Original Article

Effect of disinfection on the dimensional stability of vinyil siloxanether

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ABSTRACT

Knowing the detailed pattern of the teeth and the surrounding tissues is important to make a good impression. Vinyl siloxanether is a promising option to save the characteristics of the impressions after disinfection. This study was designed to evaluate the effect of disinfection on dimensional stability of the light consistency of vinyl siloxanether. The samples were made according to the recommendation of the American Dental Association (ADA). Forty five impression ingots of vinyol siloxanether were made and divided in three groups . First group samples were immersed in a 5.25% sodium hypochlorite solution. Second group were placed in a 2% deconex solution and last group considered as the control group. Measuring the dimensional changes on the samples was done by Digimizer image analysis software with an accuracy of 1 micron immediately, after 1-week and 2-week storage. The sodium hypochlorite group showed the highest dimensional changes in all time frames. There was a significant difference in dimensional changes between groups after two weeks ($F=19.52$, $p=<0.001$). There was a significant difference in dimensional changes between the sodium hypochlorite group and the deconex group and also between the control and the sodium hypochlorite group (mean differences=0.02, -0.03; 95%CI=(0.01-0.04), (-0.04- -0.02), respectively; both p-values<0.001). Dimensional changes increased over time ($p<0.001$). Light-bodied vinyl siloxanether shows acceptable dimensional stability after disinfection. Immersion in the deconex solution for two minutes causes fewer changes.

Keywords: Vinysiloxanether , Dimensional stability, Disinfection, Impression material

Introduction

The impression material used in restorative dentistry should be dimensionally stable[1]. Several patient-related factors such as oral hygiene, periodontal condition, and oral and maxillofacial defects, in addition to laboratory and technique-related factors, such as impression material specificities and trays are linked to the accuracy of dental impressions [2]. For this purpose, different impression materials are used, one of which is elastomeric impression materials, physically or chemically cross-linked rubbery polymers [1, 3]. However, elastomeric materials undergo dimensional changes as a result of polymerization, which is also affected by storage and disinfection conditions [3].

The dental impression that comes into contact with contaminated saliva and blood should be disinfected after leaving the patient's mouth and before pouring the casts due to cross-contamination [4]. However, the stability and precision of the dental impressions can be affected by disinfection [5]. Therefore, the disinfection method that brings the least dimensional changes is crucial for the aesthetic and functional performance of the prosthesis [6]. This process must be carried out by spraying of the disinfectant or immersion in it and using an agent that acts against various pathogens [7]. Impression materials show different behavior and a compatible disinfectant should be taken for each material [8]. Among the elastomeric impression materials, polyether and addition silicones are the most widely used, which have been evaluated for dimensional stability in previous studies and have shown favorable results [9-12]. However, some studies indicate dimensional changes of these materials after disinfection. According to the study of Lepe *et al.*, these impression materials show significant dimensional changes after 18 hours when disinfected with 2% glutaraldehyde compared to the non-disinfected group [13].

Vinyl siloxanether which, according to the manufacturer is a combination of polyether and vinyl polysiloxane [14] is a new generation of elastomeric materials available in different setting times and consistencies, with better hydrophilicity that may enhance dimensional accuracy in addition to better detail reproduction and wetting characteristics when applied to the tooth surface [2] also it has high elasticity and tear resistance [15]. EXA'lence, a vinyl polyether silicone product, has been evaluated in a number of studies for stability and surface detail reproduction after disinfection when used as a dental impression material [14, 16-19]. The current study aims to evaluate the dimensional stability of the other vinyl siloxanether product currently available, Identium after immersion in two commonly used disinfectants in dentistry, sodium hypochlorite, and deconex.

Materials and Methods

The light consistency of vinyl siloxanether (Identium; Kettenbach) was used in the current study. According to the recommendation of the American Dental Association (ADA) [20], we used a ruled metal block with parallel lines and a ring to prepare samples (**Figure 1a**). The piece was made with Computer Numerical Control (CNC) lathe. The two CD and C'D' lines and the distance between these two lines, were considered as a measure of dimensional changes (**Figure 1b**).

