A comparative digital shade analysis on the color stability of two different acrylic shade tabs using various disinfectant methods - An In Vitro Study

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Abstract

Aim: This study aim to compare and evaluate the color stability of different acrylic shade tabs using four disinfectant methods.

Settings and Design: An in-vitro, prospective

Methods and Material: In this in-vitro comparative study, Acryrock and Premadent specimens were subjected to four disinfectants i.e., immersion in 70% Isopropyl alcohol, 5.25% Sodium hypochlorite, Distilled water, and Autoclaving, and were subjected to spectrophotometric test at baseline (before immersion), 1, 7, 14 and 21 days interval. The color difference was evaluated using a digital spectrophotometer.

Statistical analysis used: Kolmogorov smirnov test was used to determine normality. ANOVA was used as data is normally distributed and Friedman was used as same solution was used at different time intervals.

Results: A significant difference was noted in the degree of shade tab colour change with Acryrock A1, A2 and Premadent shade 23, 24 in 70% Isopropyl alcohol compared to baseline.

Conclusions: This study concluded that immersion in 70% Isopropyl alcohol showed significantly higher values on color change of different acrylic shade tabs within the clinically acceptable range.

Keywords: Esthetics, Immersions, spectrophotometer.

Introduction

Shade matching in prosthodontic treatment is a very challenging task because it influences the natural appearance and esthetic outcome of dental restorations.1 The description of the color is a challenging part of science that forms an important basis for achieving superior esthetics in dentistry. With the ever-growing esthetic demands of the patients to fabricate restorations that are indistinguishable from the natural dentition, it becomes utmost necessary for the dentist to evaluate the tooth shade correctly and effectively communicate it to the laboratory technician for an accurate esthetic result. 2

There are two color matching methods in dentistry: visual (conventional) and instrumental. Visual shade determination by comparing to patient's tooth with the shade guide is the most frequently applied method in clinical dentistry. However, visual shade matching is unreliable, inconsistent, and considered highly subjective.3

Instrumental color matching has been developed to minimize color mismatches during visual color estimation. Most often used instruments are: tristimulus colorimeters, spectroradiometers, digital cameras and spectrophotometers. Color measurement can be classified and quantified in a variety of ways. Two of the most widely used colour representation systems are the Munsell System and the International Commission on Illumination (CIE) color/order system.4 The CIELAB- defines a color space (L*a*b*) in which L* represents lightness, a* represents the chromaticity coordinate for red-green and b* represents the

chromaticity coordinate for yellow-blue). Color difference, or ΔE, is defined by the following equation: $\Delta E = \sqrt{(\Delta L)2 + (\Delta a)2 + (\Delta b)2}$

The human eye can perceive light through the color receptors; however, the color matching cannot be standardized, producing unreliable and inconsistent results. The use of contemporary manual shade selection techniques can be extremely subjective and lead to unacceptable mismatches.5 To overcome the limitations of the manual visual shade matching systems, several digital shades matching devices that help in improving the accuracy and efficiency of shade selection in the clinical scenario were introduced. At such an unprecedented time where the world is facing the pandemic, infection control and disinfection protocol becomes an integral part of the dental settings. The shade tabs can be assumed to be contaminated with blood and saliva. Importance of disinfection of shade matching is to eliminate cross contamination between patients in the dental operatory which is to be disinfected before reutilization.6

Hence, there is a need to disinfect the shade guide tabs after each use which may lead to a significant difference in the change of colour of shade tabs and shade selection process, resulting in miscommunication between the dentist and the technician. The shade guides were classified as non-critical instruments according to the OSHA guidelines, 2005 and can be disinfected with 2% glutraldehyde, 70% isopropyl alcohol, 5.2% sodium hypochlorite, 2% chlorhexidine gluconate.7

The practice of conservative and esthetic dentistry is the need of the hour and with the current frequency of using the disinfectants in the ongoing pandemic there is a need for the clinician to understand the significance of shade selection and how external factors like the disinfectants can have varied effects on colour stability of the shade guides.8 Very little on the effect of disinfectant solutions on acrylic dental shade tabs is available in the literature.

