IP Annals of Prosthodontics and Restorative Dentistry 2024;10(2):129–134

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IP Annals of Prosthodontics and Restorative Dentistry

Journal homepage: https://www.aprd.in/

Original Research Article

Effects of sterilization on the color of ceramic shade guides used in fixed prosthetics

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ARTICLE INFO

Article history:
Received 23-03-2024
Accepted 29-04-2024
Available online 15-05-2024

Keywords:
Color
Aesthetics
shade
Sterilization

ABSTRACT

Introduction: Aesthetic demands are very high in dentistry, and the color of prosthetic teeth is an important factor in success. Today, despite technological advances, the shade guide is still the most widely used instrument for determining tooth color. During the color selection process, the shade guide meets mucous membranes and saliva, making it a semi-critical material. To avoid any risk of cross-contamination, the shade guide can be sterilized. The aim of this study was to assess the impact of sterilization on the color of ceramic shade guides used in fixed prosthetics.
Materials and Methods: This was a quasi-experimental study. The study population was the sample teeth of the VITA 3D MASTER® shade guide and the VITA CLASSICAL® shade guide, except for the bleaching samples. Brightness, chroma, hue and delta E (ΔE) were studied. Before and after each cycle of 120 sterilizations, measurements were taken using the VITA EASYSHADE V® Spectrophotometer.
Results: 2 to 2 comparisons of the mean brightness values show statistically significant differences between the two shades. For the same comparison, statistically significant differences were found for the shade and ΔE of the VITA 3D MASTER® shade guide.
Conclusion: Sterilization leads to variations in shade guide color. Progressive wear could lead to color changes that are not clinically acceptable and could hinder the esthetic results of prostheses. It would be important to determine the number of sterilization cycles that should not be exceeded when using shade guides.

1. Introduction

Fixed prosthetics involves replacing and/or restoring teeth with artificial substitutes that cannot be removed from the mouth by the patient.[1] When making a prosthesis, the dental surgeon works with a laboratory technician. There will be stages in the dental surgery and stages in the prosthetic laboratory. Precise measuring tools and reliable data transmission are essential for good communication.[2]

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To reproduce tooth color, the dental surgeon must first determine the tooth color before transmitting the chosen reference to the laboratory technician. The lab technician then reproduces the tooth according to the dental surgeon's instructions.

Aesthetic demand is very strong in dentistry, and the color of prosthetic teeth is a significant factor in success.[3,4]

Today, despite technological advances, the shade guide is still the most widely used instrument for determining, transmitting, and reproducing tooth color.[5]

https://doi.org/10.18231/j.aprd.2024.025
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During color selection, the shade guide meets the mucous membranes and saliva, which is a biological liquid. According to Spauding's classification of medical/surgical devices according to their capacity to transmit infection, the shade guide is a semi-critical material, and therefore at intermediate risk. To avoid any risk of cross-contamination, the shade can be sterilized.[6]

Shades are made from materials that are susceptible to degradation. Some studies have shown changes in the color of dental ceramics as a function of:[7–15]

1. The type of material used.
2. Material immersion products.
3. Material processing methods.
4. Material disinfection techniques.

Color variation could have an impact on the reliability of tooth color selection and reproduction. Studies on color changes in stains are still limited, with contradictory results[15–20]

The aim was to assess the impact of sterilization on ceramic shade guides used in fixed prosthetics.

2. Materials and Methods

This was a quasi-experimental study. It was carried out at Institut of Odontology and Stomatology of the Faculty of Medicine, Pharmacy and Odontology-Stomatology of the Université Cheikh Anta Diop of Dakar. The manipulations lasted 6 months, from January 2021 to June 2021.

The study population consisted of all the teeth sampled in the VITA 3D MASTER® shade guide and the VITA CLASSICAL® shade guide, except for the bleaching samples.

To be included in the study, the statistical units made up of the sample teeth had to be elements of a new ceramic shade guide.

From a group of 13 shade guides, including 5 VITA 3DMASTER® and 7 VITA CLASSICAL®, 2 shade guides were selected. A Vita 3DMaster shade guide with 26 teeth and a VITA CLASSICAL® shade guide with 16 teeth, making a total of 42 teeth, formed the sample.

