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Influence of Hypochlorous acid on Surface Roughness and Wettability of Addition Silicon Impression Material

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ABSTRACT
Patient saliva, plaque, or even blood can contaminate dental impressions. Disinfecting impression materials with disinfectants can help prevent contamination. However, these chemicals could alter the surface's roughness and wettability.

Objective: This research aimed to investigate how the surface roughness and wettability of addition silicon impression [polyvinyl siloxane (PVS)] change after it was immersed in two different disinfectants [5.25% sodium hypochlorite (NaOCl) for ten minutes and 200 ppm hypochlorous acid (HOCl) for 15 minutes].

Material and methods: Sixty PVS samples (Express STD, 3MESPE, USA). Specimens were separated blindly into three groups, with ten specimens in every group. The specimen was prepared using a ring mold, thirty millimeters in diameter, and three-millimeter wall thickness samples were immersed in two disinfection solutions: NaOCl at 5.25% group and HOCl at 200 ppm group. The group serving as the control received no disinfection. The samples' surface roughness (Ra) was measured using the contact profilometer, while contact angles were measured using a goniometer to determine wettability.

Results: This investigation's results indicated that the PVS's Ra and wettability significantly differed from those of the control group. Within the research's limits, 5.25% Naocl for 10 minutes of immersion disinfection influenced the surface roughness and wettability of PVS. In comparison, immersion in 200 parts per million HOCl for 15 mins was more effective as disinfection without affecting the surface roughness or wettability of PVS.

Conclusion: Within the limits of this study, 200 ppm HOCl showed promise as an efficient disinfectant that would not adversely affect the wettability and Ra of the impression material.

Keywords: Addition silicon, Hypochlorous acid, Surface roughness, Wettability, Dental impression disinfection.

INTRODUCTION

Dental impressions are a critical step in procthetic dentistry [1]. A dental practitioner runs a considerable risk of getting and/or transferring dangerous infectious diseases. Equipment supplies, tools, impressions, and casts might all be potential sources of microbial infection since they could make it easier for diseases to spread via saliva and blood. Consequently, more care must be used while fabricating, handling, and developing prosthodontic restorations [2].

In a healthy patient, there is a low danger of contamination from other patients, but in a patient with a debilitating illness or weakened immune system, the risk of cross-contamination is considerable and poses a major hazard if proper precautions are not taken [3]. Thus, a technique that prevents cross-infection without altering the Ra and wettability of the impressions is required [4]. Numerous studies have focused on removing bacteria with various disinfection solutions without altering the Ra and wettability of the impressions [5,6]. Changes in the surface roughness and wettability of the impression can significantly impact the success of the (denture, crown, bridge, inlay, and onlay) placed in the patient's mouth. This has been essential for dentists to resist disinfecting impressions to prevent loss of impression features. Immersion techniques using different disinfectants and sprays have been measured and shown to be effective [1]. Immersion is the most effective method. As the disinfectant solution comes into touch with all sides of the impression tray and material, it can sterilize them thoroughly. The ADA council on dental materials recommended spray disinfectant for irreversible hydrocolloid and immersion disinfection for additional silicone [1]. The most often used disinfectants include sodium hypochlorite (NaOCl), chlorhexidine, alcohol, glutaraldehyde, and hydrogen peroxide [7]. Because there is no universal disinfectant for impression materials, it is critical to choose a chemical disinfectant with effective antibacterial capabilities that do not alter the surface qualities of impression material [8].A disinfectant must eradicate bacteria while maintaining the details of the impression material and cast. This is crucial if you want a product that fits and functions properly. Different viewpoints exist regarding whether the disinfection process alters or worsens the impression [9].

Because of its many benefits, elastomeric impressions are often used. The most common of these materials is polyvinyl siloxane. They continually come into contact with human saliva and blood, spreading bacteria to the cast [10]. The disinfection process should be comprehensive enough to preserve the integrity of the impression's size and finish. Despite the statements of some researchers that immersion disinfectants do not affect polyvinyl siloxane, other has discovered that this immersing reduces the dimensional stability of these elastomer impressions. The American Dental Association (ADA) suggests a maximum immersion time of 30 minutes for silicon impression materials [11]. Numerous studies have focused on removing bacteria with various disinfection solutions without altering these impression and cast properties [12].