With the advent of latest computerised digital shade technology in combination with visual shade analysis and digital photography has increased the accuracy of the final shade determination. However, the digital shade analysis systems are comparatively expensive and its access to the various clinicians and academic institutions is also limited. Hence, this article gives an insight into the use of conventional visual shade analysis combined with a digital spectrophotometer for evaluating the colour change using various disinfectant solutions. The purpose of this study was to evaluate the effect of disinfectant solutions on the colour stability of different acrylic shade tabs using a digital spectrophotometer. Null hypothesis is that no noticeable colour change occurs after disinfection and sterilisation procedures.

The aim of this study is to evaluate the effect of four different disinfectants – distilled water, 5.25% Sodium hypochlorite, 70% Isopropyl alchohol and Autoclave on the color stability of two commercially available acrylic resin denture teeth.

Methodology:

Sample size of 128 shade tabs with 32 belonging to each shade tab and 8 shade tabs used in each liquid was considered. Two Acryrock shades A1 and A2 and Premadent acrylic teeth shades 23 and 24 were selected for the study. A total of 64 acryrock teeth sample having thirty- two teeth with A1 shade in one set and thirty-two teeth with A2 shade in other set were taken. Similarly, a total of 64 premadent acrylic teeth samples having thirty-two teeth with shade 23 in one set and thirty-two teeth with shade 24 in another set were taken.

According to the OSHA guidelines the four disinfecting methods selected were immersed in 70% Isopropyl alcohol, 5.25% Sodium hypochlorite, distilled water and autoclaving the samples at baseline, 1, 7, 14 and 21 days interval.8 (Figure 1-4). ΔEs of specimens were calculated between the baseline (before immersion) and 1, 7,14, 21 days of immersion in the disinfecting solution respectively. Most private practitioners are expected to have multiple shade guides, with each one being used at least twice per day for five days per week and 48 weeks per year. Each shade tab gets disinfected 480 times per year as a result. The number of disinfection cycles per shade tab is calculated using this number. The digital shade analysis of each of the samples was done using VitaEasy shade spectrophotometer (Figure 5).

Each solution was contained in a plastic container of the same dimensions on which the name of the disinfectant was labelled for ease of identification. As every shade tab has a different hue, value and chroma at every spot it was necessary to fabricate dental plaster models to mount each sample securely to ensure the accuracy and repeatability of the values recorded. The mesio-distal midline of the middle third on the labial surface of the samples was marked and evaluated for color determination. The middle third was determined with the help of a rectangular graph sheet of 4 x 4 inch and equally measuring the cervico-incisal length of each tooth and dividing into three equal thirds and marking is done with red marker on plaster model (Figure 6). We made a holder from dental plaster to keep Easyshade in place in the centre third of the shade tabs (Figure 7). The holder maintained constant and consistent conditions for all shade tabs during the measurement process, preventing ambient light from shading the tab surfaces. The Vitaeasy shade spectrophotometer was calibrated according to the manufacturer's instructions (Figure 8)

The colour assessment was performed using digital spectrophotometer prior to immersion into the solutions (baseline reading which served as control). The spectrophotometer was used for analysis of the color under color corrected fluorescent light.The

probe of the Easyshade was held perpendicular against the marked middle third of the sample and the baseline readings of all the samples were recorded (Figure 9).

The selected samples were completely immersed into their respective plastic containers and were taken out of the solutions at 1, 7, 14, and 21 days where as each cycle in autoclaving lasted for 40 minutes. The specimens were gently rinsed under tap water for 30 seconds, following which each of the samples was mounted into its plaster model, and the readings of CIE L*, a*, and b* were obtained on the LED screen and recorded. The same set of solutions was continued in the containers throughout the study period. The Easyshade was set and the readings were recorded for each specimen. The differences in the background were eliminated by having a white background of the dental plaster model during the data collection.

Lighting conditions of the area are maintained constant during the recordings. The disinfection procedures were repeated with each of the four shades, and new measurements were recorded after each disinfection cycle. To evaluate the color difference, ΔE values were evaluated between baseline and different time intervals were calculated.