Figure 1. metal block and ring.

First, the metal block and the mold were placed in a container with lukewarm water for 15 minutes. The impression material was injected on the surface of the metal block, which was limited by the metal mold. A glass slab was placed on the impression material and the assembly was transferred back into the water. Finally, a 1 kg weight was placed on it to simulate hand pressure on the tray. To ensure sufficient hardening of the material, after three minutes of the setting time, the ingots were removed where the effect of the metal block lines was visible on it (**Figure 2**).

Considering the average dimensional changes with sodium hypochlorite 0.0025±0.0149 and with Dettol 0.0003±0.0126 according to the study by Mikaeel *et al.*(14), type 1 error 0.05, and study power 80%, 15 samples were selected in each group using G*Power. The samples prepared from the impression material were placed in three different groups (15 samples in each group). According to the manufacturer's advice, the samples in the first group were immersed in a 5.25% sodium hypochlorite solution (Whitex; Shemin) for 10 minutes. The second group was placed in a 2% deconex solution (Solarsept; Borer) for two minutes. After disinfection, samples were rinsed with water and dried with gauze. The third group was considered as the control group.

To perform measurements on the samples, a mold was designed using high viscosity c-silicon impression putty and placed in the direction of the samples and the ruled block so that the sample was placed next to the metal block at the same level and height . The image of each sample was taken next to the metal block by means of the imaging camera, which was adjusted and fixed at a distance of 20 cm from the set and perpendicular to it with the help of a stand. For more accurate measurement, the center of the image was set at the intersection of the sample with the metal block that had the same diameter. Images were prepared under the same and reproducible conditions (specified and constant distance and camera angles) for all samples (**Figure 2**).

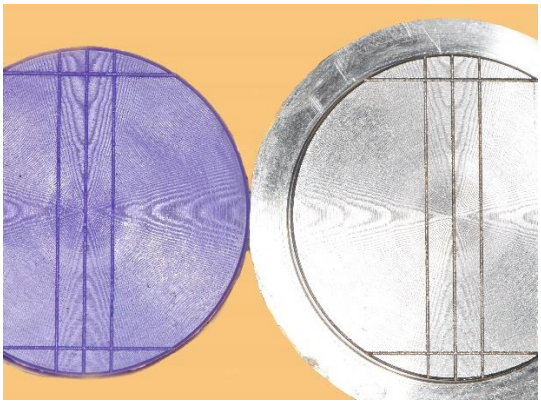

Figure2. image taken for accurate measurements

The distance between CD and C'D' lines on the metal block was measured by a 3D scanner (AutoScan-DS-EX; Shining 3D Tech Co., Ltd) with an accuracy of 10 microns and considered as a reference size (**Figure3**).

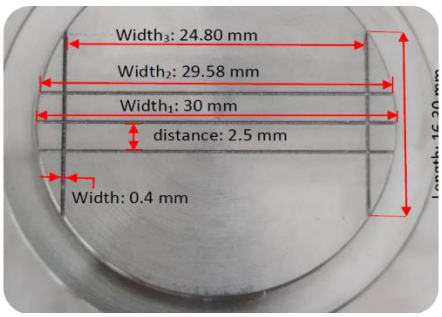

Figure 3. measurements confirmed by 3D scanner

Measuring the distance between the CD and C'D' lines on each of the samples was done by Digimizer image analysis software using the reference mentioned on the metal block, with an accuracy of 1 micron. The measurements were reassessed to confirm the repetition and in case of discrepancy, the average values were considered. After the initial measurement, the

samples were kept in closed containers at room temperature and the measurements were repeated one and two weeks later under the same previously mentioned conditions.

Statistical analysis

The mean and standard error were used to report the quantitative data. To ensure data normality, the Shapiro-Wilk test was applied. One-way analysis of variance (ANOVA) was used to compare dimensional changes between the three groups at each time point. The repeated measures ANOVA was used to find the differences among dimensional changes in measurement time points in each group. In all tests, statistical significance was considered at $p<0.05$.