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Hypochlorous acid is found in all species and is harmful to numerous bacteria and viruses. In reaction to injury and infection, neutrophil, eosinophil, mononuclear phagocyte, and lymphocyte produce HOCl via respiratory burst nicotinamide adenine dinucleotide phosphate oxidase [6]. Hypochlorous acid binds most strongly to the membrane of unsaturated lipids, impairing cellular integrity. Between 3 and 6 on the pH scale, hypochlorous acid is the most prevalent species, and its bactericidal effects are strongest in this range [13]. Due to its global prevalence, The EPA and CDC of the United States both believe hypochlorous acid is an extremely potent disinfectant. This simple chemical combination may rapidly and efficiently kill various bacteria and viruses [14].

Sodium hypochlorite is a high-level disinfectant, and numerous research indicates that it is used to disinfect elastomer impression materials. According to the ADA of infection control [15]. the optimal period for disinfection that does not influence the qualities of impression material is 10 minutes. Hence it was utilized as a positive control in this work.

The null hypothesis(H0): This study was conducted to investigate the Influence of hypochlorous acid on surface roughness and wettability of addition silicon impression material after considering the following proposed research hypotheses where:

1. The null hypothesis (H0) states that the immersion addition silicon impression material in HOCl solution has no adverse effect on surface roughness and wettability.
2. The alternative hypothesis (H1): States that the immersion of addition silicon impression material in HOCl solution will adversely affect its surface roughness and wettability.

MATERIALS AND METHODS

Specimens preparation: For every experiment, 30 samples of addition silicon impression materials were created (Express STD, 3M ESPE, USA). Disc-shaped samples, 30 millimeters in diameter and 3 millimeters in thickness, were provided. The samples were separated into control, positive control (5.25% NaOCl group, and 200 ppm HOCl group). We employed sodium hypochlorite (5.25 %, Chloraxid, Poland) and hypochlorous acid (200 ppm, freshly manufactured) as a disinfectant.

After reading the manufacturer's instructions, we mixed the Express PVS using a 3M pentamix fitted with disposable tips. The 30 mm in diameter and 3 mm thick disc-shaped piece was formed using a custom-made mould. The mould was placed on a sterile glass plate before being filled. To create a completely flat sample, we placed another glass slab of a similar size on top of the mold and pressed it down by hand for 30 seconds. To replicate the conditions within a human mouth, the samples were taken to a water bath after the required period and stored at 35 degrees Celsius. To prevent outside contamination during the experiment, tweezers were used to handle the impression samples before being placed in a sealed container.

Immersion disinfection:

The 5.25% NaOCl group put their samples for 10 minutes, the 200 ppm Hocl group for 15 minutes and the control group had no treatment. Before testing, under running water, each specimen was washed for 15 sec and then dried using a triple syringe.

Evaluation of surface roughness:

A roughness tester (contact Profilometer) with 0.001 μm accuracy was used to measure the samples' Ra, as shown in figure (1). This equipment has a sensible diamond probe (surface analyzer) that may be used to detect surface irregularities. It has been set up so that each sample receives three readings from the device, which rests each sample on a stable, rigid surface. The reading should show on the digital scale recorded in the surface roughness parameter when the stylus touches the initial point and move over the sample surface. This parameter is the average sequence of single measurements of surface peaks and valleys (ASME B46.1, 2009). Later, the roughness value was reported as the mean of the three values [16].

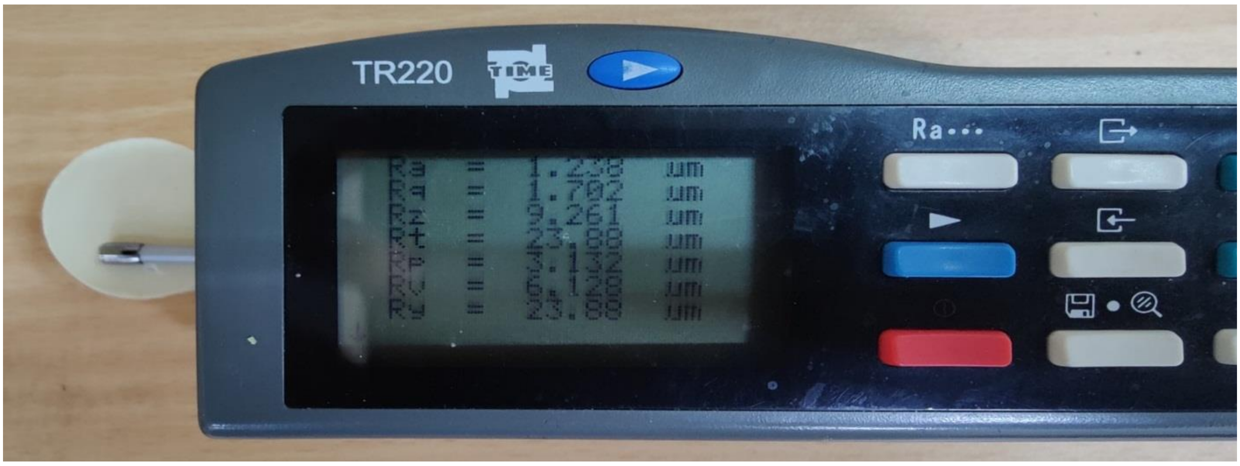

Figure (1): contact surface roughness tester (profilometer)**.**

Evaluation of wettability:

