Original Article

Effect of Storage Conditions and Disinfection with 2% Deconex® on Dimensional Stability of Two Self-Cure Acrylic Resins

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Abstract

Background and Aim: There is a gap of information on the effect of time, disinfectant, and storage conditions on the dimensional stability of direct post patterns made of self-cure acrylic resins. This study assessed the effect of Deconex® and wet or dry storage conditions on the dimensional stability of post patterns made of Duralay and GC acrylic resins.

Materials and Methods: Sixty specimens were fabricated of GC and Duralay acrylic resins (n=30) by using a stainless steel mold. The specimens in each group were divided into three subgroups (n=10). The specimens of subgroup 1 were immersed in Deconex® for 2 minutes followed by dry storage at 25°C. The specimens of subgroup 2 were stored in water at 25°C. The samples of subgroup 3 were immersed in Deconex® for 2 minutes followed by water storage at 25°C. The dimensions were measured immediately and 2 minutes, 1 hour, and 24 hours after setting. Data were analyzed by repeated measures ANOVA. One-way ANOVA and t-test were used for subgroup analysis at 5% significance level.

Results: The greatest mean dimensional changes occurred after 24 hours in both groups. In GC group, subgroup 1 experienced minimal changes during 24 hours. Duralay subgroups 1 and 2 experienced minimal changes after 1 and 24 hours; the difference between the two subgroups was not significant. Maximum changes were noted in GC subgroups 2 and 3 and in Duralay subgroup 3 ($P<0.05$).

Conclusion: In case of a 24-hour delay, storage conditions would have no effect on the dimensional stability of Duralay patterns, while GC patterns should be stored in a dry condition.

Key Words: Acrylic Resins, Dental Dowel, Post and Core Technique, Disinfection

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Introduction

Acrylic resins were introduced into dentistry in 1937 and have long been used in prosthodontics for many purposes [1]. Self-cure acrylic resins are used for fabrication of direct post-and-core patterns, implant restorations, occlusal registration, and soldering indices for fixed partial dentures [2-8]. In spite of favorable properties, they have a major drawback, i.e. a low dimensional stability. Self-cure acrylic resins are methyl methacrylate-based derivatives and they undergo polymerization shrinkage. The pure shrinkage of methyl methacrylate is approximately 21%. However, the polymerization shrinkage of dental acrylic resins is lower than the aforementioned value because a part of the material is already polymerized [2]. This dimensional instability decreases the precision of work and can result in distortion of patterns, which eventually leads to prosthetic misfit and a decreased retention [9]. The dimensional stability of self-cure acrylic resins is influenced by several factors such as the volume of acrylic resin [10], time [2,10-13], powder-to-liquid ratio [14], and storage condition [2,11,15-18].

In a study on an experimental tooth model in 1990, Koumjian and Holmes [16] reported the polymerization shrinkage of Duralay to be 39μm immediately after polymerization, 43μm after one week of storage in a dry condition, and 24μm after one week of storage in a wet condition. In 1990, Mojon et al [2] evaluated the dimensional changes of two resin indices by using a dilatometer and reported 6.5% shrinkage during the first three hours after setting of Duralay; this value reached 7.9% after 24 hours and remained constant thereafter [2].

