The effect of various disinfectants on dental shade guides

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Statement of problem. Dental shade guides are used to evaluate tooth color before prosthodontic procedures and are subjected to disinfection after use. The effect of disinfection on shade guides has not been thoroughly investigated.

Purpose. The purpose of this study was to evaluate the effect of disinfectants on the color of shade tabs.

Material and methods. Changes in the color (ΔE) of VITA Classical Shade Guide tabs were measured with a VITA Easyshade spectrophotometer in the CIELAB system and calculated after being subjected to Cavicide, Asepticare TB, Sporicidin, and distilled water (control) over a simulated period of 2 years. Statistical analysis was accomplished by a 2-way analysis of variance followed by the Tukey honestly significant difference (HSD) test (α=.05).

Results. A significant difference was noted in the degree of shade tab color change, depending on the type of disinfectant used (F=153.2, P<.001). No significant difference was noted in the amount of shade tab color change that occurred after disinfection among the different shade tabs used (F=0.611, P=.865), nor was a significant interaction noted between the type of disinfectant and the different shade tabs used (F=0.7, P=.919). Asepticare TB showed the least significant amount of change (ΔE=0.401), and Sporicidin (ΔE=0.889) and the control (ΔE=0.969) showed significantly more color change than Asepticare TB but less than Cavicide (ΔE=1.198).

Conclusions. The average total CIELAB color difference for 50% human perceptibility is approximately 1 unit (under standardized laboratory conditions). In the oral cavity, however, an average change of 3.7 ΔE units could still allow teeth to be perceived as having the same color. Therefore, although the results are statistically significant, they may not be clinically important. (J Prosthet Dent 2014;■:■-■)

Clinical Implications

Although the color of the shade tab changes significantly, depending on the type of disinfectant used, the change may not be clinically important at the 2-year level.

A disinfectant is a chemical agent used on inanimate objects (for example, floors, walls, or sinks) to destroy most recognized pathogenic microorganisms, but not necessarily all microbial forms (for example, bacterial endospores).[1] The user must consider multiple factors, including the effectiveness of the disinfectant, the nature and composition of the item to be disinfected, and the cost, safety, and ease of use of the available agents. Selecting an appropriate product that can cover all these situations is practical. Chemical disinfectants used for disinfecting surfaces that have been contaminated with patient material include alcohol, chlorine and chlorine-containing compounds, formaldehyde, glutaraldehyde, iodophors, phenolics, and quaternary ammonium compounds.[2] In this study, the effect of several of these disinfecting compounds on changes in the color of shade guides was examined.

Dental shade guides are made of either porcelain or acrylic resin, with the majority being acrylic resin. A commonly used, commercially available shade guide is the VITA Classical Shade Guide (Vident). Although the guide is made from acrylic resin, it is compatible with porcelain systems.

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Shade guides are classified as noncritical instruments because they should only come into contact with intact skin, so their risk category may be presumed to be low.[3] Noncritical items should be cleaned, or if contaminated, cleaned and then disinfected with a hospital-grade tuberculocidal intermediate-level disinfectant.[3] However, contamination with saliva must be assumed. The disinfection of shade guides in many practices is performed with solutions that are deemed to be the most convenient, often without following the manufacturer's instructions. This may lead to a significant difference in the shade selection process, resulting in miscommunication between clinicians and dental laboratories. Unsatisfactory finished restorations may be a consequence.

Very little on the effect of disinfectants on dental shade tabs is available in the literature. Cernavin[4] compared 2 standard shades from a shade guide made with acrylic resin that had been subjected to disinfection and a similar shade guide that had not been disinfected. He reported "staggering" differences from visual observation alone. The first shade guide was left in a disinfectant solution for "considerable periods of time" between patients, while the second shade guide was not treated. He recommended that shade guides should not be immersed in disinfecting solutions for periods longer than necessary and that shade guides should be replaced periodically. However, limited controls were used in this study, and the results obtained were based on subjective observation alone.

