EVALUATION OF POSSIBLE DISCOLORATION ON VITA CLASSICAL SHADE TABS USED DAILY COMPARED TO NEW REFERENCE SHADE TABS

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ABSTRACT

Introduction Visual shade selection is still a very popular way of shade selection. This method is subjective with uncertain factors like the material of the conventional shade tab and restoration is different, the companies put different colored materials on the market under the same shade tab code. Besides these aggravating factors, the shade tabs can go under discoloration over time causing further difficulty in proper shade determination. This study aims to evaluate the extent of discoloration of the regularly used shade tabs by students in the Department of Prosthodontics.

Methodology Six shades (A1, A2, A3, C2, C3, D2) were selected from nine regularly used VITA Classical shade guides (54 shade tabs in total) and compared visually and digitally (VITA Easyshade V spectrophotometer) to a corresponding brand-new reference guide. During the digital comparison L*a*b* values were recorded and the color difference (ΔE00) was calculated with the CIEDE2000 formula.

Results 38 out of the 54 shade tabs were above the perceptibility threshold (0.8 ΔE00) and visual color changes were noticed as well. Unacceptable color differences (above 1.8 ΔE00) were found in 19 cases. Only 16 shade tabs did not show visible and clinically relevant measurable discoloration.

Conclusion Conventional shade tabs are worn off and go through discoloration over time. In this study, 70.4 % of the regularly used shade tabs went through noticeable discoloration. It is recommended to keep one new shade guide to verify the color of the regularly used shade tabs in the dental office.

KEYWORDS

Prosthodontics; Dental aesthetic; Color; Spectrophotometry; Discoloration.

1. INTRODUCTION

The success of dental aesthetic rehabilitation depends on the correct tooth shade selection. The color of the restoration is an important factor in patient satisfaction [1,2]. In most cases, the tooth shade determination is still carried out visually with shade tabs. The restoration materials are rapidly developing, new materials appear on the market every year until the most frequently used shade guides were put on the market before the noughties. (Fig. 1) The VITA Classical shade guide (VC) (before VITA Lumin Vacuum, VITA Zahnfabrik, Bad Säckingen, Germany) in 1956, the Chromoscop (Ivoclar-Vivadent, Amherst, NY) in 1990, and the VITA 3D Master (VITA Zahnfabrik, Bad Sackingen, Germany) in 1998 appeared on the market [2-4]. The material, translucency, and thickness of the restorations and the conventional shade guides are not always the same. Furthermore, the different companies carry out different shades under the same shade tab code [5]. Besides these aggravating factors that might lead to unsuccess in shade determination, the shade tabs are disinfected daily to prevent cross contamination which can lead to discoloration and worsen the outcome of the shade determination as well [6,7].

Figure 1. New VITA Classical and 3D Master shade guides (left), old VITA Classical shade guides (right).

This present study aims to compare the color parameters of VC shade tabs in daily use at the Department of Prosthodontics, Semmelweis University with brand-new, reference VC shade tabs to detect color changes due to the effect of daily use which might lead to inaccuracy in shade determination.

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2. MATERIALS AND METHODS

Selection of the shade tabs:
Nine layered ceramic VC shade guide (VITA Zahnfabrik, Bad Säckingen, Germany) was selected randomly from the practice rooms of the Department of Prosthodontics, Semmelweis University, the shade tabs are used by students (manufactured 1 guide in 2010, 4 guides in 2012 1 guide in 2013, and 3 guides in 2015 and all of them are original and produced by VITA Zahnfabrik). The reference was a brand-new VC shade guide provided by the manufacturer and manufactured in 2021. Based on a previous study the A1, A2, A3, C2, C3, and D2 are the most frequent natural tooth shades [8]. In this present study, these six shades were evaluated. (Fig. 2)

Figure 2. The six evaluated shade from VITA Classical shade tab.

Visual shade selection:
To provide standard lighting Smile Lite lamp (Smile Line, Switzerland) was used for visual shade determination. The Smile Lite lamp simulated the optimal 5500 K illumination for the correct tooth shade selection [9]. (Fig. 3)

Figure 3. Smile lite lamp (5500 K).

