecting process should be thorough enough without compromising the impression's integrity in size or finish. Although some research suggests that polyethers are unaffected by the immersion disinfectants, others have discovered that this treatment method decreases the dimensional stability of these hydrophilic materials. Furthermore, the vendor suggested applying disinfectants for the limited periods while handling polyether. The American Dental Association (ADA) recommends no more than 30 minutes of immersion for polyether impression materials [16].

Hypochlorous acid is present in all animals and kills various bacteria and viruses. Through the action of an enzyme called respiratory burst nicotinamide adenine dinucleotide phosphate oxidase, neutrophils, eosinophils, mononuclear

phagocytes, and B lymphocytes generate hypochlorous acid in response to damage and infection. The unsaturated lipid membrane is where hypochlorous acid binds most strongly, compromising cellular integrity. Hypochlorous acid is the most abundant species between 3 and 6 on the pH scale, and its antibacterial effects are most potent in this range [17]. The US Environmental Protection Agency and the Centers for Disease Control and Prevention consider hypochlorous acid a very high-level disinfectant due to its widespread usage worldwide. There is a wide range of bacteria and viruses that this simple chemical combination may kill quickly and effectively [18].

Glutaraldehyde is considered as a high-level disinfectant, and many studies suggest its use to disinfect polyether impression and the best suggested time for disinfection is 10 minutes that not to affect properties of impression material [19], so it has been used in this study as a positive control.

The null hypothesis was that there was no change in the wettability or surface roughness of polyether impression material after immersing in 2% glutaraldehyde or 200 ppm hypochlorous acid.

Materials and Methods

Preparation of specimens

Thirty samples of polyether impression material (monophase, 3M ESPE, Germany) were made per each test. These samples were split into control, positive control (2% glutaraldehyde), and 200 ppm hypochlorous acid. Both glutaraldehyde (2%, Mergen, Turkey) and hypochlorous acid (200 ppm, newly manufactured) were utilized as disinfectants.

The manufacturer's directions were followed and a 3M pentamix mixing machine was used fitted with disposable tips to blend the monophase impregum polyether impression. With the help of a custom-made mold, a disc-shaped piece 30 mm in diameter and 6 mm thickness was made. Before the mold was filled a little too much, it was set on a clean glass plate. Another glass slab of the same size was put on the top of the mold, and for 30 seconds, pressure was put on it by hand to make a perfectly flat specimen. After the required amount of time, the samples were taken out of a water bath kept at 35 °C to simulate the mouth's temperature. The ones that had problems on the outside were thrown away, and a new batch was asked for. The impression samples were handled with forceps, and then stored in a container to avoid any potential for contamination from the outside throughout the experiment.

Immersion disinfection

The 2% glutaraldehyde group was immersed for specimens for ten min. The 200 ppm hypochlorous acid group was immersed for 15 min, while the control group did not treat. All specimens in each group were rinsed under running water for 15 seconds, and then dried with forced air before testing.

Evaluation of wettability

To determine their wettability, all specimens' surfaces were measured with a VINO Contact Angle Goniometer (China) (Figure 1). The specimens were placed on the Goniometer's mechanical stage, which could be adjusted to accommodate any size or shape. One drop of distilled water was used to moisten the specimens' surface at room temperature, and this was done using a needle that had already been placed. The falling water was seen using a high-definition digital camera-equipped optics gear. A series of images were captured up to the point when the drop of distilled water made contact with the surface of the specimen. Within a minute of the drop landing, the contact angle was recorded. Each drop's contact angle was measured twice, once on the right and once on the left sides of the picture (Figure 2). The final value of the contact angle for each specimen was determined by averaging the two measurements. CAST 3.0-USA KINO Software was used to record the contact angle measurements at five locations on each specimen, and the mean of these values was then determined.

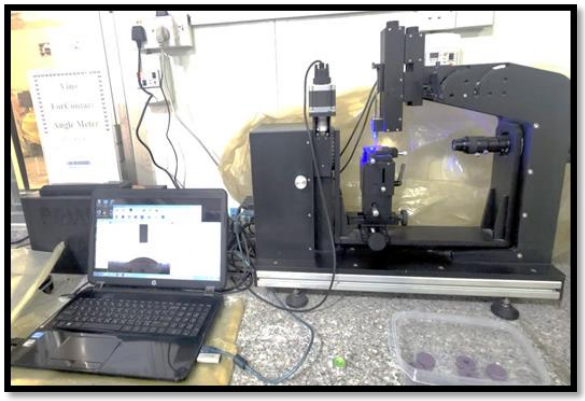

Figure 1: Contact angle goniometer with a high digital video camera and a monitor

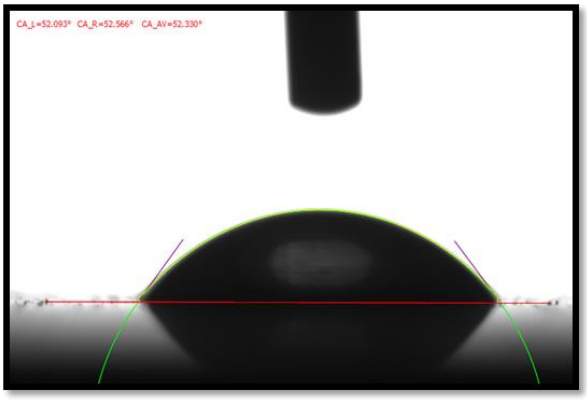

Figure 2: Contact angle measurement on both sides of the drop by software

Evaluation of surface roughness

The digital roughness tester, stylus type, contacting surface roughness (Ra) measuring unit (Profilometer, TIME Inc., China) with (0.001 m) accuracy was used to check the surface roughness of the specimens (Figure 3). Ra is a way to measure how rough the average surface of the specimen is [20].

