Original Research

Assessment of Color Changes in Vita 3D-Master Shade Guide after Sterilization and Disinfection

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Abstract

Purpose: Dental shade guides are commonly used for color determination and should be disinfected and sterilized. The purpose of this study was to evaluate the color change of Vita 3D Master shade tabs after disinfection and sterilization. **Material and methods:** Overall, 98 samples (shade tabs) were randomly selected from 14 new, unused Vita 3D sets, including the following shades: 2M1, 3L1.5, 3M1, 3M2, 3M3, 3R1.5 and 4M1. In each set, values of 2, 3 and 4, chroma of 1, 2 and 3 and hue were selected for the comparison of different shades. All tabs were measured using the Vita Easyshade device at baseline. The first group was disinfected with Deconex and the second group was sterilized by autoclaving in a simulated annual application. All the tabs were measured again using the same device. This process was repeated to simulate 2 and 3 years of usage. Statistical analysis was conducted by repeated measures analysis of variance (ANOVA) and independent t-test and paired sample t-test. **Results:** In the disinfected group, we observed significant differences in value and chroma in all periods ($p<0.001$). However, hue showed no significant difference after the first year of simulated treatment ($p=0.527$), though it was significantly different in the second and third simulations ($p<0.001$). In the sterilized group, all variables showed a significant difference for each year ($p<0.05$). Considering total color difference (ΔE), there was a significant difference between the two groups in the first, second and third simulated years; ΔE increased in the sterilized group more than in the disinfected samples ($p<0.001$). **Conclusions:** The color change of shade tabs was significant both after disinfection by a chemical solution and by sterilization through autoclaving. However, although disinfectants may not have a clinically important effect, sterilization should be considered as an interfering factor during color-matching procedure.

Keywords: color, 3D Master shade guide, sterilization, disinfection.

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Introduction

Restoration of anterior teeth in the esthetic zone is of critical importance for both dentists and patients. According to patients' perception, the final color of the restoration is considered to be one main determinant of a successful treatment (1). Accurate color determination remains a challenge in dentistry. Selection of an appropriate shade can be difficult and complicated, considering the various aspects of tooth color determination including hue, value and chroma (2,3).

The facility of choosing the correct color for a ceramist is one of the most important breakthroughs in fixed prosthodontics and restorative dentistry. Sorensen and Torres defined five levels of weakness regarding common color-matching procedures: observer, viewing conditions, inadequate technique, poor communication and available shade guides (4).

The observer error relates to the fact that visual shade selection is a subjective method (5). Therefore, factors such as age and experience of the operator, eye fatigue, optical disease and psychological variables may affect human perception of color (2,6).

Viewing conditions and external light play a dominant role in color determination. For instance, metamerism is a phenomenon which causes the color of different objects to differ when the light source changes, even if their color appears exactly the same under another light source (7). Another problematic issue is communication between dentist and ceramist. Using shade guides is an intermediate step, therefore doubling the possibility of error, either by the dentist when selecting the shade or by the ceramist while replicating it (8).

A color shade guide should be fixed and unchangeable. The Vitapan Classical Shade Guide is assumed to be the gold standard and is a very popular system among those used by many dentists (9, 10). Vita 3D Master guides were introduced in 1998 and have a greater number of shade tabs. Color determination is systemically performed according to value, chroma and hue (11). Although advancements in technology have helped modern dentistry in color assessment by introducing spectrophotometers and colorimeters, it is suggested that both visual and instrumental color-matching methods be used (12). There are many different three-dimensional color spaces based on retinal sensitivity, among which L*a*b* and L*C*h* are the most commonly used for tooth color analysis due to color space uniformity and accurate reflection of human senses (13).

Shade guide errors may arise from different factors. For example, shade guides are fabricated from porcelain or resin. Porcelains used to make shade guides are not the same as porcelains used in restorations; also shade guides from the same manufacturer may not be identical (14-16). Furthermore, shade guides must be disinfected or occasionally sterilized after use, which in turn make them prone to color changes (17). Huang et al. reported significant color change in shade tabs after disinfection. However, ΔE was below the level of clinical importance (16).

The purpose of this study was to evaluate the color change of Vita 3D Master different shade tabs after disinfection and sterilization. The null hypothesis, according to shade guide manufacturer claims, is that no significant color change happens after disinfection and sterilization procedures.

Material and Methods

Ninety-eight shade tabs were selected from 14 new, unused Vita 3D Master shade guides (Vita Zahnfabrik H. Rauter GmbH & Co., Germany, 2012) including the following shades: 2M1, 3L1.5, 3M1, 3M2, 3M3, 3R1.5 and 4M1. We logically chose shade tabs of different values (2, 3, 4), chroma (1, 2, 3) and hue (L.M,R). The 98 samples were divided randomly into two equal groups of sterilization and disinfection.