The visual shade selection was evaluated on the fact of the color difference between the used and the reference shade tabs but the degree of the color difference was not recorded. The observers, two dental students and one dentist who is an expert in dental shade selection went through the Ichihara test before the visual shade selection. (Fig. 4)

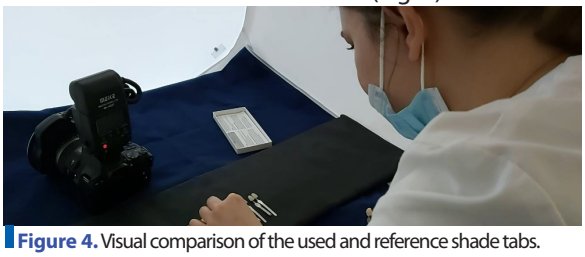

Figure 4. Visual comparison of the used and reference shade tabs.

Digital shade determination:
For digital comparison, a VITA Easyshade V spectrophotometer (VITA Zahnfabrik, Bad Säckingen, Germany) was used. The standardization of the lighting conditions was essential because the spectrophotometer measured the reflected light for this the shade tabs were evaluated in a dark box, through a little hole the same size as the tip of the spectrophotometer. To provide a standard position the shade tab holder was used. In the holder, the shade tab was positioned centrally with the help of a custom-made deep-drawn foil case (positioning foil). The holder with the positioning foil was placed in the dark box under the hole. (Fig. 5) To standardize the position of the spectrophotometer an acrylic stand was made to hold the device.

Figure 5. Positining the shade tabs .

One point measurement was made on every shade tab after calibration based on the instructions of the manufacturer. Every shade tab was measured three times. The spectrophotometer measures L*a*b* values. (Fig. 6) The L*a*b* values were recorded in an Excel file.

Figure 6. The VITA Easyshade V spectrophotometer measures L*a*b* values.

Calculating the color difference:
The ΔE shows the color difference between the used and the corresponding reference shade tabs. The color difference (ΔE00) was calculated with the CIEDE2000 formula. [10]

$$\Delta E_{00}\sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2+\left(\frac{\Delta C'}{k_C S_C}\right)^2+\left(\frac{\Delta H'}{k_H S_H}\right)^2+R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)}$$

Where ΔL', ΔC', and ΔH are the differences in lightness, chroma, and hue. ΔR is an interactive term between hue and chroma differences. The weighting functions for the lightness, chroma, and hue components, respectively shown by SL, SC, SH. The kL, kc and kh parametric factors are correction

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terms for experimental conditions. In the present study kL=kc=kh=1. [11,12] Based on a previous study wherein the Semmelweis University participated in the color difference was not noticeable to half of the observers between 0 and 0.8 ΔE00 [13]. Between 0.8 and 1.8 ΔE00 half of the observers noticed the color difference, but it was considered acceptable, but above 1.8 ΔE00 the color difference was unacceptable. Correspondingly, in this present study, the perceptibility threshold (PT50:50%) is defined in 0.8 ΔE00 and the acceptability threshold (AT50:50%) is in 1.8 ΔE simultaneously. Based on the AT50:50% and PT50:50% the color difference of the shade tabs were divided into three groups: invisible, acceptable, and unacceptable color differences. (Fig. 7)

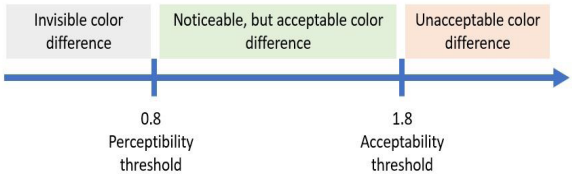

Figure 7. The shade tabs are divided into three groups based on the perceptibility and acceptability thresholds.

3. RESULTS

*The ΔE00 was calculated based on the L*a*b* values. (Table 1)*

Table 1. Measured L*a*b and calculated ΔE values in the case of all shades and samples.