Results and Discussion

In this study, the effect of disinfectants on the dimensional stability of vinyl siloxanether (Identium) (light body) impression material was evaluated in 45 impressions discs of which fifteen were disinfected with deconex and 15 with sodium hypochlorite 5.25% . Fifteen samples were taken as the control group.

Mean dimensional changes immediately, one, and 2 weeks after disinfection are shown in **Figure 4**. The slope of the dimensional changes in the impressions that were disinfected with sodium hypochlorite or deconex was mild in the first week and almost similar to each other, but then increased in the second week. In the control group, the slope of dimensional changes in the first and second weeks were similar.

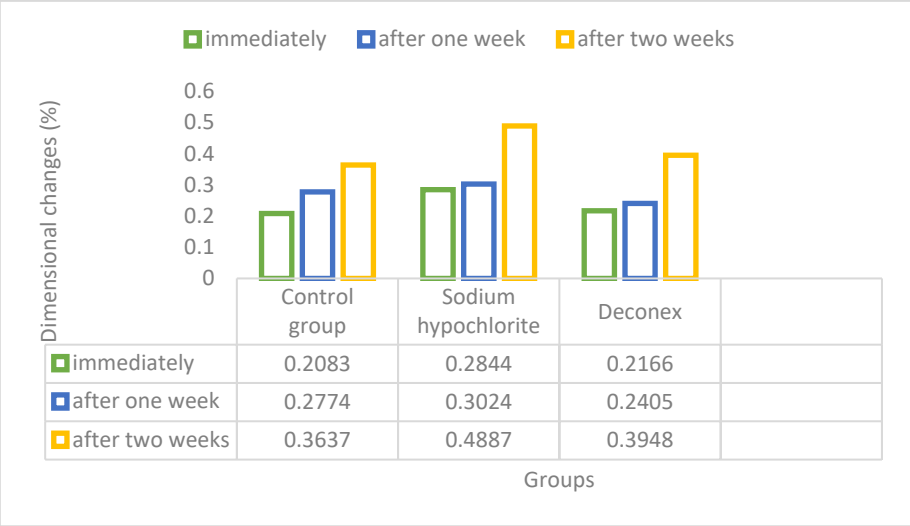

Figure 4. mean dimensional changes (%) in three groups and measurement times

Impressions that were disinfected with sodium hypochlorite showed the highest dimensional changes compared to the other groups in all time frames. Data distribution was normal both in groups and time frames ($p>0.05$, Shapiro-Wilk test). There was a significant difference in dimensional changes between groups after two weeks of disinfection using one-way ANOVA ($F=19.52$, $p=<0.001$) (**Table 1**).

Post hoc analysis (Tukey test) showed that there was a significant difference in dimensional changes while comparing the sodium hypochlorite group with the deconex group and also the control group (mean differences=0.02, -0.03; 95%CI=(0.01-0.04), (-0.04- -0.02), respectively; both p-values<0.001). there was no significant difference between the control and deconex groups (mean difference=-0.08, 95%CI= (-0.021-0.1), p=0.302).

Considering the normality of data in every group and the results of the sphericity test (p=0.114 in the control group, p=0.668 in the sodium hypochlorite group, and p=0.950 in the deconex group) repeated measures ANOVA was used to compare the dimensional changes between time frames after disinfection in each group. The results of the analysis showed that dimensional changes increase significantly over time ($p<0.001$ in all groups) (**Table 1**).

Table 1. Dimensional changes after disinfection in three groups

		Dimensional changes (%) mean± SE (Min, max)			df	F	p-value∞
		Control group (N=15)	Sodium hypochlorite (N=15)	Deconex (N=15)			
Time after disinfection	Immediately	0.2083±۰/۰۰۴۸ (0.1330, 0.3104)	0.2844±0.0059 (0.1290, 0.4233)	0.2166±0.0060 (0.0604, 0.3346)	2	3.40	0.053

After one week	0.2774± (0.1774, 0.3991)	0.3024±0.0058 (0.1572, 0.4274)	0.2405±0.0057 (0.0864, 0.3669)	2	2.10	0.135
After two weeks	0.3637±0.0042 (0.2500, 0.4596) [€]	0.4887±0.0032 (0.4153, 0.5604) [¥ €]	0.3948± (0.2983, 0.4919) [¥]	2	19.52	<0.001*
df	2	2	2			
F	30.32	25.08	32.20			
p-value**	<0.001*	<0.001*	<0.001*			

[∞]One way-ANOVA

[€] There was a significant difference between the control and the sodium hypochlorite group

[¥] There was a significant difference between the sodium hypochlorite group and the deconex group

*Significant at the 0.05 level.