Figure 1- Distilled water

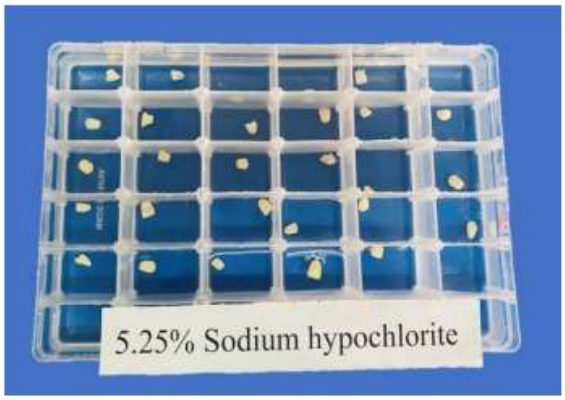

Figure 2 - 5.25% Sodium hypochlorite

Figure 3 – 70% Isopropyl alcohol

Figure 4 - Autoclave

Figure 5 – VITA Easyshade Spectrophotometer

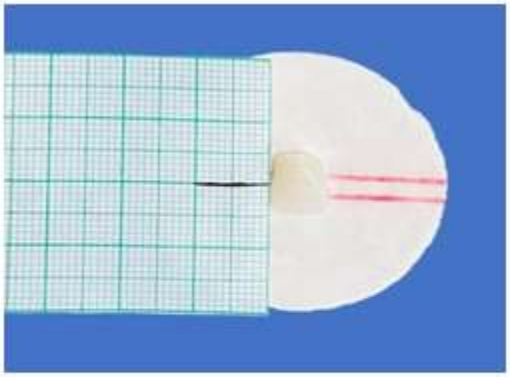

Figure 6 – Locating the middle third of specimen with marking made on graph sheet

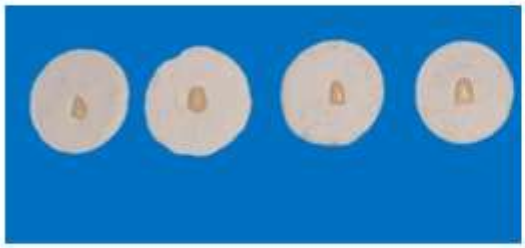

Figure 7: Holder from dental plaster to keep Easyshade in place

Figure 8: calibration was done according to manufacturer's instructions.

Figure 9 : Probe of the Easyshade was held perpendicular against the marked middle third of the sample

RESULT:

The mean, median, and standard deviation of the readings of ΔE from different shade tabs for each selected shade tab at every specified interval of time of immersion in a solution of distilled water, sodium hypochlorite, isopropyl alcohol, and autoclave compared with baseline is depicted in table 1-4. The difference in color change of Acryrock A1 and A2 and Premadent 23 and 24 within each of the study groups with change in time is depicted in table 5-6. The ΔE values for different acrylic shade tabs were compared with their respective baseline values (before immersion), and the statistically significant differences detected were indicated with the appropriate superscript (*).

On Day 21, the color change of Acryrock A1 was significantly higher in isopropyl alcohol compared to others (Figure 10). At the 3 preceding time points, there were no significant differences. For Acryrock A2, the color change was significantly higher with autoclaving on Day 1 and Day 7 (Figure 11).

On Day 14, autoclave demonstrated significantly lesser color change than the other groups and no significant differences were found on Day 21. For Premadent shade 23, significantly lesser color change was observed with autoclave on Day 14 and isopropyl alcohol on Day 21(Figure 12). For Premadent shade 24, significantly lesser color change observed with autoclave on Day 14 and with isopropyl alcohol on Day 21(Figure 13). Differences in color change of Acryrock A1 and Acryrock A2 within each of the study groups with change in time was observed. (Figure 14, 15). Differences in color change of Premadent 23 and Premadent 24 within each of the study groups with change in time was observed. (Figure 16,17).

For Acryrock A2, such observations were made in sodium hypochlorite, isopropyl alcohol, and autoclave groups. For Premadent shade 23, significant differences in color changes between time points were observed in all the four groups. For Premadent shade 24, such observations were made in sodium hypochlorite, isopropyl alcohol, and autoclave groups.

A significant difference was noted in the degree of shade tab colour change with Acryrock A1, A2 and Premadent shade 23 ,24 in 70% Isopropyl alcohol.