Pohjola et al[5] evaluated the effect of Cavicide (Metrex) on the VITA Classical Shade Guide (Vident). Ten shade tabs of shades B2, D2, C1, and A3.5 were selected and measured with the EasyShade spectrophotometer (Vident). At baseline, 3 of the 10 shade tabs were set aside as controls. The remaining 7 shade tabs were treated for 480 cycles to simulate 1 year's usage, after which EasyShade readings were remade. This was repeated 3 times to simulate 3 years of use. The authors found a statistically significant increase in the value (L*) and chroma (C*). However, they did not test other disinfectants or methods of disinfecting.

The purpose of this study was to measure the effect of disinfection on various shade tabs. The null hypothesis was that no significant difference would be found in the amount of shade tab color change (ΔE) for any of the disinfectants used.

MATERIAL AND METHODS

Five VITA Classical Shade Guides (Vident) were treated with Cavicide (Lot 12-1091, Metrex), 5 with Sporicidin (Lot 12221, Sporicidin Co), 5 with Asepticare TB (Lot C031521, Ecolab), and 5 with distilled water (control). All shade tabs (B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4, and C4) were included in each set.

Cavicide was chosen as 1 of the disinfectants because this study attempted to elaborate on the findings of Pohjola et al.[5] Their data seem to contradict the manufacturer's claim that Cavicide does not contain chemicals harmful to the shade guide. They only used 4 different dental shade tabs. Sporicidin and Asepticare TB were evaluated by the American Dental Association, and their effectiveness against *Mycobacterium tuberculosis* conformed with the manufacturer's specifications and followed US Environmental Protection Agency standards.[6] The 3 disinfectants, Cavicide, Sporicidin, and Asepticare TB, represent 3 different classes of disinfectants (isopropyl alcohol, quaternary ammonium, and glutaraldehyde with sodium phenate) that do not contain chemicals harmful to VITA Classical Shade Guides. Disinfectants containing phenol, methyl ethyl ketone, or iodine are harmful to the shade guide, as indicated on the Vident Web site (http://vident.com/products/shade-management/sterilizing-and-disinfectingshade-guides/).

The 5 sets of shade guides that were treated with Cavicide were sprayed until wet from a universal spray bottle (Sprayco). Approximately 6 sprays were used each time, which is the equivalent of about 6 mL of solution. After allowing them to sit for 3 minutes, they were wiped until visibly dry with 3×3 gauze (Lot 8995; Richmond Dental Company). This application method was used per the manufacturer's instructions against *Mycobacterium tuberculosis*. The 5 sets of shade guides that were treated with Sporicidin were sprayed until wet (approximately 6 sprays), allowed to sit for 10 minutes, then wiped until visibly dry with 3×3 gauze (per the manufacturer's instructions to be tuberculocidal). The 5 sets of shade guides that were treated with Asepticare TB were sprayed wet (approximately 6 sprays) for 6 minutes and air-dried until visibly dry (per the manufacturer's instructions to be tuberculocidal). The 5 sets of controls were sprayed with distilled water (approximately 6 sprays), allowed to sit for 10 minutes, then wiped dry with 3×3 gauze. To ensure consistency between testing cycles and to replicate clinical conditions, 1 tester using gauze of the same roughness and manufacturer did all of the testing.

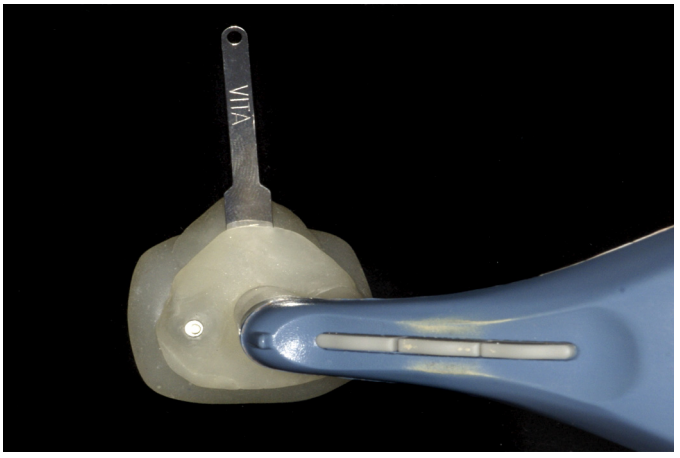
The testing process was repeated for 960 cycles to simulate 2 years of use. It was assumed that a private office would have many sets of shade guides and the typical set might be used twice a day, 5 times a week, 48 weeks a year. Shade tabs were measured every 40 cycles, equivalent to 1 month's use.

