Color Stability of Shade Guides After Disinfection and Autoclave Sterilization

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Abstract: Shade selection for dental restorations involves many factors, and one of the most important is the shade tabs used in the selection process. Dental shade guides used to evaluate tooth color before prosthodontic procedures should be disinfected after use. Chemical solutions and autoclave sterilization have been widely used for disinfection of Dental shade guides, but their effect on color stability of shade guides tabs after repeated procedures is still unclear. **The aim** was to evaluate whether disinfection protocol applied in Burydah Dental collage that include autoclave sterilization or chemical disinfectants has any effects on color stability of shade guides (VITA 3D-Master Shade System) at one year of usage. **Material and methods:** the CIELAB values of eighteen shade tabs, non-used vita 3d-master shade guides were measured with vita easy shade compact, two chemical disinfectants HAMA -surf spray and HAMA instru(KOL AL HEMAYA MEDICAL FACTORY-Riyadh, Saudia Arabia) and autoclave were used for disinfection. in order to simulate 120, 180 and 360 day usage, the first shade guides group were immersed into disinfectant solutions for15minx120, 15minx180 and 15minx360. second shade guides group were sprayed for 120,180 and 360 cycles the third shade guides group was autoclaved at 135°c/10minx120, 135°c/10minx180 and 135°c/10minx360. CIELAB measurements of all tabs were repeated at 120, 180 and 360 day periods. in order to measure the color changes at shade guides,120, 180 and 360 day CIELAB values were compared with initial measurements by using the formula of "delta e=([l1-l2]2+[a1-a2]2+[b1-b2]2)1/2. 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, in case of autoclave sterilization 2M1, 2M2 tabs that increase with the time periods. No significant difference was noted in the amount of shade tab color change that occurred after disinfection among the different shade tabs used in all time periods. **CONCLUSIONS:** Within the limitation of this study, it was found that utilization of HAMA- instru. and HAMA-Surf spray for up to one simulated years causes minute changes in the color of VITA Tooth guide 3D-Master Shade Guide after simulated treatments, these changes didn't cause a clinically significant difference and were not perceptible to the clinician. Repeated cycles of autoclave sterilization for one year caused statistically significant changes in the color coordinates of the two shade guides 2M1 and 2M2,these differences are considered not clinically acceptable. With the other tabs autoclaving causes minute changes in the color that didn't cause a clinical significant difference and were not perceptible to the clinician.

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1-Introduction

Evaluation of tooth color is typically accomplished using dental shade guides prior to restorative and prosthodontic procedures.

The successful achievement of clinically acceptable color match is closely related to the spectral coverage of the shade guide, clinician experience, and the viewing.

The apparent color of natural teeth is the result of the reflectance from the dentin modified by the absorption, scattering, and thickness of the enamel, Seghi etal., (1986). Therefore, an understanding of the optical properties of teeth is imperative for accurate and consistent color reproduction. Color and its elements, such as hue, value, and chroma; translucency and opacity; light transmission and scattering; and metamerism and fluorescence, influence the esthetics of a dental restoration, Lee et al.,(2001).

Generally, the shade of esthetic restorations is keyed to a shade guide. However, shade guides themselves have demonstrated inconsistent color and do not adequately represent the color of natural teeth, which increases the challenge of color matching. Lee et al., (2002) Restorative dentistry is a blend of science and art. The success of restorative dentistry is determined on the basis of functional and esthetic results. To achieve esthetics, four basic determinants are required in sequence; viz., position, contour, texture and color. Because esthetic dentistry imposes several demands on the artistic abilities of the dentist and the technician, knowledge of the underlying scientific principles of color is essential. Color combination not only improves esthetics but also

makes the restoration appear natural and attractive, Sikri (2010).

Shade guides are classified as non-critical instruments because they should only comeinto contact with intact skin and so their risk category may be presumed to be low. Non-critical items should be cleaned, or, if contaminated, cleaned and then disinfected with a hospital-grade tuberculocidal intermediate-level disinfectant.

However, contamination with saliva must be assumed. Disinfection of shade guides in many practices is carried out with solutions that are deemed to be the most convenient, often times without following manufacturer's instructions. It is not clear whether this leads to a significant difference in the shade selection process leading to unnecessary miscommunication and misunderstanding between the clinicians and dental laboratories that would result in unsatisfactory finished restorations., Rutala and Weber (2004).