In 2005, Mahshid et al [11] evaluated the effect of time, disinfecting agent, and storage conditions on the dimensional stability of Duralay acrylic patterns. They fabricated thirty-six Duralay acrylic patterns by using the simulation method and divided them into three groups (n=12) of glutaraldehyde, sodium hypochlorite, and control. Each group was divided into two subgroups (n=6) for storage in dry and wet conditions. The length, coronal diameter, and apical diameter of the posts were measured immediately and at 1, 3, 6, 9, and 24 hours after polymerization by using a digital caliper. They concluded that the linear changes of Duralay acrylic resin in the tested time points did not follow a constant trend [11]. In 2004, McDonnell et al [12] assessed the effect of time on the accuracy of GC and Duralay acrylic resins used for the assembly of implant frameworks for soldering. Measurements were made at 15 minutes, 2 hours, and 24 hours after polymerization. This in-vitro experimental study showed that the two materials remained accurate only for 15 minutes following polymerization [12]. In 2006, Mosharaf and Ghasemzadeh [18] evaluated the linear dimensional changes of Duralay self-cure acrylic resin in different storage conditions. They fabricated twenty self-cure acrylic resin specimens by using a brass mold measuring 3×12×20 mm. After setting, the specimens were divided into two groups of ten for storage in wet and dry conditions. The dimensions of the specimens were measured immediately and at 1 and 9 hours after setting by using a digital caliper. The results showed that if Duralay acrylic resin was cast within one hour after setting, the storage conditions would have no significant effect on its dimensional stability. However, in case of a delay of more than one hour (between Duralay pattern fabrication and casting), the pattern should be preferably stored in wet conditions [18]. In 2007, Ghanbarzadeh et al [17] assessed the effect of storage conditions on the dimensional stability of post-and-core self-cure acrylic patterns. They fabricated a metal cylinder in the form of post-and-core to make thirty Duralay acrylic patterns. The specimens were divided into three subgroups for storage in a dry condition at 25°C (subgroup 1), in 100% humidity at 25°C (subgroup 2), and in 100% humidity at 4°C (subgroup 3). Measurements were made immediately and after 24 and 48 hours by using an optical measurement device. The results showed that prolonging the storage time had a negative effect on the dimensional stability of Duralay acrylic resin patterns, and the best storage conditions for 24 hours was 100% humidity at 25°C [17].

Unfortunately, despite the wide usage of these resin patterns, there is a lack of a consensus on the effect of time, disinfecting agents, and storage conditions on their dimensional stability, especially with regard to new-generation materials. Therefore, some dental personnel store these patterns in water, while some others store them in a dry condition. In many cases, they send the patterns to the laboratory without disinfecting them. Therefore, this study aimed to assess the effect of 2% Deconex®, as a disinfecting agent, and storage conditions (dry and wet) on the dimensional stability of two commonly used acrylic resins, namely Duralay and GC.

Materials and Methods

Two commonly used acrylic resins, namely Duralay (Reliance Dental Mfg. Co., Worth, IL, USA) and GC Pattern Resin (GC Corp., Tokyo, Japan) were used to fabricate 60 specimens (n=30) in a stainless steel test block. The minimum required sample size in each study group was

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estimated to be 10 by the use of Minitab software (Minitab Inc., State College, Pennsylvania, USA), based on previous studies and by considering $\alpha=0.05$, $\beta=0.2$, a standard deviation (SD) of 0.174, and a minimum significant difference of 0.2 [17]. The test block had five lines including three horizontal and two vertical lines (d1 and d2) for later assessment of the linear dimensional stability (Figure 1). In addition, it had a ring-like component placed around the cylinder's boarders to confine the acrylic resin and to standardize the specimens. The acrylic resins were prepared according to the powder-to-liquid ratio recommended by the manufacturer. The mixing time was 45 seconds, and the space between the test block and the ring was filled with acrylic resin. According to Cho and Chee [19], the polymerization of Duralay and GC acrylic resins occurs averagely 7 minutes and 3 minutes after mixing, respectively. Therefore, we allowed 10 minutes for the specimens to completely polymerize. After polymerization, the ring was removed, and the specimens were removed from

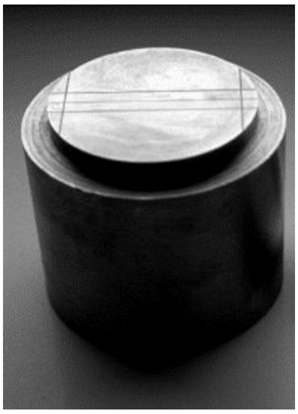

Figure 1. Stainless steel test block

the mold and were divided into three subgroups (n=10) as follows:

Subgroup 1: The dimensions of the specimens were measured immediately after setting. After two minutes of immersion in 2% Deconex® (Borer Chemie AG, Zuchwil, Switzerland) the measurements were repeated. All the specimens were then rinsed with water and were dried and stored at 25°C in a dry condition. The measurements were repeated after 1 and 24 hours.

Subgroup 2: The dimensions of the specimens were measured immediately after setting, after two minutes of immersion in water at 25°C, and after 1 and 24 hours.

Subgroup 3: The specimens were measured immediately after setting. After 2 minutes of immersion in 2% Deconex®, another measurement was made. The specimens were washed with water and were stored in water at 25°C. The measurements were repeated after 1 and 24 hours.