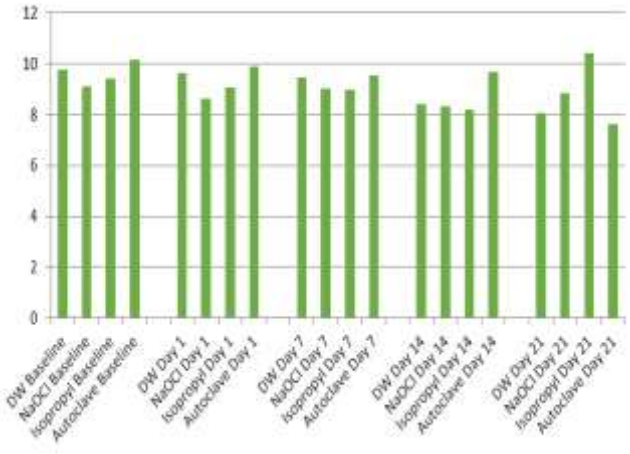

Figure 10: Difference in color change of Acryrock A1 between the study groups at a given time point.

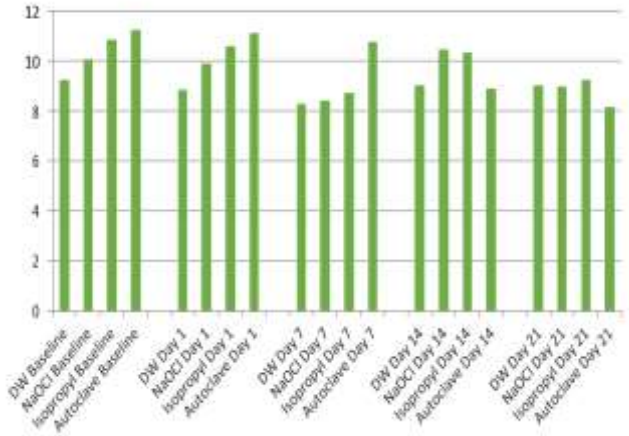

Figure 11: Difference in color change of Acryrock A2 between the study groups at a given time point

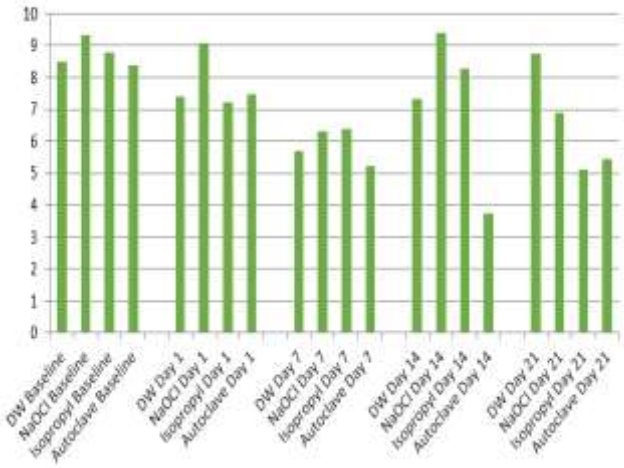

Figure 12: Difference in color change of Premadent 23 between the study groups at a given time point

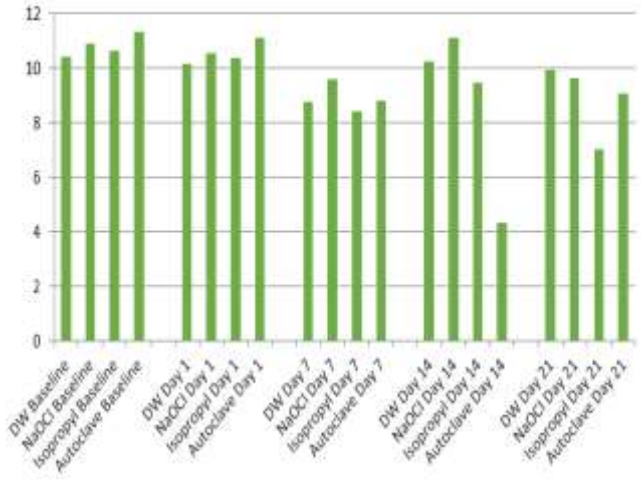

Figure 13: Difference in color change of Premadent 24 between the study groups at a given time point