Because the VITA Easyshade spectrophotometer (Vident) has been determined to have high reliability and accuracy (96.4% and 92.6%, respectively),[7] it was used to measure the shade tabs. Each of the 16 tabs was tested separately. Once each shade tab had been secured in place in the acrylic resin device (Figs. 1, 2), the probe was used to measure (Fig. 3), and the L*a*b values were recorded from the screen (Fig. 4).

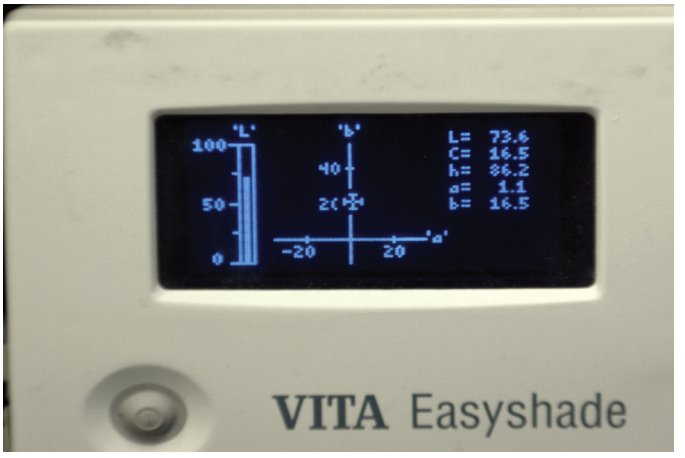
The Tooth Single mode was used to measure the middle one third of the shade tab. This area was measured because the middle site best represents the color of the tooth material.[8] An

1 Acrylic resin device fabricated with Triad and Pindex pins.

2 Acrylic resin device with cover allowing only consistent thirds of the shade tab to be measured.



3 Measuring L*a*b values.



4 Recording L*a*b values.

acrylic resin device was fabricated to mount each shade tab securely. The base and the cover of the acrylic resin device were made from light-polymerized urethane dimethacrylate (Triad; Dentsply Intl), while the pins securing the back and front acrylic resin pieces were made from Pindex Dual Pins (Coltène/Whaledent Inc). This allowed readings to be recorded from the same area on all the tabs and allowed only the middle third of the shade tab to be visible. The acrylic resin device allowed only a consistent one third of the shade tab to be measured (Fig. 2).

One initial recording of each shade tab was made. Records were then made for each shade tab after every 40 cycles (to simulate 1 month's use). The acrylic resin device was used for every measurement to ensure consistency and to eliminate the acrylic resin device as a potential confounding factor. Each reading of L*, a*, and b* was read from the LED screen and recorded.

To calculate the change in color (ΔE), the following formula set by the International Commission on Illumination (CIE) was used:

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

where L^*_2, a^*_2, and b^*_2 were the recordings after 2 years of simulated use. L^*_1, a^*_1, and b^*_1 were the initial recordings.

To determine the sample size, a power analysis was performed from the mean difference at 2 years between Cavicide (2.5) and the control (1.2) from the Pohjola et al[5] study. With n=5, 4 groups, a 2-tailed test, α=.05, and an effect size of 0.58, the power was equal to 100% for the disinfectant. With n=5, 16 groups, a 2-tailed test, α=.05, and an effect size of 0.40, the power was equal to 97% for the shade tabs. A sample size of 5 for a period of 2 years was used for each disinfectant tested and the control.