To determine the linear dimensional changes, the same operator measured the length of the horizontal lines between the vertical lines by using a digital caliper (Mitutoyo Corp., Tokyo, Japan) with a 10-µm accuracy. Data were analyzed by one-way repeated measures analysis of variance (ANOVA). Because all the interaction effect p-values were less than 0.05, the data were analyzed by one-way ANOVA, and independent sample t-test was used for subgroup analysis. Multiple comparisons were done by Tukey's honest significant difference (HSD) test. $P=0.05$ was considered as the level of significance.

Results

The dimensional changes seen in this study were in the form of shrinkage. Table 1 summarizes the descriptive values of the dimensional stability of the study groups. The statistical analysis showed that the highest mean dimensional changes occurred after 24 hours in both groups. In GC group, subgroup 1 (dry condition) experienced minimal changes in the dimensional stability in 24 hours. Duralay subgroups 1 and 2 (no disinfection) experienced minimal changes after 1 and 24 hours; this difference between the two subgroups was not significant. Maximum changes were noted in GC subgroups 2 and 3 (wet condition) and in Duralay subgroup 3 (after disinfection) ($P<0.05$; Diagram 1 and Table 2).

Discussion

A review of the literature revealed a gap of information on the dimensional changes of self-cure acrylic resins when stored in wet and dry conditions. Moreover, studies on the effect of disinfecting agents on the dimensional stability of

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Table 1. Descriptive values of dimensional stability of two materials (GC and Duralay) in three storage conditions (n=10, 1=Dry, 2=Wet, 3=two minutes of immersion in in 2% Deconex® followed by water immersion) in 0(d0), 2 min (d2min), 1 (d1h) and 24 h (d24d) after complete polymerization

Material			Minimum (Millimeter)	Maximum (Millimeter)	Mean (Millimeter)	Std. Deviation
GC	1	d0	24.76	24.86	24.83	.02
		d2min	24.48	24.82	24.77	.10
		d1h	24.46	24.77	24.69	.09
		d24h	24.36	24.65	24.57	.08
	2	d0	24.67	24.83	24.75	.05
		d2min	24.59	24.77	24.68	.04
		d1h	24.50	24.65	24.54	.04
		d24h	24.37	24.52	24.42	.05
	3	d0	24.73	24.82	24.77	.02
		d2min	24.55	24.65	24.60	.03
		d1h	24.46	24.61	24.53	.05
		d24h	24.32	24.46	24.38	.04
Duralay	1	d0	24.82	24.86	24.83	.01
		d2min	24.78	24.82	24.80	.01
		d1h	24.60	24.77	24.72	.05
		d24h	24.53	24.65	24.59	.04
	2	d0	24.76	24.86	24.82	.02
		d2min	24.70	24.80	24.77	.03
		d1h	24.66	24.76	24.72	.04
		d24h	24.50	24.66	24.62	.04
	3	d0	24.74	24.82	24.78	.02
		d2min	24.50	24.68	24.58	.05
		d1h	24.48	24.56	24.51	.02
		d24h	24.40	24.50	24.44	.03

self-cure acrylic resin patterns are scarce. A controversy exists regarding the ideal storage conditions for self-cure acrylic resins. Therefore, this study sought to assess the dimensional changes of Duralay and GC self-cure acrylic resins after 2 minutes, 1 hour, and 24 hours of storage in dry and wet conditions with and without disinfection in 2% Deconex®. The results showed that GC subgroup 1 and Duralay subgroups 1 and 2 experienced minimal changes in dimensional stability after 1 and 24 hours. This difference between the two Duralay subgroups was not significant. The highest mean changes in both GC and Duralay specimens occurred after 24 hours. The greatest changes occurred in GC subgroups 2 and 3 (wet condition) and in Duralay subgroup 3. This suggests the negative effect of disinfection with 2% Deconex®. The current study showed that time lapse had a