Spectrophotometers and spectroradiometers are instruments designed to produce the most accurate color measurements. Spectrophotometers differ from spectroradiometers primarily because they include a stable light source. There are two types of basic designs commonly used for these instruments. The traditional scanning instrument consists of a single photodiode detector that records the amount of light at each wavelength. The light is divided into small wavelength intervals by passing it through a monochromator. A more recent design uses a diode array with a dedicated element for each wavelength. This design allows for the simultaneous integration of all wavelengths. Both designs are considerably slower than filter colorimeters. However, these are the routinely used color-measuring devices. Vita Easy Shade is an example of a spectrophotometer Sikri (2010).

In a study carried out to evaluate the effect of various disinfectants on dental shade guides it was concluded that 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, Huang et al.,(2014).

The VITA 3D-MASTER (vita company USA) shade system covers virtually all tooth shades that occur in nature and is designed to provide systematic coverage of the entire tooth color space. The concept of the 3D-MASTER system is based on a color classification principle where the values of lightness, chroma and hue have been positioned an equal distance from each other. Therefore, the shade determination can be easily carried out according to systematic criteria Ongul et al.,(2012).

Sterilization and Disinfection of VITA® Shade Guides. Autoclave Instructions: The VITA Shade Guides can be autoclaved in a steam or chemiclave to a maximum temperature of 284ºF (140ºC). Use of a dry autoclave will damage the Shade Guides and will void any warranty either expressed or implied. Follow the autoclave manufacturer instructions for autoclave cycle times. Surface Disinfection: Follow the Disinfectant Manufacturers instructions for proper use of surface disinfectants of VITA Shade Guides. Disinfectants with Phenols, Accelerated Hydrogen Peroxide, Iodine, Methyl Ethyl Ketone, or Chloroform have been shown to damage the Shade Guides and should be avoided when possible, Paravina(2009); Rauter (2011).

In a better-controlled study, Pohjola et al. (2007) evaluated the effect of Cavicide (Metrex) on the Vita Classic shade guide (Vident). Ten shade tabs of shades B2, D2, C1, and A3.5, were selected and measured with the EasyShade shade device (Vident). At baseline, three of the ten shade tabs were set aside as controls. The remaining seven shade tabs were treated for 480 cycles to simulate a year's usage after which Easy Shade readings were taken again. This was repeated for three times to stimulate 3 years of use.The data Pohjola et al. (2007) collected showed that there was a statistically significant increase in the value (L*) and chroma (C*). However, they did not test other disinfectants or methods of disinfecting. Their data seems to contradict the manufacturer's claim that Cavicide does not contain chemicals harmful to the shade guide.

There are several methods and devices that can be used by dentists for color selection, Chu et al., (2010). They are mainly divided into visual and instrumental devices, Sikri (2010). Digital instruments, such as, Vita Easy shade spectrophotometer have shown to be more accurate and more reproducible than conventional visual examination, Judeh and Al-Wahadni (2009). Nevertheless, conventional shade matching techniques are still considered the most common and the preferable used technique to select the color due to its simplicity and accessibility Brien and Ram (2007). Even with its popularity, it has been revealed that it is both inconsistence and not accurate Ozat et al., (2013). Primarily, due to that color perception in nature is considered inconsistent and relatively inaccurate. It was reported that color selection can vary between different genders. It can also differ among different dentists and by the same dentist at different intervals, Prabu et al., (2012). There have also been reported discrepancies related within similar shade tab from the

same manufacturer, and also between different shade guide systems Todorovic et al.,(2013).

Since the VITA Easyshade Spectrophotometer (Vident) has been determined to have high reliability and accuracy (96.4%, 92.6%, respectively), it was used to measure the shade tabs Kim-Pusateri et al.,(2009). Therefore, absolute care must be followed in performing shade matching including handling and sterilization of the shade guide itself. Manufacturer's recommendation for sterilization of conventional shade guide includes chemical disinfectants with solutions that doesn't include component of phenol or methyl ethyl ketone Rauter and VITA Toothguide (2011).

The purpose of this study is to evaluate the long term effect of chemical disinfection on the color of porcelain shade guide.