The hypotheses were analyzed by a 2-way ANOVA followed by the Tukey honestly significant difference (HSD) test (α=.05).

RESULTS

The effect of disinfection on shade tabs was studied. Statistical analysis with 2-way ANOVA revealed no significant difference in color change (ΔE) among the shade tabs (Table I, F=0.611, P=.865) nor a significant interaction between the type of disinfectant used and the different shade tabs used in the degree of shade tab

TABLE I. ANOVA table for disinfectant and interaction between shade tab and disinfectant

Source of Variation	*df*	SS	MS	*F*	*P*
Shade tab	15	0.537	0.036	0.611	.865
Disinfectant	3	26.956	8.985	153.184	<.001
Shade tabs × Disinfectants	45	1.868	0.042	0.708	.919
Error	256	15.016	0.059		
Total	320	283.290			

TABLE II. Descriptive statistics for disinfectant

Source of Variation	Mean ΔE	SD
Disinfectant		
Asepticare TB	0.401[a]	0.22
Sporicidin	0.889[b]	0.15
Control (distilled water)	0.969[b]	0.26
Cavicide	1.198[c]	0.29

[a–c]Means with the same letter are not significantly different.

TABLE III. Descriptive statistics for shade tab

Source of Variation	Mean ΔE*	SD
Shade Tab		
A1	0.885	0.39
A2	0.835	0.37
A3	0.900	0.43
A3.5	0.870	0.39
A4	0.830	0.31
B1	0.810	0.34
B2	0.895	0.40
B3	0.845	0.39
B4	0.905	0.43
C1	0.900	0.34
C2	0.905	0.37
C3	0.910	0.35
C4	0.855	0.40
D2	0.755	0.33
D3	0.86	0.41
D4	0.870	0.40

*No significant difference.

color change (Table I, F=0.7, P=.919). However, statistically significant differences were noted in color change (ΔE) among the 4 disinfectant groups (Table I, F=153.2, P<.001).

The analysis revealed that the shade tabs treated with Asepticare TB showed the least amount of color change (ΔE=0.401, Table II). Sporicidin and the control showed more color change than Asepticare TB (ΔE=0.889 and 0.969, Table II) but less color change than Cavicide (ΔE=1.198, Table II).

DISCUSSION

Shade tabs disinfected with Asepticare TB showed the least amount of color change (ΔE=0.401), while the shade tabs treated with Cavicide showed the most amount of color change (ΔE=1.198). The shade tabs treated with Sporicidin had color change comparable with the control group (ΔE=0.889, 0.969). These data supported the rejection of the null hypothesis that no significant difference would be found in the shade tab color change depending on the type of disinfectant used, although the controls also changed.

The average total CIELAB color difference for 50% human perceptibility is approximately 1 unit (under standardized laboratory conditions).[9] In the oral cavity, however, an average change of 3.7 ΔE units could still allow teeth to be perceived as having the same color.[10] None of the changes found in this study was greater than 3.7 ΔE units.

This experiment is similar in design to the study done by Pohjola et al.[5] However, in that study, only 5 shades were evaluated. The entire set of the VITA Classical Shade Guide was examined in this study. The data Pohjola et al collected suggested a statistically significant increase in the value (L*) and chroma (C*) after 3 years of simulated use of shade tabs B2, D2, C1, and A3.5; however, the changes were "not perceptible" to the authors. They were unable to detect a difference visually.

In this study, the mean change in color (ΔE) among the different shade tabs proved to be nonsignificant after 2 years of simulated use (Table III). Because the change was nonsignificant, further examination of (L*) and chroma (C*) was unnecessary. It can be concluded that no individual shade tab will change significantly within each set, provided that the entire set is disinfected simultaneously after each use. Therefore, if a set of VITA Classical Shade Guide tabs is disinfected in the same manner after clinical use, no individual shade tab should need to be replaced before the others.