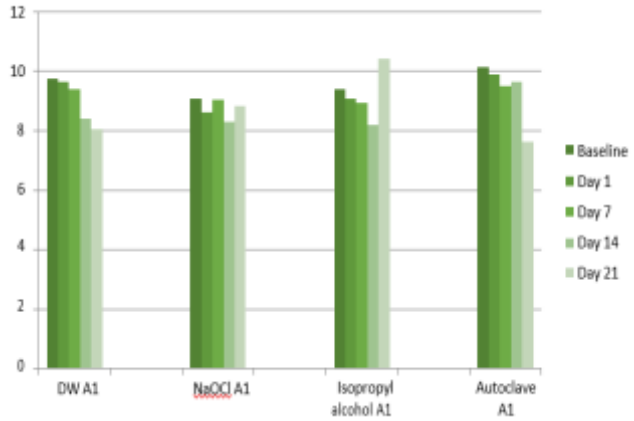

Figure 14: Difference in color change of Acryrock A1 within each of the study groups with change in time

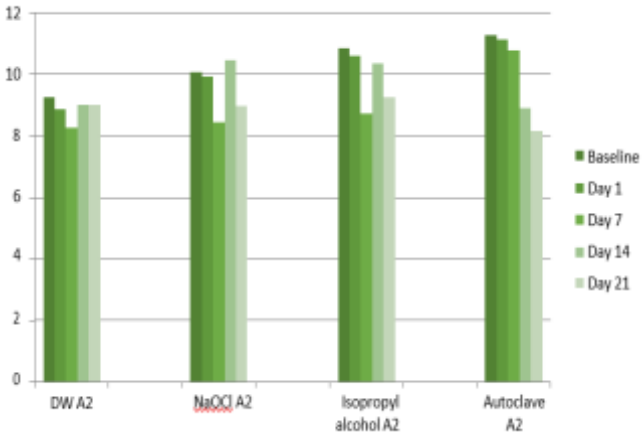

Figure 15: Difference in color change of Acryrock A2 within each of the study groups with change in time

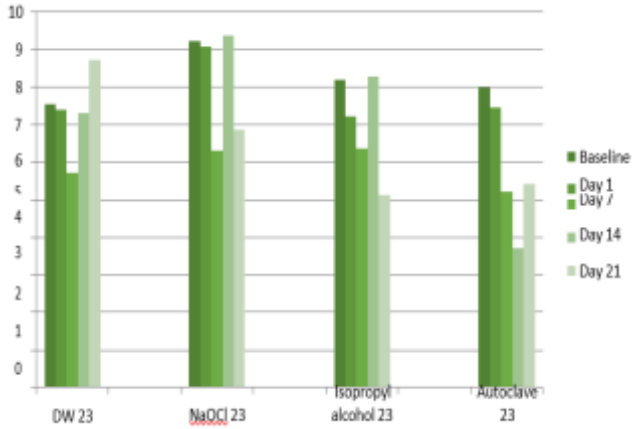

Figure 16: Difference in color change of Premadent 23 within each of the study groups with change in time

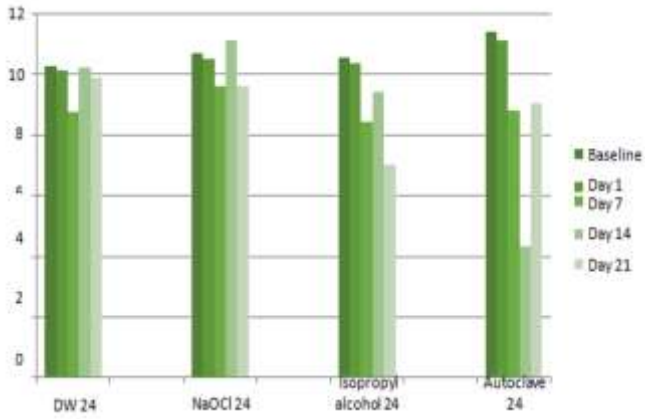

Figure 17: Difference in color change of Premadent 24 within each of the study groups with change in time