** repeated measures ANOVA

In the present study, the dimensional stability of vinyl siloxanether (light-bodied) was evaluated using two commonly used disinfectants in dentistry. According to the protocol of the ADA specification 19, standardized stainless steel dies and metal rings were used for the preparation of the impression samples [20]. On average, the dimensional changes of the ingots obtained from the impression material in all groups and at different time points were below 0.5% which is consistent with the previous studies and below the acceptable limit of the ADA specification 19 [11, 14, 16-18, 21, 22]. The highest mean percentage of shrinkage (0.4887± 0.0032%) was related to the group disinfected with 5.25% sodium hypochlorite which was observed two weeks after disinfection and it was significantly higher than the other groups. Over time, dimensional changes increased significantly in both disinfected and non-disinfected groups. The results of the current study are similar to the previous ones showed that dimensional changes occur over time in all groups regardless of storage conditions.

Despite recent advances in 3D imaging and digital dentistry, traditional molding methods are still important [2]. There is currently no general conclusion about the method of dental impression disinfection. According to the literature, immersion of dental impressions in chemical disinfectants seems to be the most effective method to prevent the transferring of pathogens to the casts without considerable dimensional shrinkage [5]. However, the chemical reactions with the disinfectant can cause dimensional changes in the impression material. Vinyl siloxanether is a new type of elastomeric impression materials that is a combination of polyethers and vinyl polysiloxanes. Its behavior such as dimensional stability, tear resistance, and flexibility under different conditions has been examined in a limited number of studies [17, 18, 23] .

A recent study compared the dimensional stability of different impression materials using a traveling microscope. Similar to the current study, vinyl siloxanether (Identium) was used. Vinyl siloxanether exhibited less dimensional change compared to polyether or polyvinyl siloxane. Light-bodied vinyl siloxanether had a more dimensional change than medium-bodied vinyl siloxanether (mean value 0.05370 vs. 0.05330 respectively). Considering surface detail reproduction, 90% of the vinyl siloxanether impressions were acceptable [24]. Altıntaş *et al*. also used a similar impression material as the current study and prepared the impressions in a similar way to evaluate the surface roughness. Disinfected light-bodied vinyl siloxanether (Identium) showed the highest surface roughness compared to the other disinfected materials (polyvinyl siloxane and polyether). Ra values were significantly higher in impressions that were disinfected with sodium hypochlorite for 10 minutes. For the vinyl siloxanether group, the Ra values of the impressions that were treated with CaviCide for 3 minutes were significantly lower than the group treated with sodium hypochlorite for 10 minutes [7].

Soganci *et al*. evaluated the dimensional stability of vinyl polyether siloxane (EXA'lence) and polyether (Impregum) using the 3D scanner and software. Impressions were disinfected with 5.25% sodium hypochlorite and glutaraldehyde by immersion. Except for a significant difference between vinyl polyether siloxane and polyether at 120–180 micron intervals and before disinfection, they recorded no significant difference in dimensional changes between the two impression materials disinfected with two chemicals at different measurement times [16].

Walker *et al*. studied the dimensional integrity of dental impressions based on the method of ADA specification 19. They concluded that vinylpolysiloxane (Aquasil Ultra) impressions that were disinfected using dual phenol for 10 minutes and 0.5% sodium hypochlorite for 10 minutes or 1 hour and polyether impressions (Impregum PentaSoft) that were immersed in dual phenol for 10 minutes showed dimensional changes up to 0.40% after two weeks. In both vinylpolysiloxane and polyether groups, no significant difference was observed between disinfected and non-disinfected impressions one and two weeks after disinfection. However in the polyether group, 24 hours after disinfection, all disinfected materials showed a significant expansion compared to the non-disinfected group. Dimensional changes significantly increased after the first week in both impression materials whether they were disinfected or not [11]. Compared to the present study, they used a lower concentration of sodium hypochlorite and used different molding materials.