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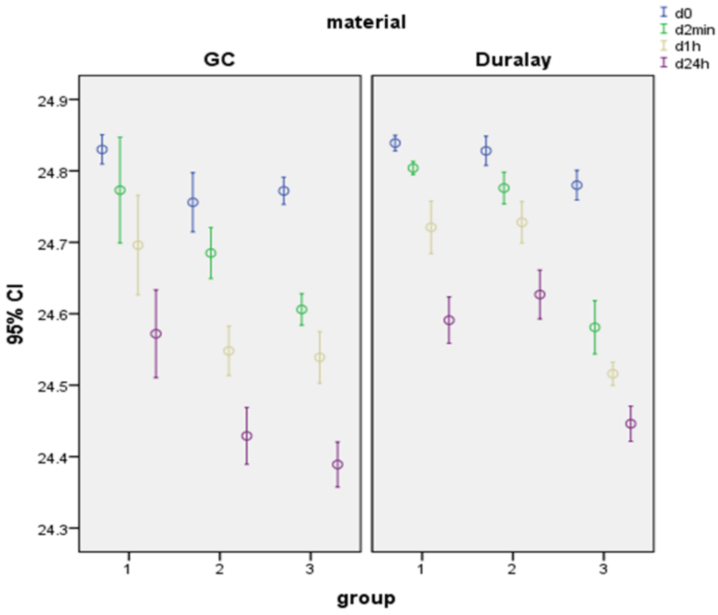

Diagram 1. Mean dimensional changes in the studied groups. CI=Confidence Interval, d=the distance (mm) between the two vertical lines on the stainless steel model

Table 2. P-values of one-way analysis of variance (ANOVA) in comparing the dimensional stability of Duralay and GC acrylic resins at 0 minute (d0), 2 minutes (d2min), 1 hour (d1h), and 24 hours (d24h) after mixing in the three experimental conditions

Material	Time interval			
	d0	d2min	d1h	d24h
GC	<0.001	<0.001	<0.001	<0.001
Duralay	<0.001	<0.001	<0.001	<0.001

negative effect on the dimensional stability of GC and Duralay acrylic patterns, which is in accord with the results of most of the previous studies on self-cure acrylic resins [2,10-13]. Based on our results, storage in dry conditions was more suitable for GC self-cure acrylic specimens after 1 and 24 hours. However, for Duralay specimens, storage in wet or dry conditions made no difference after 1 and 24 hours. However, disinfection with 2% Deconex® caused the greatest dimensional changes in Duralay specimens.

In 1982, Pagniano et al [20] reported that acrylic resins show maximum linear changes during the first hour after mixing the powder and liquid and demonstrate relative stability during the next nine hours. In 1990, Mojon et al [2] concluded that the greatest change occurs in the first three hours, and this rate reaches 7.9% after 24 hours. In 2004, McDonnell et al [12] evaluated the passive fit of frameworks indexed with Duralay and GC acrylic resins after 15 minutes, 2 hours, and 24 hours. The results showed that GC and Duralay acrylic indices

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remained accurate for only 15 minutes after polymerization [12]. In 1990, Koumijian and Holmes [16] showed that storage in dry conditions caused greater shrinkage in acrylic resins; Ghanbarzadeh et al [17] and Mosharaf and Ghasemzadeh [18] have also supported this finding in their studies. However, this finding was in contrast to the results of a study by Mahshid et al [11] in 2005 on Duralay acrylic specimens. They showed that only the coronal and apical diameters of the post were significantly influenced by the interaction effect of time, disinfecting agent, and storage conditions, while the time lapse alone only affected the coronal diameter of the post. In addition, they found no significant difference in the effect of storage in wet and dry conditions on the dimensional stability of Duralay acrylic patterns [11]. This finding is in accord with our results with regard to Duralay specimens. Mahshid et al [11] also evaluated two disinfecting agents, namely glutaraldehyde and sodium hypochlorite, and demonstrated that glutaraldehyde caused shrinkage, while sodium hypochlorite caused expansion of acrylic resins. A review of the literature shows that factors such as the method of mixing the powder and liquid and the volume of acrylic resin can be responsible for the differences observed among the results of previous studies [11]. The current study was conducted on GC and Duralay acrylic resins, and the method of mixing and the volume of acrylic resin were the same for all the specimens. Thus, it seems that the type of acrylic resin is probably responsible for the changes in the dimensional stability after storage in different conditions or after immersion in disinfecting agents.

Conclusion

Within the limitations of this in-vitro study, it was concluded that:

1)Two minutes of immersion in 2% Deconex® followed by a dry storage caused minimal changes in the dimensional stability of GC resin patterns after 1 and 24 hours.

2)The greatest mean changes in both GC and Duralay specimens occurred after 24 hours.

3)Storage in dry conditions was more suitable for GC self-cure acrylic specimens. However, with regard to Duralay specimens, storage in wet or dry conditions made no difference after 1 and 24 hours.

Disinfection with 2% Deconex® caused the greatest changes in the dimensional stability of Duralay specimens.

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