Sample 1	L	a	b	ΔE
A1	83.4	-0.3	14.2	0.8067
	83.4	-0.3	14.2	0.8090
	83.4	-0.3	14.2	0.8924
			Average:	0.8360
A2	81.3	1.8	19.2	1.5699
	81.5	1.8	19.4	1.7837
	81.6	1.8	19.4	1.9317
			Average:	1.7618
A3	76.6	2.1	19.1	3.2300
	76.5	2.1	19.3	2.9667
	76.5	2.1	19.4	3.0437
			Average:	3.0802
C2	73.7	1.3	17.7	0.4014
	73.7	1.3	17.7	0.4000
	73.6	1.3	17.6	0.4582
			Average:	0.4199
C3	70.3	2.4	19.2	1.6633
	70.5	2.4	19.2	1.7519
	70.4	2.4	19.2	1.6076
			Average:	1.6743
D2	77.2	-0.4	12.1	1.1648
	77.3	-0.3	12.2	1.0154
	77.3	-0.3	12.3	1.3272
			Average:	1.1691

Sample 2	L	a	b	ΔE
A1	82.7	-0.2	14.6	0.4355
	82.5	-0.2	14.5	0.2686
	82.6	-0.2	14.4	0.4900
			Average:	0.3981
A2	79	1.7	14.2	0.1855
	78.9	1.7	14.2	0.2097
	78.9	1.7	14.2	0.1506
			Average:	0.1819
A3	83.4	1.2	14.2	0.4972
	83.4	1.2	14.2	0.3595
	83.4	1.2	14.2	0.4335
			Average:	0.4301
C2	83.4	1.6	14.2	0.3174
	83.4	1.6	14.2	0.4588
	83.4	1.6	14.2	0.2975
			Average:	0.3579
C3	83.4	2.5	14.2	0.6130
	83.4	2.5	14.2	0.5185
	83.4	2.5	14.2	0.3258
			Average:	0.4857
D2	83.4	-0.2	14.2	0.4058
	83.4	-0.2	14.2	0.3830
	83.4	-0.3	14.2	0.7483
			Average:	0.5124

Sample 3	L	a	b	ΔE
A1	85.5	-0.2	15.7	2.3754
	85.5	-0.2	15.7	2.3530
	85.5	-0.2	15.8	2.5210
			Average:	2.4165
A2	81	1.9	19.2	1.3592
	81.1	1.8	19.1	1.4678
	81	1.8	19.1	1.4945
			Average:	1.4405
A3	77.2	2.5	20	2.8037
	77.1	2.5	20	2.6280
	77.2	2.4	20	2.6294
			Average:	2.6870
C2	75.3	2	19.9	1.6174
	75.2	2	19.9	1.4395
	75.4	2	19.9	1.6441
			Average:	1.5670
C3	71.2	2.2	19.5	2.4059
	71.4	2.2	19.4	2.5026
	71.6	2.1	19.3	2.5557
			Average:	2.4881

D2	76.7	-0.3	13	0.8542
	76.6	-0.2	13.1	0.7166
	76.8	-0.3	12.9	1.0045
			Average:	0.8584

Sample 4	**L**	**a**	**b**	**ΔE**
A1	85	-0.3	15.4	2.0014
	84.4	-0.3	15.5	1.6376
	84.5	-0.3	15.5	1.8471
			Average:	1.8287
A2	80.9	1.8	19.2	1.3214
	80.9	1.8	19.1	1.3467
	80.9	1.8	19.1	1.4346
			Average:	1.3676
A3	78	1.5	23	1.2772
	78	1.5	23	1.0736
	78	1.4	23	1.1257
			Average:	1.1588
C2	74.2	1.8	18.9	0.6477
	74.5	1.7	18.7	0.5899
	74.5	1.7	18.7	0.7283
			Average:	0.6536
C3	70.6	2.4	20	2.0451
	70.4	2.5	20	1.2750
	70.4	2.5	20.1	1.2535
			Average:	12557
D2	76.5	0.1	14.1	1.2385
	76.7	0.1	14	1.2750
	76.4	0.1	14.1	1.2535
			Average:	1.2557