Table 1: Difference in color change of acryrock a1 between the study groups at a given time point

c		N	Mean	Std. Deviation	F value	P value
Baseline	Distilled water	8	9.76	1.232	0.732	0.509
	NaOCl	8	9.08	1.136		
	Isopropyl alcohol	8	9.41	0.968		
	Autoclave	8	10.13	1.44		
Day 1	Distilled water	8	9.638	2.0368	1.309	0.291
	NaOCl	8	8.625	1.0727		
	Isopropyl alcohol	8	9.075	1.0553		
	Autoclave	8	9.900	1.2547		
DAY 7	Distilled water	8	9.425	.5946	0.509	0.679
	NaOCl	8	9.038	.7855		
	Isopropyl alcohol	8	8.950	1.6861		
	Autoclave	8	9.525	1.1055		
DAY 14	Distilled water	8	8.425	1.1411	2.704	0.064
	NaOCl	8	8.313	1.0274		
	Isopropyl alcohol	8	8.200	.8053		

	Autoclave	8	9.650	1.5446		
DAY 21	Distilled water	8	8.075	1.1247	17.469	<0.001*
	NaOCl	8	8.837	.7130		
	Isopropyl alcohol	8	10.438	.8331		
	Autoclave	8	7.613	.5866		

One way analysis of variance; p≤0.05 considered statistically significant; * denotes statistical significance. Mean - ΔE value

Table 2: Difference in color change of Acryrock A2 between the study groups at a given time point

		N	Mean	Std. Deviation	F value	P value
Baseline	Distilled water	8	9.24	1.266	0.518	0.662
	NaOCl	8	10.071	1.932		
	Isopropyl alcohol	8	10.843	1.88		
	Autoclave	8	11.26	1.981		
Day 1	Distilled water	8	8.863	1.0836	6.075	0.003*
	NaOCl	8	9.913	.6446		
	Isopropyl alcohol	8	10.588	1.1470		
	Autoclave	8	11.138	1.4657		
DAY 7	Distilled water	8	8.275	.7285	13.43	<0.001*
	NaOCl	8	8.438	.5706		
	Isopropyl alcohol	8	8.712	.3044		
	Autoclave	8	10.775	1.5097		
DAY 14	Distilled water	8	9.025	.5285	5.42	0.005*
	NaOCl	8	10.463	.5012		
	Isopropyl alcohol	8	10.350	1.4343		
	Autoclave	8	8.913	1.2253		
DAY 21	Distilled water	8	9.025	.5285	2.81	0.058
	NaOCl	8	8.975	.3882		
	Isopropyl alcohol	8	9.275	1.3636		
	Autoclave	8	8.163	.6022		

One way analysis of variance; p≤0.05 considered statistically significant; * denotes statistical significance

Table 3: Difference in color change of Premadent 23 between the study groups at a given time point

		N	Mean	Std. Deviation	F value	P value
Baseline	Distilled water	8	8.493	1.368	0.487	0.716
	NaOCl	8	9.324	1.427		
	Isopropyl alcohol	8	8.76	1.61		
	Autoclave	8	8.391	1.599		
Day 1	Distilled water	8	7.388	1.9105	2.52	0.078
	NaOCl	8	9.075	1.7871		
	Isopropyl alcohol	8	7.212	1.3851		
	Autoclave	8	7.462	.8700		
	Distilled water	8	5.713	2.7373	0.74	0.533

DAY 7	NaOCl	8	6.300	.9577		
	Isopropyl alcohol	8	6.375	1.4558		
	Autoclave	8	5.225	1.4038		
DAY 14	Distilled water	8	7.325	1.4370	10.01	<0.001*
	NaOCl	8	9.388	3.2717		
	Isopropyl alcohol	8	8.275	2.3542		
	Autoclave	8	3.725	.9498		
DAY 21	Distilled water	8	8.738	1.6221	10.28	<0.001*
	NaOCl	8	6.888	1.0467		
	Isopropyl alcohol	8	5.125	1.6568		
	Autoclave	8	5.438	1.4131		

One way analysis of variance; p≤0.05 considered statistically significant; * denotes statistical significance