2-Materials and Methods

2.1.Materials:

2.1.1. Shade tabs:

VITA 3D-Master Shade Guide (VITA Zahnfabrik H. Rauter GmbH & Co. KG D-79713 Bad Sackingen, Germany) was used in this study. eighteen shade tabs were selected according to the following: 2L1.5, 2L2.5, 3L1.5.3L2.5, 4L1.5 and 4L2.5 - 2M1, 2M2, 3M1, 3M2, 4M1 and 4M3- 2R1.5, 2R2.5, 3R1.5, 3R2.5, 4R1.5 and 4R2.5, respectively in order to include wide range of different color values.

Initially, Tabs were visually inspected to detect any color defects. Selected shade tabs were divided into three groups A, B and C (n=6) VITA Easyshade Compact (VITA North America) was used in this study.

2.1.2. Disinfectant solutions

Two types of disinfectant solutions that applied according to the disinfection protocol applied in Burydah Dental collage have been used in this study: Two chemical disinfectants HAMA -surf spray and HAMA instru (KOL AL HEMAYA MEDICAL FACTORY-Riyadh, Saudia Arabia) and autoclave sterilization cycles were used for disinfection (product composition (table 1).

Table 1- composition of disinfectants solutions

HAMA -surf spray	HAMA instru
Benzalkonium chloride, Quaternium 12, Cocamidopropylbetaine, C9-11pareth 8, polyaminopropylbiguanide	Benzalkonium chloride, Didecyldimethyl ammonium chloride, Poly(hexamethylene biguanide) hydrochloride, less than 5% Amphoteric surfactants, Disinfectants, Perfume

2.1.3. Specimens:

Specimens were divided into 3 groups (n=6), according to the tested solution; (Figure 1).

-Group A tabs (2R1.5, 2R2.5, 3R1.5, 3R2.5, 4R1.5 and 4R2.5) were sterilized with immersion in HAMA-instru. Using dosing device add 20ml from the solution to 1 liter of clean water (2%), soaking time was 15 minutes for (virucidal, bactericidal and fungicidal).After disinfection, rinse tabs thoroughly with distilled water.

-Group B tabs (2L1.5, 2L2.5, 3L1.5.3L2.5, 4L1.5 and 4L2.5) were sterilized by using HAMA-Surf spray. Spray tabs from a distance of approximately 30cm so that they are completely moistened and let the disinfectant to take action over a period of 30 seconds, then wipe tabs with clean tissue

-Group C tabs (2M1, 2M2, 3M1, 3M2, 4M1 and 4M3) were sterilized by autoclave 135°C/10min x360.

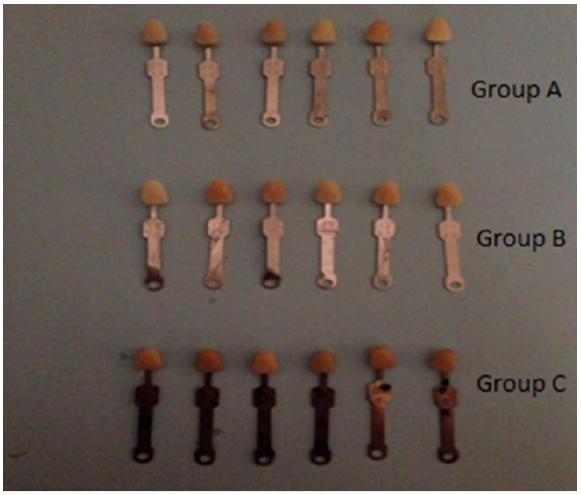

Figure 1-Groups of Taps after treatment

The same volume of all solutions was used and prepared by the same technician. The application time of each solution tested was based on results from other studies and recommendations of their respective manufacturers, which show that these times are necessary to ensure high antimicrobial efficacy of these products.

2.2.Methods:

2.2.1. Color measurements

Color measurements of each specimen were taken before immersion and after 120, 240 and 360 immersion cycles for each tested solution and autoclave. Before each disinfection procedure, the specimens were rinsed with distilled water for 3 min and dried with tissue paper without dehydration of the tabs. After this, the samples were immediately immersed in their respective solutions. All chemical solutions were renewed after each disinfection procedure.