Sample 5	**L**	**a**	**b**	**ΔE**
A1	84.6	-0.7	14.3	1.6811
	84.5	-0.8	14.1	1.6676
	84.5	-0.8	14.2	1.6853
			Average:	1.6780
A2	82.6	1.2	22.8	3.4936
	82.6	1.2	22.8	3.5478
	82.4	1.1	22.7	3.5342
			Average:	3.5252
A3	79.4	1.3	23.2	0.2823
	79.5	1.3	23.2	0.1972
	79.5	1..3	23.5	0.2548
			Average:	0.2447
C2	73.1	1.4	18.5	0.5001
	73.4	1.4	18.5	0.5287
	73.2	1.4	18.7	0.4785
			Average:	0.5024

C3	70.6	2.5	20.6	2.1944
	70.8	2.6	20.7	2.3054
	71	2.6	20.7	2.3658
			Average:	2.2885
D2	76.4	-0.3	13.1	07190
	76.3	-0.3	13.1	0.5973
	76.4	-0.3	13	0.7673
			Average:	0.6946

Sample 6	**L**	**a**	**b**	**ΔE**
A1	85.1	-0.3	15.4	2.0628
	85.1	-0.3	15.4	2.0423
	85.1	-0.3	15.4	2.1757
			Average:	2.0963
A2	80.7	1.8	19.2	1.2010
	80.8	1.8	19.2	1.31.53
	80.7	1.8	19.2	1.34.69
			Average:	1.2877
A3	77	2.2	18.9	3.1564
	77.2	2.3	19.4	2.6884
	77	2.2	19	2.9957
			Average:	2.9468
C2	73.7	1.7	18.9	0.4481
	73.8	1.7	19.4	0.6065
	73.7	1.8	19	0.5242
			Average:	0.5263
C3	70.3	2.3	19.6	1.7691
	70.2	2.4	19.9	1.7182
	70.2	2.4	19.9	1.6544
			Average:	1.7139
D2	76.5	-0.3	12.8	0.6811
	76.4	-0.2	13.2	0.6761
	76.5	-0.3	12.8	0.7901
			Average:	0.7158

Sample 7	**L**	**a**	**b**	**ΔE**
A1	84	-0.4	15	1.3043
	84.2	-0.3	15.2	1.4443
	83.9	-0.4	15	1.3509
			Average:	1.3665
A2	82.2	1.6	19.4	2.1999
	82.3	1.8	19.7	2.3416
	82.1	1.7	19.4	2.2419
			Average:	2.2611
A3	76.6	2.2	19.5	3.1270
	76.3	2.4	20	2.9797
	76.4	2.4	20	3.0293
			Average:	3.0453

C2	76	1.5	19.3	1.8827
	75.8	1.6	19.4	1.5868
	76	1.5	19.4	1.8821
			Average:	1.7839
C3	70.5	2.2	19.6	1.9351
	70.7	2.2	19.6	2.0242
	70.5	2.3	19.9	1.8697
			Average:	1.9430
D2	75.9	-0.4	12.9	0.5190
	75.7	-0.4	12.8	0.4322
	75.9	-0.3	13.1	0.5414
			Average:	0.4957

Sample 8	**L**	**a**	**b**	**ΔE**
A1	85.6	0.1	16.2	2.6028
	85.6	0.1	16.4	2.6278
	85.5	0	16	2.6098
			Average:	2.6135
A2	80.3	1.6	18.4	0.8195
	80.4	1.7	18.4	0.8772
	80.4	1.6	18.3	0.9546
			Average:	0.8838
A3	77.9	1.4	22.8	1.3436
	78.3	1.4	23.2	0.8669
	78.1	1.4	23	1.0554
			Average:	1.0886
C2	74.3	1.6	18.8	0.6449
	74.5	1.6	18.9	0.6638
	74.3	1.7	18.9	0.6470
			Average:	0.6519
C3	71.4	2.3	19.4	2.5128
	71.2	2.4	19.5	2.3079
	71.4	2.2	19.2	2.3714
			Average:	2.3973