Brightness, chroma, hue and delta E (ΔE) were studied. These elements are commonly used in different color representation systems.

The measuring instruments used were a VITA EASYSHADE V® Spectrophotometer (fig 1), and a repositioning key in the medial area of the tooth to ensure that the position would be the same for each manipulation. The repositioning key was made of resin (fig 2).

Class B autoclave was used for moist heat sterilization of the shade guide.

The complete sterilization cycle was followed. Pre-disinfection was carried out by soaking in quaternary ammonium, followed by cleaning with water before packaging and sterilization.[4]

Colorimetric data (luminosity, saturation and hue) and delta E were recorded for the sterilized stainer at the following intervals:

1. Before the start of handling, corresponding to time zero (T0).
2. After 120 sterilization cycles corresponding to time 1(T1).
3. After 240 sterilization cycles corresponding to time 2 (T2).
4. After 360 sterilization cycles corresponding to time 3 (T3).
5. After 480 sterilization cycles corresponding to time 4 (T4).

Data entry was performed using Epi Info® version 7 software. Data analysis was performed with R software version 4.2.3. To see the evolution of variables as a function of time, the repeated measures ANOVA (parametric test) or the Friedman test (non-parametric) were performed according to the applicability criteria, which consisted in studying the distribution of residuals (mixed model). The significant Friedman test was followed by the Wilcoxon signed-rank pairwise test to identify groups that differed. Bonferonni adjustment was used for the p-value of the 2-to-2 comparison.

The materials required for this study were purchased from our own funds. There is therefore no conflict of interest.

3. Results

showing the averages of colorimetric variables for different sterilization times for the VITA 3DMASTER® shade guide and the VITA CLASSICAL® shade guide show differences.

3.1. VITA 3DMASTER®

Mean brightness increased from -0.38 to -0.98 from T0 to T1 and decreased slightly from T2 to T4. The overall p is statistically significant (Table 1).

2-to-2 comparisons of brightness averages show statistically significant differences between T0 and T1, T0 and T2, T0 and T3, and T0 and T4 (Table 2).

Mean chroma increased between T0 and T1, then decreased before increasing from T2 to T3. The overall p-value of 0.595 was not statistically significant (Table 1).

Mean hue decreased between T0 and T4. The overall p <0.001 is statistically significant.

Variations in hue were statistically significant between T0 and T1, between T0 and T2, and between T1 and T4(Table 3).

Mean ΔE increased progressively from T0 to T4. The overall p of 0.007 is statistically significant (Table 1). The increase in delta E was statistically significant between T0 and T3 and T0 and T4 (Table 4).

3.2. VITA CLASSICAL®

Mean brightness increased from -2.34 to -2.44 from T0 to T1 and from -2.54 to -2.13 from T2 to T3. The overall p is statistically significant (Tab V).

The 2-to-2 comparison of mean brightness according to the number of sterilization cycles of the VITA CLASSICAL® shade guide showed a statistically significant difference between T0 and T4, p = 0.028 (Tab VI).

Figure 1: Vitaeasyshade V® spectrophotometer

Figure 2: Repositioning key

4. Discussion

Dental stains are commonly used for color determination in fixed prosthetics and can be sterilized to avoid cross-contamination. The aim of this study was to assess the impact of sterilization on ceramic stains used in fixed prosthetics. Indeed, there are a few studies on the effect of autoclaving on shade stability.

As there are several ceramic shade guides available, using two from the same manufacturer could be considered a limitation of this study. However, the manufacturer was the first on the market with the renowned VITA CLASSICAL® shade guide. The VITA 3D MASTER® shade guide is the first shade guide whose distribution is based on the CIE L*a*b system (luminosity, chroma, hue). It is therefore based on internationally accepted scientific standards for color measurement. It thus facilitates color measurement.[20] In addition, VITA 3D MASTER® are the most widely used by dentists.[3]

The sample size of this study was 42, larger than that of FAHMY et al who took 6 and BALOUCH et al who took 20[17–21]. The sample size is smaller than that of a study by SCHMELING et al, who took 90, and that of DASHITI et al, who took 49.[22,23]

Sterilization was repeated 480 times, compared with other studies which used fewer cycles, such as SCHMELING et al (120 cycles), FAHMY et al (360 cycles) and BALOUCH et al (180 cycles). However, DASHITI et al performed the highest number of cycles, 720.[23]

The color changes of the samples studied were measured by spectrophotometer. Indeed, the VITA EASY SHADE® is one of the most widely used instruments in instrumental color measurement studies. It is the most recent spectrophotometer in the Vita range.