A VINO Contact Angle Goniometer (China) [Figure 2] was used to test each sample surface to determine how wet they were. The mechanical stage of the goniometer, which could be adjusted to fit any form or size, was used to place the samples. The surface of the samples was moistened with one drop of distilled water at room temperature.

A needle that had already been inserted was used for this procedure. A high-definition digital camera and optical tools were used to observe the dropping water. Before the drop of distilled water contacted the sample's surface, many photographs were taken. After the drop landing, the contact angle was measured within a minute. For each drop, we measured the contact angle twice. Each sample's final contact angle value was determined by averaging the two readings. Five locations on each sample were used to quantify the contact angle using the CAST 3.0-US KINO program. Then, These values' average was calculated.

Figure (2): wettability testing machine

Statistical analysis

A one-way analysis of variance (ANOVA) was used to analyze the differences between the study groups. Furthermore, the least significant difference (LSD) post-hoc test was used to compare the mean value of each experimental group. Statistically highly significant (HS) was considered when a probability (P) value $\leq$ 0.01. (P) value of $\leq$ 0.05 was deemed to be significant (S), while (P) value > 0.05 was considered non-significant (NS). IBM SPSS® software (the statistical package for social sciences) version (23.0) analyzed the computerised data.

Ethical approval: The Ethical Committee of Baghdad University College of Dentistry approved this research. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

3. RESULTS

The average and standard deviation of surface roughness measurements are seen in table (1). There were significant changes (p > 0.05) in the samples treated with different chemical disinfectants. Table (2) showed that the LSD test was utilized to compare the mean values of the different study groups. The test showed that all of the study groups were different in significant ways.

Table (1): Mean and standard deviation (SD) for the surface roughness of PVS materials

Compared study groups	Mean differences (I-J)	Sig.	95%confidence interval Lower bound	Upper bound
Control NaOCl	-.088	.000	-.096	-.081
NaOCl HOCl	.394	.000	.386	.401
Control HOCl	.305	.000	.297	.313

Table (2): Multiple comparisons of surface roughness test between groups using LSD test

Groups	N	Mean	SD	p-value
Control	10	.007	.728	0.000
5.25% NAOCl	10	.004	.817	
200ppm HOCl	10	.008	.422	

In addition, table (3) showed the mean and SD of contact angle measurements. Comparing the wettability values of specimens treated with various disinfectants solution revealed significant differences (p>0.05). Table (4) demonstrated that an LSD test was performed to compare the mean value across study groups. The test indicated a statistically significant difference between all study groups except between the control group and the HOCL group, where the difference was not statistically significant.

Table (3): Mean and standard deviation for the contact angle of addition silicon impression materials immersed in disinfectant solutions

Groups	N	Mean	SD	P-value
Control	10	1.83	67.45	0.000
5.25% NAOCl	10	1.28	62.50	
200ppm HOCl	10	.423	67.99	

Table (4): Multiple comparisons of contact angle test between groups using LSD test

Compared study groups	Mean differences (I-J)	Sig.	95%confidence interval Lower bound	Upper bound
Control NaOCl	**4.943**	**.000 (S)**	**3.483**	**6.403**
NaOCl HOCl	**-5.709**	**.000 (S)**	**-7.169**	**-4.248**
Control HOCl	**-0.766**	**.407 (NS)**	**-2.226**	**0.694**

4. DISCUSSION

The potential for cross-infection and contamination through dental impressions has long been discussed [17]. The ADA has recommended high disinfection criteria for dental equipment, including dental impressions, to prevent cross-infection among dental team members [18]. Widely utilized for both diagnostic and definitive impression processes are elastomer impression materials. The impression material can be disinfected with any appropriate disinfectant by immersion or spraying. Elastomer impressions and dental casts that have not been disinfected harbor many bacteria. The study emphasizes that washing impressions with water alone is ineffective in disinfection. Therefore, dentists must disinfect the Elastomer impression before sending it to the laboratory. Although infection control is highly prioritized in dental clinics, it is typically neglected in laboratories [19].