D2	77	-0.2	12.3	0.9468
	77	-0.2	12.3	0.7907
	77	-0.2	12.3	1.0962
			Average:	0.9446

Sample 9	**L**	**a**	**b**	**ΔE**
A1	88.6	-0.9	17.3	4.6140
	88.6	-0.9	17.3	4.5907
	88.6	-0.9	17.4	4.7307
			Average:	4.6451
A2	83.1	0.8	18.6	2.9254
	83	0.8	18.7	2.8458
	83.1	0.7	18.3	2.9927
			Average:	2.9213
A3	77.9	1.6	23	1.3655
	77.9	1.6	23	1.1637
	77.8	1.6	23	1.2975
			Average:	1.2756
C2	73.1	1.6	18.7	0.4976
	73.4	1.6	18.6	0.4972
	73.2	1.6	18.7	0.4051
			Average:	0.4666
C3	73.1	2.3	20.7	3.9351
	73.1	2.3	20.9	3.9202
	73.1	2.3	20.9	3.8479
			Average:	3.9011
D2	78.6	-0.1	13.8	2.2484
	78.5	-0.1	13.8	2.0854
	78.5	-0.1	13.8	2.2939
			Average:	2.2092

Only 16 shade tabs were under the 0.8 ΔE values. 38 shade tabs were above 0.8 ΔE and 19 of the 38 exceeded the 1.8 ΔE values. (Table 2)

Table 2. The number of shade tabs above 0.8 ΔE_{00} ($PT_{50:50\%}$) and 1.8 ΔE_{00} ($AT_{50:50\%}$) in the case of six shades.

	A1 9 Samples	**A2 9 Samples**	**A3 9 Samples**	**C2 9 Samples**	**C3 9 Samples**	**D2 9 Samples**	**All 54 Samples**
Under 0.8 ΔE	8	8	7	2	8	5	38
Above 1.8 ΔE	5	3	4	0	6	1	19

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The most deviations were found in the case of A1, A2, and C3, eight out of nine shade tabs were above the PT50:50% in all of these cases. In the case of C3 six shade tabs were also above the AT50:50%,in the case of A1 and A2 five and three shade tabs were found unacceptable (above AT50:50%) color difference. Categorization and Fisher's exact test equivalent to the Chi-square test were done. The test showed that in the combined groups A1, A2, and C3 significantly (p=0.00056) worse outcome was noticeable than other shades in total. The three examined categories were combined on the basis that they have the lowest proportion of ΔE00 results indicating invisible color difference. (Figs. 8,9)

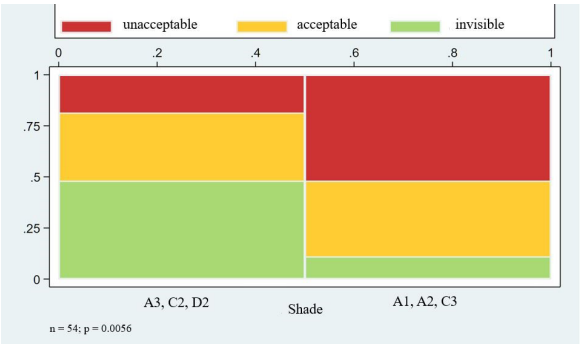

Figure 8. Distribution of ΔE00 categories defined based on the perceptibility and acceptability thresholds in groups formed based on shades and combined according to the similarity of the distribution. Fisher's exact test.

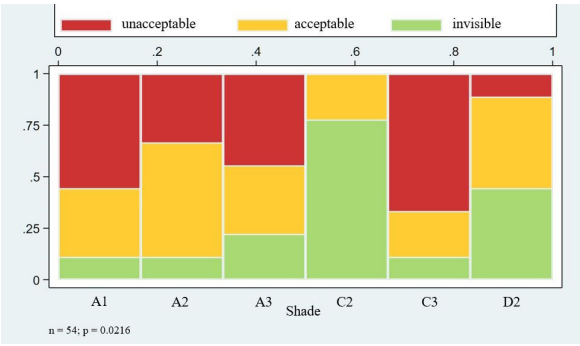

Figure 9. Distribution of ΔE00 categories defined based on the perceptibility and acceptability thresholds in groups formed based on shades. Fisher's exact test.