Brightness, chroma, hue and ΔE are the 4 parameters used to examine color difference.

4.1. Impact of sterilization on brightness

After 480 sterilization cycles, brightness decreased. These results are in line with those of DASHITI et al, FAHMY et al and SCHMELING et al.

On analysis, statistically significant values ($p<0.001$) as in the study by DASHITI et al ($p<0.001$) for luminosity were found. These data reject the null hypothesis that no significant difference would be found after repeated sterilization cycles.

Brightness is the most important parameter in color development; if it decreases, the color also becomes darker and darker. These results are in line with those of SCHMELING et al and FAHMY et al, who concluded that all samples became darker after autoclave sterilization cycles.

4.2. Impact of sterilization on saturation

In these simulations, the evaluations showed an increase in tint saturation. These results are similar to those of DASHTI et al, who noted an increase in saturation from the first year of simulation. The saturation of VITA 3D MASTER® and VITA CLASSICAL® stains increased during the 24 months of sterilization, but the difference was not statistically significant ($p>0.05$). These results are in line with those obtained by SCHMELING et al, and FAHMY et al, who concluded that all samples became darker after autoclave sterilization cycles. VITA CLASSICAL® samples became redder, while VITA 3D MASTER® samples became

Table 1: Comparison of average colorimetric variables according to different sterilization times for the Vita 3DMASTER® shade guide (N=26)

Variable	T0(M-SD)	T1(M-SD)	T2(M-SD)	T3(M-SD)	T4(M-SD)	P value
Brightness	-0.38 (0.97)	-0.98 (1.00)	-0.99 (1.10)	-0.93 (1.00)	-1.00 (0.93)	<0,001
Chroma	-3.29 (1.07)	-3.12 (1.45)	-3.20 (1.14)	-3.04 (1.83)	-3.23 (1.22)	0.595
Hue	0.21 (1.06)	-0.12 (1.15)	-0.09 (1.10)	-0.16 (1.30)	0.04 (1.14)	<0,001
Delta E	3.45 (1.08)	3.56(1.13)	3.58 (1.08)	3.60 (1.18)	3.62 (1.09)	0.007

Table 2: 2 to 2 comparison of average brightness according to the number of sterilization cycles of the VITA 3DMASTER® shade guide.

Variable	Compare cycles	Effectif	P adj
Brightness	T0 /T1	26	0.0000816 ****
Brightness	T0/T2	26	0.001 **
Brightness	T0/T3	26	0.000127 ***
Brightness	T0/T4	26	0.000123 ***
Brightness	T1/T2	26	1 ns
Brightness	T1/T3	26	1 ns
Brightness	T1/T4	26	1 ns
Brightness	T2/T3	26	0.044 *
Brightness	T2/T4	26	1 ns
Brightness	T3/T4	26	0.947 ns

Table 3: 2 to 2 comparison of average hue according to the number of sterilization cycles of the Vita 3DMASTER® shade guide.

Variable	Compare cycles	Effectif	P adj
Hue	T0 /T1	26	0.002 **
Hue	T0/T2	26	0.000968 ***
Hue	T0/T3	26	0.436 ns
Hue	T0/T4	26	1 ns
Hue	T1/T2	26	1 ns
Hue	T1/T3	26	0.88 ns
Hue	T1/T4	26	0.026 *
Hue	T2/T3	26	0.909 ns
Hue	T2/T4	26	0.069 ns
Hue	T3/T4	26	1 ns

Table 4: 2 to 2 comparison of the average delta E according to the number of sterilization cycles of the Vita 3DMASTER® shade guide.