Disinfection method

Deconex (lot: 128745, borer chemie, Switzerland) was chosen because of its popularity in dental clinics for disinfection. Dental disinfectants have different compositions. Deconex belongs to the isopropyl alcohol group, which is not harmful to Vita Shade Guides according to the Vident Web site (http://vident.com/products/shade-management/strilizing-and-disinfectingshade-guides/). Deconex is considered to have antibacterial, antifungal and virus-neutralizing effects.

All samples were sprayed with Deconex solution, kept for 3 minutes in a lidded dish, and then wiped by gauze for drying according to the manufacturer's instruction. After 480 cycles of repeating the process (it was assumed that the process of color selection was performed twice a day, 5 days a week by a clinician; therefore 480 repetitions is equal to 1 year performance), the samples were ready for color measurements. This procedure was also repeated for 2 and 3 years of simulated treatment.

Sterilization method

Sterilization was performed on 49 samples, according to the shade guides manufacturer's instructions, at 135 °C under a pressure of 4 PSI for 10 minutes. The samples were steam autoclaved (Getinge 442SL, Getinge Group) 240 times, which was equivalent to the usual clinical application per year

(once a day, 5 days a week). This procedure was also repeated for 2 and 3 years of simulated treatment.

Color measurement

Color measurement was carried out using a Vita Easyshade Advance spectrophotometer (Vita Zahnfabrik, Germany). The middle third of the shade tabs was used to measure the color in Single Tooth Mode on the Easyshade device. To maintain a fixed position for Easyshade at the middle third of the shade tabs, we made a holder from acrylic resin. The holder provided fixed and identical conditions for all shade tabs in the measurement procedure and prevented environmental light shading the tab surfaces (Fig. 1).

Figure1. Acrylic holder

An acrylic holder was made from heat-cured acrylic resin (Meliodent, Germany) to mount each shade tab. It had two parts, upper and lower, which were assembled using two metallic pins at 5 mm from the center of the shade tab. Thus, the two pieces of the acrylic holder completely encircled each shade tab and the tip of the spectrophotometer device came from a hole on the upper part to the same area on all tabs (Fig. 2).

Figure 2. Spectrophotometer in acrylic holder

For each sample, we recorded color indices including L *, a * and b *. After sterilization and disinfection procedures, total color difference (ΔE) of all samples was calculated by the following formula:

$$\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$$

The acrylic holder was used for all measurement in order to ensure consistent results. The Easyshade Device provides two more values, C * (chroma) and H * (hue), that were also recorded. For statistical analysis, we used repeated measures analysis of variance (ANOVA) and independent t-test and paired sample t-test.

Results

The effect of sterilization and disinfection on shade tabs is reported in Table 1. The difference between the sterilization and disinfection groups was significant for ΔE in all three years of simulated treatment ($p<0.001$) according to Student's t-test.

In order to compare the differences in value, chroma and hue with the baseline, a paired sample t-test was used for each sample. Comparisons were made in disinfected and sterilized groups independently. L* changes were significant. The value decreased in both groups, although the reduction in the sterilized group was more significant.

Evaluations showed a significant difference in chroma between the baseline and all simulations ($p<0.001$); during these simulations, chroma decreased in the disinfected group and increased in the sterilized group. In the disinfected group, the change in hue was not significant for the first year, but was significant in the second and third years. In the sterilized group, change in hue was significant for all years. Hue increased in the disinfected group and decreased in the sterilized group.

In addition, we evaluated the effect of disinfection and sterilization on different hues (3R1.5, 3L15, and 3M1). Changes in the first year were not significant in both groups; greater change was observed in the L hue (yellowish) compared with other hues.

In the Chroma group (3M1, 3M2 and 3M3), the 3M2 sample increased in the disinfected group each year and decreased in the 3M3 and 3M1 samples; 3M3 showed greater reduction in chroma.

Our findings also revealed that changes in value were not significantly different between the disinfected and sterilized groups in 2M1, 3M1, 4M1 samples ($p>0.05$).

Table 1. Differences in ΔE between the two groups

ΔE	Groups	Mean	Standard deviation	P-value
Baseline and 1st year	Disinfected	1.57	0.76	<0.001
	Sterilized	3.13	0.97	
Baseline and 2nd year	Disinfected	1.31	0.49	<0.001
	Sterilized	4.68	1.19	
Baseline and 3rd year	Disinfected	1.98	0.71	<0.001
	Sterilized	5.40	1.13	

Changes in color value, chroma and hue are presented in Table 2.