Color measurements were evaluated using VITA Easyshade Compact (VITA North America). Before each measurement session, the spectrophotometer was calibrated with its white reference tile, using the white calibration standard provided, according the manufacturer's instructions.

In order to standardize sample's color measurement the same area of each tab (middle third) was tested for each measurement, An acrylic jig was fabricated for securely mounting each shade tab. The base and the cover of the acrylic jig were made from light-polymerized Triad (Dentsply, York, PA) while the securing pins were made from Pindex Dual Pins (Coltène Whaledent Inc, Cuyahoga Falls, OH,). This allowed readings to be taken from the same area on all the tabs. The acrylic jig allowed only the middle third of the shade tab to be visible. Two pins secured the back and front acrylic pieces, Peterson et al.,(2014). One initial recording of each shade tab was taken. Data were collected by averaging three readings of each shade tab at the same time. To simulate the annual usage of a shade guide, shade guides will undergo 360 disinfection cycles per year. readings and visual inspections were done at base line and after120, 240 and 360 disinfection cycles. The spectrophotometer was set to multimeasure mode in which three readings were taken in the middle third of the tab. Then, the mean value of these readings was recorded. The lighting conditions of the area in which measurements were taken were constant throughout the data collection period.

The color change values of all tabs were calculated by mean and standard deviation of ΔE* with the use of CIE L*a*b* color system. Individual analysis was performed using the three variables inherent to the device, in which L* represents the coordinate the lightness or darkness of the object, a* indicates the red-green chromaticity of the object, and b* corresponds to the yellow/blue axis of the object.

Color differences (ΔE*) of specimens were calculated using the formula: $\Delta E^* = \{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\}^{1/2}$ [10], where ΔL*, Δa* and Δb* are the differences in L*, a* and b* values before and after immersion at each time interval[21]. For this study, only the ΔE* result was used for analysis.

2.2.2. Statistical analysis

Since the same specimens were evaluated before immersion and after several immersion periods, statistical analysis of data was performed using two-way repeated measures analysis of variance (ANOVA). When significant differences were found, Tukey's *post hoc* test at 95% probability level was applied.

3-Results

3.1. Effect of disinfection and autoclave on shade tabs:

All sets of shade tabs of the three experimental groups were included in the statistical analysis. Statistical analysis

Mean and standard deviation of ΔE* for VITA 3D-Master Shade Guide tabs after 120, 240 and 360 cycles for the tested solution and autoclave are presented in Table 1, Figures 2 and 3.

According to the results, the values of ΔE* ranged from 0.142 to 0.989 for immersion tabs group A and from 0.094 to 1.023 for spray tabs group B and 0.386 to 7.905 for autoclave tabs group C during the 120, 240 and 360 cycles.

Generally, through an intra-cycle analysis, the results indicated that two solutions tested during the 120,240 and 360 cycles, provided similar changes in color stability (ΔE*) in group A&B. In addition, most of the biggest changes in color stability (ΔE*) for the tabs studied was caused by autoclave group C. All tabs became darker after autoclave sterilization cycles. They became more yellow. Repeated cycles of autoclave sterilization caused changes in the color coordinates of the shade guides. However, these differences are considered acceptable except for 2M1, 2M2 where the changes became more big.

Through an inter-cycle analysis, as a general rule, the results indicated that the two solutions used showed a similar trend in the fluctuation of ΔE* in tested tabs, in which the variation in ΔE* seemed to increase up with the increase in cycles. The same results were also obtained from group C autoclave.

There were insignificant differences among the time periods at any disinfection methods except for group C autoclave (2M1, 2M2 tabs). All the disinfection methods caused insignificant color change. However mean Delta E values obtained with autoclave technique for 2M1, 2M2 tabs was significantly different from the others.