Variable	Compare cycles	Effectif	P adj
Delta E	T0/T1	26	0.911 ns
Delta E	T0/T2	26	0.25 ns
Delta E	T0/T3	26	0.026 *
Delta E	T0/T4	26	0.049 *
Delta E	T1/T2	26	1 ns
Delta E	T1/T3	26	1 ns
Delta E	T1/T4	26	1 ns
Delta E	T2/T3	26	1 ns
Delta E	T2/T3	26	1 ns
Delta E	T3/T4	26	1 ns

Table 5: Average comparison of different variables according to the number of sterilization cycles for the Vita Classical® shade guide (N=16)

Variable	T0(M-SD)	T1(M-SD)	T2(M-SD)	T3(M-SD)	T4(M-SD)	P value
Brightness	-2.34(1.11)	-2.44(1.15)	-2.54(1.04)	-2.13(1.80)	-2.48(1.08)	0.001
Chroma	-3.01(1.26)	-2.36(2.36)	-2.98(1.29)	-2.93(1.35)	-2.96(1.44)	0.090
Hue	-2.09(1.03)	-1.69(1.72)	-2.12(1.14)	-1.83(1.56)	-2.14(1.17)	0.105
Delta E	4.08 (1.07)	4.16(1.08)	4.16(1.06)	4.09(1.16)	4.18(1.10)	0.099

Table 6: 2 to 2 comparison of average brightness according to the number of sterilization cycles of the Vita Classical® shade guide.

Variable	Compare cycles	Effectif	P adj
Brightness	T0/T1	16	0.459 ns
Brightness	T0/T2	16	0.089 ns
Brightness	T0/T3	16	0.15 ns
Brightness	T0/T4	16	0.028 *
Brightness	T1/T2	16	0.275 ns
Brightness	T1/T3	16	1 ns
Brightness	T1/T4	16	1 ns
Brightness	T2/T3	16	1 ns
Brightness	T2/T4	16	0.245 ns
Brightness	T3/T4	16	1 ns

yellower.

4.3. Impact of sterilization on hue

The results showed a decrease in hue of VITA CLASSICAL® and VITA 3D MASTER® shade guides after repeated sterilization cycles. These results are similar to those of DASHTI et al, who noted a decrease after sterilization cycles. The decrease in hue is greater on the VITA 3D MASTER® shade guide than on the VITA CLASSICAL® shade guide. The difference is even statistically significant ($p<0.001$) for the VITA 3D MASTER® shade guide.

4.4. Impact of sterilization on ΔE

Variations in ΔE are greater on the VITA 3D MASTER® shade guide than on the VITA CLASSICAL®, and the difference is statistically significant for the VITA 3D MASTER®. These results are identical to those of DASHTI et al, who also found statistically significant differences. However, these differences are considered clinically acceptable for the VITA 3D MASTER® shade guide, as their ΔE was no greater than 3.7. The studies by FAHMY et al and BALOUCH et al found clinically acceptable ΔE values.

Beyond statistically significant changes, it is important to note values that are not clinically acceptable. For the VITA 3D MASTER® shade guide, even if the difference is statistically significant, the values are still clinically acceptable. However, for the VITA CLASSICAL® shade guide, the ΔE values are not clinically acceptable. This is not an effect of sterilization, but a value found before any manipulation. The reliability of the shade guide could be called into question, as was already the case in the study by TORODOVIC et al.

Repeated autoclave sterilization cycles caused changes in the color coordinates of samples from both shade guides.

The ΔE can be a useful tool for detecting and finding color differences. Nevertheless, it still has its own limitation. It doesn't show the direction of change, which is why it's important to study the other color parameters, brightness, chroma and hue.

The surface condition of the tinters also appeared to be affected. Wear was visible to the naked eye on all sterilized samples.

5. Conclusion

Sterilization leads to variations in shade guide color. Progressive wear could lead to non-clinically acceptable color changes, which could compromise the esthetic results of the prosthesis. It would be important to determine the number of sterilization cycles that should not be exceeded when using shade guides.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Cite this article: Binta C, Sidy DP, Nene T, Medina F, Malick NP, Sow MM, Babacar ME, Benjamin D. Effects of sterilization on the color of ceramic shade guides used in fixed prosthetics. *IP Ann Prosthodont Restor Dent* 2024;10(2):129-134.