Some bacteria survive the cleaning of impressions and will eventually be transferred to the resulting dental cast. Viruses and germs from the oral cavity are carried on contaminated dental casts, with some surviving for extended durations [20]. Therefore, minimizing the bacterial load on the gypsum cast is significantly more crucial than on the tooth impressions [21]. Dentists are responsible for preventing cross-contamination in dental clinics, including cleaning impressions well before sending them to the dental laboratory [22, 23]. **Jagger *et al.*** **[21]** reported in a survey of dental technicians in the United Kingdom that just 4% of laboratories cleaned impressions. In comparison, 56% did not know whether dental office impressions had been disinfected [24]. Dental labs receive many impressions, some of which are contaminated with blood and food particles due to improper sterilization. According to studies, 67% of all laboratory-sent dental impressions, crowns, dentures, wax, and other materials include pathogenic bacteria [25].

There have been studies on the immersion of elastomer impression material with various disinfection solutions to investigate its effect on some physical properties of impression material, so the current study used hypochlorous acid as a new disinfection solution to the immersion of additional silicon impression material because it has several advantages, such as disinfection of the impressions and casts with a minimum adverse effect on the essential properties of addition silicon impression material.

Wettability is the capacity of a liquid to wet a surface and its propensity to spread across that surface. The viscosity of a liquid affects a surface's wettability, surface imperfections, and pollution.[26] When preserving the physical properties of impression material, the type of disinfectant and the time the impression spends in the disinfectant are crucial factors. Similarly, the effect of disinfection on the wettability of impression materials is a crucial factor since wettability is known to directly affect the size and number of air bubbles that may form in cast models poured from an impression material [27].

In 1990, **Pratten *et al.*** **[28]** discovered that short-term immersion disinfection could change the wettability of dental impressions. This research showed that disinfection with hypochlorous acid for 15 minutes did not affect the wettability of the tested impression materials. Similar to prior research on PVS materials[28,29]. Polyvinyl siloxane impression material test results for wettability do not match [30]. This difference may be attributable to using different disinfectants or immersion times. In addition, the results of this study showed that immersion of PVS impression in sodium hypochlorite for 10 minutes significantly decreased the contact angle, indicating an increase in the wettability of PVS impression. This appears to confirm recent research on the addition of polymerized silicone impression materials [30]. This because the surface and chemical composition may be altered throughout the disinfection process by diluting or absorbing particles in the impression material, increasing surface roughness, and increasing surface wettability.

In the surface roughness test, the null hypothesis was rejected because elastomers subject to chemical disinfection solutions (5.25% sodium hypochlorite and 200 ppm hypochlorous acid) exhibited a statistically significant change in surface roughness. Surface roughness is an additional crucial factor assumed that impression materials would accurately replicate the details of the oral cavity and that the dental cast and prosthesis will reflect this accuracy. Procedures for disinfection and sterilization should not affect the roughness of the impression, as castings created from rough impressions will have a rougher surface than the impression itself. The roughness value of a prosthesis should ideally not exceed 0.2 μm, the value below which no further reduction in food or plaque buildup may be noticed and the value above, which significant plaque accumulation is expected[31, 32].

According to the current study, surface roughness considerably increased in the Naocl group compared to the control group, which was similar to previous findings [30]. This could be due to the surface characteristics, and the chemical composition of the impression material could be altered during the disinfection process by diluting or absorbing the surfactant present in the impression material increasing surface roughness. This is in disagreement with **Al-Kheraif** [32] and **Kotha *et al.*** [33]. This difference could be attributable to using various disinfection solutions, test measures, or impression materials.

Also, the Ra was significantly decreased in the Hocl group compared to the control group. This result may be because of the reaction of hypochlorous acid with silicon, which generates a thin silicon dioxide, a thin layer covering the surface of silicon material. The surface becomes more polished without any textured surface features [34]. While, this result disagrees with **kadhim and Abass** [6] and **Ghadeer *et al.*** [35]. This disagreement may be due to using a different material or test measurement.

Further studies are required to study the properties of elastomers after immersing in a hypochlorous acid disinfectant.

5. CONCLUSIONS

Within the limits of this study, 200 ppm HOCL showed promise as an efficient disinfectant that would not adversely affect the wettability and Ra of the impression material.

Data Availability: The data used to support the findings of this study are available from the corresponding author upon request.

Declaration of Interests: The authors declared that there is no conflict of interest regarding the publication of this article.

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