No significant difference was noted in the amount of shade tab color change that occurred after disinfection among the different shade tabs used ($F=0.511$, $P=.701$), nor was a significant interaction noted between the type of disinfectant and the

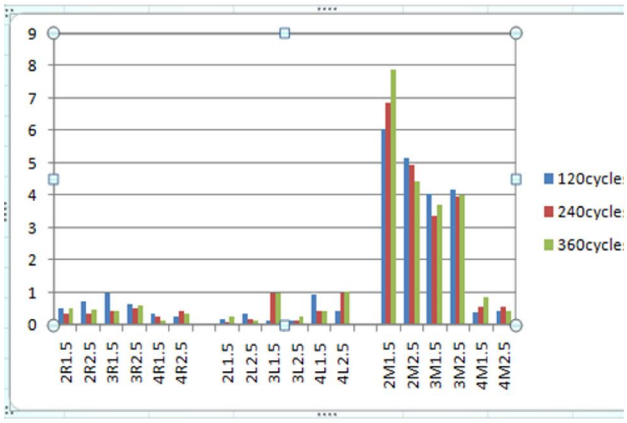

Figure 2. Change in Color (Δe) of Shade Tabs

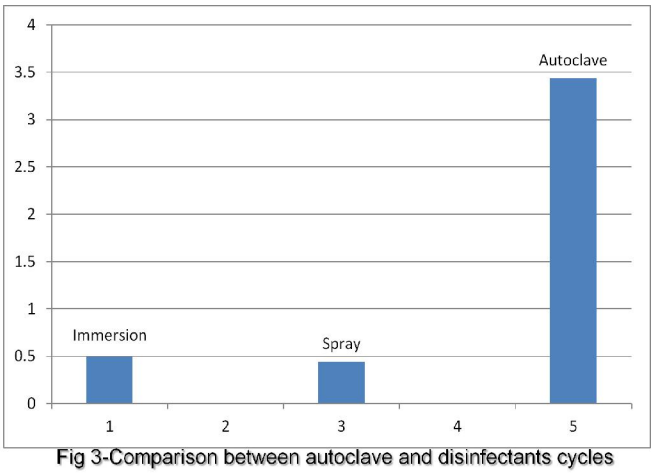

Fig 3-Comparison between autoclave and disinfectants cycles

Table 2. The interaction between shade tab and disinfectant

		ΔE and S D					
Groups	Tabs	120 Cycles		240 Cycles		360 Cycles	
A Immersion	2R1.5	0.522	± 0.054	0.345	± 0.043	0.505	± 0.050
	2R2.5	0.725	± 0.064	0.340	± 0.012	0.455	± 0.024
	3R1.5	0.989	±0.061	0.421	± 0.056	0.438	± 0.057
	3R2.5	0.631	± 0.002	0.525	± 0.031	0.615	± 0.012
	4R1.5	0.341	± 0.028	0.240	± 0.033	0.142	± 0.052
	4R2.5	0.250	± 0.090	0.430	± 0.023	0.325	± 0.043
B Spray	2L1.5	0.150	± 0.020	0.094	± 0.061	0.272	± 0.016
	2L2.5	0.340	± 0.074	0.165	± 0.040	0.114	± 0.026
	3L1.5	0.120	± 0.057	0.995	± 0.011	0.989	± 0.061
	3L2.5	0.129	± 0.011	0.130	± 0.016	0.241	± 0.072
	4L1.5	0.957	± 0.030	0.435	± 0.009	0.445	± 0.070
	4L2.5	0.415	± 0.015	0.996	± 0.021	1.023	± 0.021
C Sterilization	2M1	6.077	± 0.024	6.857	± 0.051	7.905	± 0.019
	2M2	5.142	± 0.017	4.967	± 0.041	4.445	± 0.022
	3M1	4.051	± 0.054	3.370	± 0.042	3.725	± 0.031
	3M2	4.200	± 0.008	3.962	± 0.051	3.995	± 0.070
	4M1	0.386	± 0.032	0.537	± 0.022	0.857	± 0.018
	4M2	0.436	± 0.050	0.541	± 0.007	0.430	± 0.043

4-Discussion

The use of chemical solutions and autoclave for shade guide sterilization has been highlighted due their effectiveness in reducing microorganismsm, Pavarina et al., (2003). However, color changes in shade guide tabs especially with autoclave have been reported as one of the main deleterious effects caused by these substances, Pohjola et al., (2007).

Since there is a few studies available about the effect of chemical solutions and autoclave on the color stability of shade guide and this effect is of great esthetic importance during shade selection to prosthodontic users, this research was conducted to evaluate the effect caused by disinfection protocol applied in Burydah Dental collage that include autoclave sterilization or chemical disinfectants for shade guide disinfection, Koksal and Dikbas (2008). Some authers might consider a period of 360 immersion, spray or autoclave cycles too long for an experimental period. However, an *in vitro* study over a short period of evaluation could not reliably reproduce the effect of the solutions on the color stability of the shade guide tested. These facts make it difficult to interpret the results of the present investigation because they do not allow a direct comparison with data of other studies.