Table 4: Difference in color change of Premadent 24 between the study groups at a given time point

		N	Mean	Std. Deviation	F value	P value
Baseline	Distilled water	8	10.426	1.99	0.496	0.715
	NaOCl	8	10.88	1.872		
	Isopropyl alcohol	8	10.624	1.766		
	Autoclave	8	11.347	2.031		
Day 1	Distilled water	8	10.138	1.6852	0.388	0.762
	NaOCl	8	10.525	1.6816		
	Isopropyl alcohol	8	10.388	1.6983		
	Autoclave	8	11.100	2.2709		
DAY 7	Distilled water	8	8.750	1.2570	1.13	0.352
	NaOCl	8	9.612	.7376		
	Isopropyl alcohol	8	8.425	1.8148		
	Autoclave	8	8.812	1.3260		
DAY 14	Distilled water	8	10.238	1.5510	22.74	<0.001*
	NaOCl	8	11.125	1.2068		
	Isopropyl alcohol	8	9.438	2.4721		
	Autoclave	8	4.325	1.7645		
DAY 21	Distilled water	8	9.938	.6567	16.08	<0.001*
	NaOCl	8	9.638	.9576		
	Isopropyl alcohol	8	7.013	.6875		
	Autoclave	8	9.038	1.2761		

One way analysis of variance; p≤0.05 considered statistically significant; * denotes statistical significance

Table 5: Difference in color change of Acryrock A1 and A2 within each of the study groups with change in time

Group	Day	A1		P value	A2		P value
		Mean±SD	Mean rank		Mean±SD	Mean rank	
Distilled water	BL	9.76±1.232	3.28	0.062	9.24±1.266	3.03	0.261
	1	9.63±2.03	3.06		8.86±1.08	2.75	

	7	9.42±0.59	3.13		8.27±0.72	1.75	
	14	8.42±1.14	2.13		9.02±0.52	2.75	
	21	8.07±1.12	1.69		9.02±0.52	2.75	
NaOCl	BL	9.08±1.136	2.29	0.567	10.071±1.932	3.29	0.001*
	1	8.62±1.07	2.13		9.91±0.64	3.13	
	7	9.03±0.78	2.75		8.43±0.57	1. 06	
	14	8.31±1.02	2.25		10.46±0.5	3.75	
	21	8.83±0.71	2.88		8.97±0.38	2.06	
Isopropyl alcohol	BL	9.41±0.968	2.41	0.004*	10.843±1.88	3.63	0.012*
	1	9.07±1.05	2.25		10.58±1.14	3.5	
	7	8.95±1.68	2.19		8.71±0.3	1.69	
	14	8.2±0.8	1.69		10.35±1.43	2.94	
	21	10.43±0.83	3.88		9.27±1.36	1.8	
Autoclave	BL	10.13±1.44	3.56	0.015*	11.26±1.981	4.01	0.001*
	1	9.9±1.25	3.38		11.13±1.46	3.88	
	7	9.52±1.1	2.38		10.77±1.5	2.75	
	14	9.65±1.54	2.88		8.91±1.22	2	
	21	7.61±0.58	1.38		8.16±0.6	1.38	

Friedman's test; p≤0.05 considered statistically significant; * denotes statistical significance

Table 6: Difference in color change of Premadent 23 and 24 within each of the study groups with change in time

Group	Day	Premadent 23		P value	Premadent 24		P value
		Mean±SD	Mean rank		Mean±SD	Mean rank	
Distilled water	BL	7.53±2.08	2.49	0.01*	10.26±1.42	2.78	0.054
	1	7.38±1.91	2.31		10.13±1.68	2.63	
	7	5.71±2.73	1.44		8.75±1.25	1.5	
	14	7.32±1.43	2.75		10.23±1.55	3.25	
	21	8.73±1.62	3.5		9.9±0.65	2.63	
NaOCl	BL	9.21±1.96	3.57	0.007*	10.69±1.32	2.87	0.014*
	1	9.07±1.78	3.38		10.52±1.68	2.69	
	7	6.3±0.95	1.63		9.61±0.73	1.81	
	14	9.38±3.27	3.19		11.12±1.2	3.63	
	21	6.88±1.04	1.81		9.63±0.95	1.88	
Isopropyl alcohol	BL	8.19±1.472	3.13	0.012*	10.54±1.92	3.86	0.001*
	1	7.21±1.38	2.88		10.38±1.69	3.75	
	7	6.37±1.45	2.13		8.42±1.81	2.13	
	14	8.27±2.35	3.5		9.43±2.47	2.81	
	21	5.12±1.65	1.5		7.01±0.68	1.31	
Autoclave	BL	7.98±1.821	3.93	0.002*	11.38±2.34	3.62	0.001*
	1	7.46±0.87	3.75		11.1±2.27	3.5	
	7	5.22±1.4	2.5		8.81±1.32	2.75	
	14	3.72±0.94	1.25		4.32±1.76	1	
	21	5.43±1.41	2.5		9.03±1.27	2.75	