The ΔE00 of nine samples compared to the reference in every six shades are shown in Fig. 10. The perceptibility and acceptability thresholds are marked with an orange line. During the visual comparison, the observers found visible color differences in 38 cases.

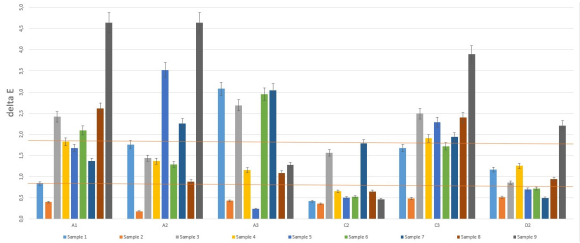

Figure 10. The ΔE00 values of the shade tabs compared to the reference separated to shades. The orange line shows the perceptibility (0.8 ΔE) and acceptability thresholds (1.8 ΔE).

4. DISCUSSION

Evaluation of the method of visual shade selection is a popular topic in dentistry. The most commonly used shade guide for visual shade selection is still the VC shade guide which contains 16 shades [14-16]. In dental practices to prevent cross-contamination the shade guides are disinfected regularly, [17] which can lead to changes in the shade [6,18]. Al Amri et al. evaluated the effects of the disinfectant liquid on VITA Lumin shade tabs with VITA Easyshade. In their study, 80% of the randomly selected shade tabs showed higher ΔE values than the perceptibility threshold [19]. In another previous study the effect of three disinfectants - Cavicide, Asepticare TB, and Sporicidin – was evaluated with a VITA Easyshade spectrophotometer on VC shade tabs [17]. The study evaluated two years of usage and based on the results the shade tabs did not undergo color changes in this period. Arrejaie et al simulated the effects of one, two and three years of disinfection with three different disinfectants on VITA Toothguide 3D Master shade guides. The measurements were carried out with A 7000A Colour Eye (X-rite, Grand Rapid, MI, USA) spectrophotometer [20].

Clinically significant color change was not described even after the three-year simulation, but the number of simulated disinfectant cycles was less than in other similar articles Hombesh et al evaluated the survivability of VITA 3D Master shade guides. The measurements were carried out with a spectrophotometer and two years were simulated. The test group was treated with isopropyl alcohol (70%), for the control group distilled water was used. A significant color difference was found between the control and the test group but without any clinical significance [6]. Alshetri et al treated the VC shade tabs with a disinfectant containing 70% ethanol and isopropyl alcohol. The potential color difference after the disinfection was evaluated digitally (Shade Eye NCC colorimeter) and visually [18]. Discoloration on the shade tabs was found in the case of 17.8% after two years of simulation, after three years it was raised to 28.9%. Pohjola et al found increased L* (lightness) and c*(chroma) values after two and three years of simulated disinfection with Cavicide disinfectant [21]. Alsethri and Pohjola both recommend keeping one reference shade guide in the dental office to check the color of the frequently used shade guides regularly [18,21]. In this present study the potential discoloration of the shade tabs - used by students in the Department of Prosthodontics, Semmelweis University - was evaluated due to everyday usage. During the visual comparison a visible color difference was found on 38 shade tabs. The color difference was not commeasurable, but the transparency of the edges was less visible on the used shade tabs compared to the new reference. (Fig. 11,12) Regarding the C2 shade tabs the best result was observed because discoloration was only found in two cases. (Fig. 13)

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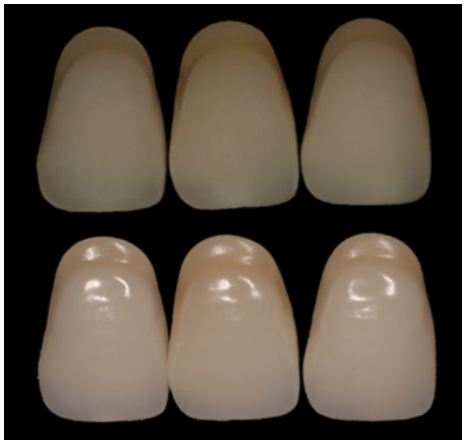

Figure 11. D2 shade tabs. Reference shade tab on the left side. Discolored shade tabs on the middle and on the right side. For the upper pictures a cross polarization filter was used to remove glare.