The results of our study showed that there was no significant difference in the dimensional changes of the vinyl polyether silicone (light body) between the disinfected and control groups, immediately and one week after disinfection. There was a significant difference in the dimensional changes in the second week between the group disinfected with sodium hypochlorite and the other two groups but clinically acceptable.

Similar to the current study, Sinobad *et al*. showed notable dimensional changes in the group of impressions treated with 5.25% sodium hypochlorite (up to 1.89% after one week). Condensation and addition type silicone impressions and epoxy resin master mode were used in this study [21]. In the study by Mikaeel *et al*. dimensional accuracy and surface detail reproduction of polyether, vinyl polyether silicone, and polyvinyl siloxane impressions after disinfection were evaluated by microscope. In this study, maximum dimensional changes of vinyl polyether silicone impressions occurred 48 hours after disinfection with 5.25% sodium hypochlorite (mean± SE % dimensional changes 0.0123 ± 0.0049 using the immersion technique and 0.0127 ± 0.0057 using the spray technique). Dimensional changes were significantly different immediately after disinfecting with sodium hypochlorite and 48 hours later [14].

In the current study, the use of deconex disinfectant had little effect on dimensional stability compared to the control group and unlike the sodium hypochlorite group, it was not significant in one and two weeks after disinfection. The maximum dimensional changes in this group were recorded as 0.3948± in two weeks after disinfection. This is consistent with previous studies [8, 25] that have evaluated dimensional changes of elastomeric materials following treatment with alcohol.

Nassar *et al*. investigated the dimensional stability of vinyl polyether silicone (EXA'lence) with a method similar to the present study. The disinfectant they used was 2.5% glutaraldehyde. At the time immediately and one week after disinfection, there was no significant difference comparing the dimensional changes in the disinfected and non-disinfected groups of light-bodied material which is consistent with the current study. The difference in the extra light-bodied regular set group was significant one week after disinfection which was not investigated in the present study. After two weeks, the difference in dimensional changes between the light-bodied group (fast set) was significant [17]. The present study also showed the difference between the groups after two weeks.

Bonding arrangements in polymer chains and cross-linking lead to a contraction in elastomeric chemicals [17]. After disinfection, dimensional changes in dental impressions occur following a chemical reaction with the disinfectant, and materials such as polyether have water absorption values [5]. Volatile substances released from the polyether and water absorption lead to its dimensional changes over time [26]. According to the manufacturer, polyether makes up 5 to 20% of the vinyl siloxane ether structure. Therefore, it will show polyether properties. Special properties of the filler components and the reaction of the elastomeric parts with the filler also affect dimensional accuracy [14].

One of the limitations of the present study is the lack of a 3D measuring scanner in the city where the study was conducted. Therefore, only linear dimensional changes of the desired material were measured. To overcome this problem, images were taken and measured with measurement software with an accuracy of one micron.

Conclusion

According to the findings of this study, it is possible to use the method of immersing in deconex solution for two minutes to disinfect the light-bodied vinyl siloxanether. This method does not cause statistically and clinically significant dimensional changes until two weeks after disinfection and is almost similar to the changes observed in the control group. Although immersion in 5.25% sodium hypochlorite solution for 10 minutes causes more dimensional changes than the previous method, while the changes are not statistically and clinically significant until one week after disinfection, and it is better for the impression to be poured within this time. According to the acceptable range of 1.5%, the changes that occurred in two weeks do not have much effect on the dimensional stability of the material. In general, the light-bodied vinyl siloxanether impression material can be used up to two weeks after taking impressions, regardless of the disinfection conditions. Although after two weeks, it undergoes statistically significant dimensional changes but clinically acceptable. Further studies on other consistencies of this material used in various prosthetic impressions and in different storage conditions and disinfecting methods are suggested.

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