In this study, color changes in shade guide tabs were measured by spectrophotometer, Kim-Pusateri et al., (2009). This instrument eliminated the subjective interpretation of visual color alteration. The CIE L*a*b* system for measuring chromacity was chosen to record color changes, as it is well suited for determining small color differences.

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, Huang et al.,(2014).

Most of the literatures have been reported that human observers can be expected to detect color differences of 1 ΔE unit under standardized laboratory conditions, Kuehni and Marcus (1979).

ΔE was used in this study to analyze the color difference before and after disinfecting. It represents the distance between two measured colors, where the bigger the ΔE the bigger the difference however, an average change of 3.7 ΔE units could still allow teeth to be matched as having the same color, Johnson and Kao (1989). None of the changes in groups A&B were greater than 3.7 ΔE units.

Maximum ΔE value in this study was 7.905 group C after 360 cycles tab 2M1 which is greater than the clinical threshold. Looking at the pattern of ΔE results in this study after using HAMA -surf spray, and HYMA solu, we can see that the maximum effect of disinfectants solutions takes place within group A the first 120 cycles espicially2R & 3R ΔE 0.989. Subsequently, it decreased after 240 and then start to increase after 360 cycles. While in group B maximum effect of disinfectants spray was found after the 360 cycles especially in tab 4L2.5 ΔE 1.023, all this results were lower than the clinical threshold 3.7 ΔE units.

Alshethri et al.,(2014) found similar conclusions on Vitapan Classical shade guide using MinutenSpray. The highest ΔE value was 0.86 which is also below the perceptible threshold. He also found that the maximum effect occurred after 1year of disinfection, but he did 480 disinfection cycles per year. Pohjola et al., (2007) also examined the effect of a disinfectant (Cavicide) on Vitapan classical shade guide and found that the maximum color difference ΔE was 2.5 after two years. Yet, visual inspection in his study concluded that the difference is not perceptible. ΔE can be a helpful tool in detecting and finding color differences. Nevertheless, it still has its own limitation. It doesn't show the direction of the change in the color space. Therefore, further evaluation into the L* a * b* is necessary.

The study showed no significant changes along the evaluation period with disinfectant solutions for a*, b*and L* values. This results were contraverse with study carried out using different materials which concluded that there is a significant increase in the L* value with Minuten Spray, Lysol (QDC) and Lysol IC (RDC). Increased L* value reflects a lighter color. This noticed difference after disinfection might be related to the ingredients of the disinfectant. According to the Material Safety Data Sheets, Minuten Spray and Lysol IC (RDC) are ethanol based (30-60%), and Lysol (QDC) has Didecyl Dimethyl Ammonium Chloride. Shade tabs disinfected with HYMA-Spray showed the least amount of color change (Δe =0.401), while the shade tabs treated with HYMA -Sol showed a littel amount of color change (Δe=1.198).

The shade tabs treated with autoclave showed the most amount of color change (Δe=7.905). These results were in accordance with the results obtained by Max Schmeling et al.,(2014) whom concluded that All specimens became darker after autoclave sterilization cycles. However, specimens of Vita Classical became redder, while those of the Vita System 3D-Master became more yellow. Repeated cycles of autoclave sterilization caused statistically significant changes in the color coordinates of the two shade guides. However, these differences are considered clinically acceptable.

Due to lack of information, further studies are mandatory for better understanding the process of color alteration of shade guide, evaluating different disinfection procedures and solutions, which is highly efficient.

Conclusions

Within the limitation of this study, it was found that utilization of HAMA-instru.and HAMA-Surf spray for up to one simulated years causes minute changes in the color of VITA Tooth guide 3D-Master Shade Guide after simulated treatments, these changes didn't cause a clinically significant difference and were not perceptible to the clinician.

Repeated cycles of autoclave sterilization for one year caused statistically significant changes in the color coordinates of the two shade guides 2M1 and 2M2. These differences are considered not clinically acceptable. With the other tabs autoclaving causes minute changes in the color that didn't cause a clinical significant difference and were not perceptible to the clinician.

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