During the measurement, the sample was placed on a stable and rigid surface. A diamond-tipped stylus made contact with the sample in a way that did not cause any resistance as it moved in the opposite direction. The equipment was set up so that the stylus tip would scan a length of 11 mm. The surface roughness was measured in three random places on each specimen, and then the mean was found. This process is done for several times for each specimen.

Figure 3: Digital roughness tester (profilometer)

Results and Discussion

Table 1 displays the average and standard deviation of contact angle measurements. When comparing Ra values across samples treated with different chemical disinfectants, no statistically significant changes were found (p>0.05).

Table 2 presents the average and standard deviation of Ra readings. When compared Ra values across samples treated with different chemical disinfectants, no statistically significant changes were found (p>0.05).

Table 1: Mean and SD for the contact angle of polyether impression materials subjected to chemical disinfection

Groups	N	Mean	SD	p-value
Control	10	40.03	1.68	0.285
2%Glutaraldehyde	10	40.76	1.50	
200ppm HOCL	10	41.12	1.38	

Table 2: Mean and SD for Ra of polyether impression materials subjected to chemical disinfection

Groups	N	Mean	SD	p-value
Control	10	0.412	0.036	0.744
2%Glutaraldehyde	10	0.403	0.050	
200ppm HOCL	10	0.417	0.037	

More than one strategy has been developed for cleaning and sterilizing impressions. Chemical disinfection may be achieved by spraying or immersing the area to be sterilized in a solution of chloride compounds, iodophors, 2% glutaraldehydes, or a combination of synthetic phenols [20].

Polyethers were chosen as the impression material because of their hydrophilic nature and sensitivity to the disinfection procedures. Numerous manufacturers provide polyether imprint materials. However, it is advised that impression materials be studied separately to determine the effectiveness of the disinfectant and offer a suitable disinfection approach. Monophase [19] Impregum was chosen for this study because it is a widely used polyether impression material among dental practitioners.

Spray disinfection, immersion disinfection, and mixing the disinfectant in the gypsum before dumping the model are the three main chemical disinfection techniques. Because it ensures that the whole imprint and impression tray will be submerged in the disinfectant, immersion disinfection is the gold standard. Furthermore, the time intervals recommended by ADA and CDC for the immersion disinfection of elastomeric impression materials should not exceed 30 min [21, 22].

Finding a disinfectant that is both efficient against bacteria and readily accessible, inexpensive, user-friendly, and unlikely to alter the basic properties of imprint materials is crucial. One liter of hypochlorous acid may be made in 8 minutes from one liter of water, one gram of table salt, and vinegar. This is because the cost of the necessary production equipment has decreased, and the manufacturing procedure is straightforward and inexpensive [23]. At a concentration of 200 ppm, hypochlorous acid is effective in decontaminating inert surfaces carrying noroviruses and other enteric viruses [16], so it was used in this study.

Immersion disinfection with 2% glutaraldehyde for 10 minutes or with 200 ppm hypochlorous acid for 15 minutes did not alter the wettability of polyether impression materials, as demosntrated by the current study and consistent with the reports of earlier studies [19]. Thus, the null hypothesis can be accepted.

Glutaraldehyde is a saturated dialdehyde that is widely used as a high-level disinfectant. However, the findings of the present study reveal that glutaraldehyde is the effective immersion disinfection for Impregum when applied for just 10 min [19].

Surface tension is the contractile force inside a liquid that promotes drop formation and

prevents it from spreading over a solid surface. The degree to which a drop spreads over a solid surface is referred to as wetting. The advancing contact angle is a measure of a surface's wettability by a certain liquid. The higher the angle, the greater the possibility of air trapping on the surface, which might lead to cavities in the impression or dies. Wetting the impression surface with a die stone is crucial since it has been proven that the contact angle of water on the impression material is proportional to the number of bubbles created in the dies poured from the material [24]. The result of this study indicate that the contact angle for the three test groups had non-significant difference,and this is in agreement with previous studies [25].

The surface's roughness is also a significant problem. The accuracy with which an impression material captures the details of the mouth cavity should be reflected in the dental cast and, ultimately, in the prosthesis. Casts formed from rough impressions will have a rougher surface than the impression. Therefore, disinfection and sterilization treatments should not alter the impression's roughness. With a roughness value below 0.2 μm, further reduction in food or plaque development cannot be forecasted, and the considerable plaque buildup may be expected beyond this threshold; any prosthesis should preferably have a roughness value of less than 0.2 μm. The rougher surfaces on a prosthesis may readily cause inflammation of the soft tissues that support it [26-28]. Chemically disinfected samples investigation. This result is consistent with the findings from other studies [29].

Some research suggests that disinfectant treatments alter the surface chemistry of an impression material, perhaps resulting in a change in hydrophilicity and surface roughness. Hydrophilic dental impression materials, such as polyether, may be difficult to sterilize. Iodophor, on the other hand, shows promise as an efficient disinfection for Impregum soft without compromising the wettability of the material or the surface roughness.

Conclusion

Within the parameters of the study, it was determined that a concentration of 2% glutaraldehyde was safe for the immersion disinfection for ten minutes, while a concentration of 200 ppm hypochlorous acid showed promise as an effective disinfectant that would not impact on the wettability or the surface roughness of the material.

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Authors' contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

The author declared that they have no conflict of interest.

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