The results for the Cavicide group are consistent with the data Pohjola et al[5] collected. A statistically significant change was observed between the Cavicide group and the control after 2 years of simulated use. The difference in the ΔE for the control group between this study and that of Pohjola et al can be explained by the treatment of the controls in the current study, which were sprayed with distilled water and allowed to sit for 10 minutes and then wiped dry. Thus, the action of wiping the shade tabs clean may have caused abrasion and led to a significant change in ΔE. Despite this, ΔE was similar for the control and Cavicide, and the difference may not be clinically important (ΔE=0.969, ΔE=1.2). The Asepticare TB group had the least amount of change (ΔE=0.401). These specimens were air dried and not wiped (following the manufacturer's instructions). Therefore, shade tabs could be disinfected without wiping.

Because only 1 operator performed all of the testing in a consistent manner,

and because only 1 brand and consistency of gauze was used for the entire project, the Cavicide, Sporicidin, and control groups were assumed to have been wiped in the same manner. Hence, the only difference between the groups was the disinfectant. The mean change in ΔE between Cavicide, Sporicidin, and the control was 1.198, 0.889, and 0.969. According to the statistical analysis, the Sporicidin group had a nonsignificant change in ΔE compared with the control group.

Although the results of this study are statistically significant, the mean change in ΔE for all the groups may not be clinically noticeable after 2 years of simulated usage. Therefore, even though the shade tabs were measured after every 40 cycles (1 month's equivalent use), the authors decided that the final statistical analysis would be based on the data collected at the end of the 2 years of simulated use (960 cycles). However, if the shade tabs were to be continuously used for more than 2 years, they would exhibit a change in ΔE that could lead to inaccurate shade matching.

The data of this study appear to contradict the manufacturer's claim that Cavicide, Asepticare TB, and Sporicidin do not contain chemicals harmful to the shade guide. However, given that the change in ΔE caused by Cavicide, Asepticare TB, and Sporicidin may not be clinically noticeable after 2 years of simulated use and disinfection, it seems reasonable that the shade tabs have proven their longevity and may be due for replacement. But at least at 2 years, they are still usable.

Several limitations exist within this study. Although shade tabs are made out of acrylic resin, they are meant to represent the available dental porcelain shades. This can cause several problems, such as inaccurate color matching and possible exhibition of metamerism (a color match between 2 objects under 1 illumination may be a mismatch under a different illuminant). Although every effort was made to position the probe in a consistent manner by using a device (Fig. 2), the area that was measured was the middle third of the shade tab. Because these shade tabs are not constructed from porcelain, but rather layered acrylic resin, each area of the shade guide may have an inconsistent change in ΔE.

Translucency of the restorative material plays a large role in mimicking the appearance of the natural tooth. However, the VITA Classical Shade Guide tabs do not measure translucency. As a result, this aspect is often left to the master ceramist's experience with porcelain application.

Clinically, the perception of color may vary among individuals; in fact, individuals may vary in their ability to match color. Finally, ΔE values are nondirectional and do not indicate whether the shade tabs get darker or lighter.

Although the VITA Classical Shade Guide is a popular shade guide in the dental office, other shade guides are available on the market. No studies have been done on the effect of disinfectants on the VITA Toothguide 3-D Master shade guide, the VITA Linearguide 3-D Master shade guide, the VITA Bleachedguide 3D-Master shade guide, or the Chromascope shade guide. Whether these shade guides are manufactured in the same manner as the VITA Classical Shade Guide is unclear. Because the arrangement of the shade tabs for the VITA Toothguide 3-D Master shade guide and the VITA Linearguide 3-D Master shade guide implement a different protocol of shade matching (by value first), whether changes of ΔE in the shade guide would have a significant effect on this protocol is uncertain.

CONCLUSION

In this study, a significant difference was found in the amount of color change, depending on the type of disinfectants used and following the manufacturer's protocol. The shade tabs tested with Asepticare TB showed the least amount of change, while those tested with Cavicide showed the most. The shade tabs tested with Sporicidin showed changes in color comparable with distilled water (the control). No significant differences were found in color change (ΔE) among the shade tabs, and no significant interaction was found between the type of disinfectant used and the shade tabs.

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