Table 2. Recorded variables before and after sterilization and disinfection including mean and standard deviation in the first, second and third years

Disinfected group				Sterilized group			
Variable	**Mean**	**ST**	**P-value**	**Variable**	**Mean**	**ST**	**P-value**
Baseline value	75.286	2.8021		Baseline value	76.071	2.9175	
Value (1st year)	73.769	2.9635	<0.001	Value (1st year)	73.900	2.8157	<0.001
Value (2nd year)	74.247	2.6945	<0.001	Value (2nd years)	72.314	2.6810	<0.001
Value (3rd year)	73.912	2.7419	<0.001	Value (3rd year)	71.797	2.6929	<0.001
Baseline hue	83.631	2.2992		Baseline hue	84.471	2.3821	
Hue (1st year)	83.694	2.3060	0.527	Hue (1st year)	83.282	2.0052	<0.001
Hue (2nd year)	85.298	2.2680	<0.001	Hue (2nd year)	83.820	2.4672	<0.001
Hue (3rd year)	85.229	2.6146	<0.001	Hue (3rd year)	83.538	2.3827	<0.001
Baseline chroma	18.714	4.7229		Baseline chroma	18.224	4.5244	
Chroma (1st year)	18.469	4.6515	<0.001	Chroma (1st year)	20.129	4.4769	<0.001
Chroma (2nd year)	18.476	4.7129	<0.001	Chroma (2nd year)	20.596	4.5191	<0.001
Chroma (3rd year)	18.541	4.7201	<0.001	Chroma (3rd year)	21.212	4.2129	<0.001

Discussion

Restorations of anterior teeth have always been a major issue among esthetic procedures for dentists and patients. The color of the restored tooth is an important factor for patient satisfaction with the restoration process (2, 18). This is particularly challenging due to subjectivity of the matter (19,20).

One of the most important aspects of the color-matching process is shade guide selection. On the other hand, sterilization and disinfection affect the shade tab after each application. We used ΔE to examine the color difference. In addition, color variables including hue, chroma and value were evaluated in the current study for greater consistency with the Vita 3D-Master shade system.

We observed significant differences in value and chroma over all simulations in the disinfected group. However, hue did not show a significant difference in the first simulated year, although it was significant in the second and third years of simulated treatment. In the sterilized group, all variables showed a significant difference for each year. These data reject the null hypothesis that no significant difference would be found after repeated disinfection and sterilization.

There was a significant difference in terms of ΔE between the two groups in the first, second and third simulated years; ΔE changed in the sterilized group more than in the disinfected group. As ΔE was below 3.7 in the disinfected group, this is assumed to be a "match". However, for the sterilized group ΔE was

greater than 3.7, so the difference was perceptible and noticeable[21]. Thus, it seems that after sterilization, shade tabs are unusable in clinical practice.

Value decreased more significantly in the sterilized group compared with the disinfected group. However, chroma decreased in the disinfected group and increased in the sterilized group, while inverse outcomes were obtained for hue.

The current findings are inconsistent with those obtained by Pohjola and colleagues. They evaluated the effect of disinfection on shade tab changes; although values showed a significant difference in the second and third simulations, this variable showed an overall increase. Correspondingly, they reported that chroma showed a significant difference in each simulation, as in our research. However, they found no significant change in hue. In addition, Pohjola reported similar outcomes with respect to ΔE; in the disinfected group, they observed a significant increase in ΔE for each year of simulated treatment (22).

The results of this study showed an increase in chroma in the sterilized group and a decrease in the disinfected group for each simulation. The difference could be due to heat stress, while the pressure of the autoclave affects not only the surface but also the entire structure of the shade tab. Therefore, a greater difference for chroma was observed in the sterilized group.

Moreover, chroma decreased each year in the disinfected group, which could be due to micro-damage to the surface caused by the disinfectant in low levels.

ArRejaie studied the effect of disinfection on shade tabs, and showed no significant difference between the studied samples in relation to time. These findings were consistent with our results in the disinfectant group. The extent of ΔE was below the perceptible level (ΔE=1) and the clinically acceptable level (ΔE=3.7). This is in contrast to our study, in which the change was greater than the perceptible level and lower than the clinically acceptable level; a difference which may be explained by different disinfectant materials (23).

Huang et al. (2014) showed a significant difference in the color of the shade tabs, depending on the type of disinfectant. In our study, the amount of color change for Cavicide disinfectant (ΔE=1.198) was the same as with Deconax solution after 2 years (ΔE=1.310). This is related to the use of the same material, isopropyl alcohol (16).

According to Pohjola's research, two factors affect the color of shade tabs after disinfection: abrasion of surface characterization by wiping and deposition of surface residue (22). It seems that in our study, the second factor was dominant because value decreased and chroma increased.

After 3 years, ΔE for disinfected shade tabs was 1.98. Although this is statically significant, it is below 3.7 and therefore clinically acceptable. However, we should consider that color perception is subjective and varies among different people; therefore continued usage of shade tabs may lead to inaccurate color matching. In sterilized samples, mean ΔE was 3.1 in the first year, therefore shade tabs should be used with caution even in the first year.

This study has several limitations. Because of the dramatic change caused by sterilization, color assessment should be performed at intervals of less than 1 year; for example after 1, 3 and 6 months. Furthermore, a comparison of different shade guides such as Vita Classical would be useful. Finally, use of different methods of sterilization such as gas sterilization may show different results.

Conclusion

It can be concluded that the process of disinfection and sterilization may change the color of shade tabs and ultimately affect shade-match procedure. The shade tabs that were autoclaved showed much greater color change than those that were disinfected. , No significant differences were seen among different shade tabs.

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