Friedman's test; p≤0.05 considered statistically significant; * denotes statistical significance

Discussion:

According to results of the present research, null hypothesis was refused. This study investigated whether significant changes in colour occurred after using four disinfectant methods with different acrylic shade tabs. According to the standardized

laboratory conditions, the average total CIELAB color difference is approximately 1 unit for 50% human perceptibility.10 The tolerance for shade guides set by American Dental Association (ADA) is set at limit of ΔE 2 and the average color difference between teeth and matched shade tabs in the oral environment is set at ΔE 3.7. It is clinically significant to know that when ΔE approaches 3.0, under clinical conditions, by more than 90% of observers, the color mismatch will be visually detectable. Change in shade dissatisfies clinician, technician and patient.11

Surface colour analysis is often done with spectrophotometers. The quantity of spectral reflection from the body is measured. It's a photometer that measures intensity using colour, or more precisely, wavelength. A light source, monochromator, and detector make up the optical elements. Light sources are diffracted in general. Several wavelengths are passed through the test sample and the entrance slit12. The sample preferentially absorbs different wavelengths of light. After that, the light goes through the exit slit and strikes the detector. The detector transforms light intensity at a specific wavelength into an electrical signal, which is subsequently amplified and presented on a screen or plotted on a chart. To precisely measure colour, a spectrophotometer is recommended. A colorimeter measures the total amount of light absorbed, whereas a spectrophotometer measures the amount of light absorbed at different wavelengths. Colorimeters, on the other hand, measure the total quantity of light absorbed, whereas spectrophotometers measure the amount of light absorbed by a given wavelength. Over time, spectrophotometers have shown to be trustworthy and accurate

Yap et al (1999) compared the color matching difference between computerized colorimetry and human eye assessment. 13 In agreement with the previous study, the testing instrument was accurate and reliable in the present study. Pohjola et al in 2007 conducted a study in which they observed a statistically significant increase in the value and chroma of the shade tabs subjected to disinfection with Cavicide disinfecting agent (Metrex Research) after 2 and 3 years of simulated treatment on Classic Vitapan shade guide (Vident).5

A study conducted by Ma et al evaluated the influence of 120 sterilization cycles on the colour stability of two ceramic shade guides and concluded that repeated cycles of autoclave sterilization caused statistically significant changes in the colour co-ordinates of the two shade guides.14,15

Shade tabs disinfected with autoclave showed the least amount of color change, while the shade tabs treated with isopropyl alcohol showed the most amount of color change.16,13 Color stability is considered the most clinically significant property in shade matching and to evaluate the effect of various disinfectants on shade tabs is advantageous.

Limitations of the study: 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. The ΔE values are unidirectional and do not indicate whether the shade shades get darker or lighter.

Conclusion:

Following conclusions were made within the limitations of the study:

1. All the disinfectant solutions used produced a perceivable change in color (ΔE>1).
2. Sodium hypochlorite produced more definite and early change in colour on shade tabs from VITA Classical Shade Guide tabs and Premadent acrylic teeth shades.
3. Isopropyl alcohol produces definite change in colour.
4. Of all the disinfectants autoclaving produced very little change in colour.
5. However, distilled water was associated with smaller ΔE values.
6. One shade guide should be retained as a control and periodically compared with the shade guide in use to determine when the shade tabs in use should be replaced or discarded.

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