Figure 12. The color difference is visible with the naked eye. The discolored shade tabs on the right side and the reference shade tabs on the left side. For the upper pictures a cross polarization filter was used to remove glare.

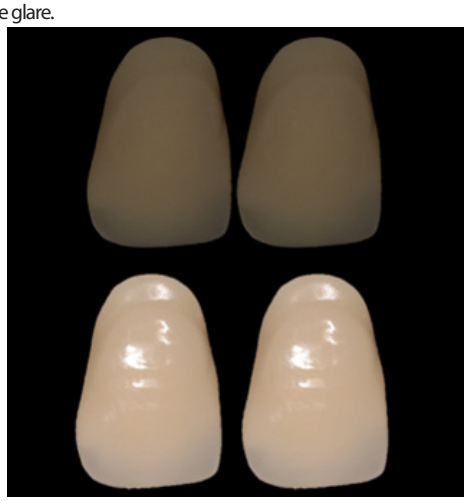

Figure 13. C2 shade tabs reached the best results, in this photo discoloration was not visible. For the upper pictures a cross polarization filter was used to remove glare.

During the spectrophotometric digital measurement, 38 out of 54 shade tabs showed higher values than 0.8 ΔE00 (perceptibility threshold) and belonged to the visible color difference group. The most frequent shade tabs were A1, A2, and C3 shade tabs in the visible color difference group. This can be attributed to the more frequent use of the mentioned shades and the increased number of disinfection cycles. The ΔE00 was above 1.8 in the case of 19 shade tabs, so 35.2% of the tested tabs belonged to the unacceptable color difference group. These tabs were considered clinically useless due to the unacceptable discoloration. The most frequent shades in the unacceptable color difference group were the A1 and C3. Only 29.6% of the tested shade tabs did not show noticeable color differences during the digital comparison. (Fig. 14)

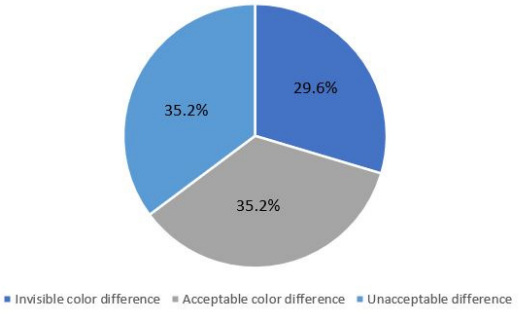

Figure 14. Percentage distribution of invisible, acceptable and unacceptable color differences among the tested shade tabs.

CONCLUSION

35.2 % of the tested VC shade tabs underwent unacceptable color changes. The present study demonstrated that the shade tabs were worn out, and discolored over time. The discoloration was even detected visually. The color changes might affect the color of the final restoration and lead to esthetic failures. The shade tabs used daily need to be checked regularly and have to be replaced if discoloration is detected.

AUTHOR CONTRIBUTIONS

DF: Conceptualization, Methodology, Investigation, Writing-Original draft, Visualization, Project Administration **JB:** Conceptualization, Methodology, Writing-Review and Editing, Supervision **PH:** Conceptualization, Writing-Review and Editing, Supervision

CONFLICT OF INTEREST

Authors declare that there is no conflict of interests.

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CV

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Questions

1. What are the most commonly used shade guides?

❑a. Vita Classical and Vita 3D Master;
❑b. Vita Classical and Ivoclar Universal A-D shade guide;
❑c. Vita 3D Master and Vita Bleachguide 3D Master;
❑d. None of the above.

2. The visual shade selection is:

❑a. Objective;
❑b. Not used anymore;
❑c. Subjective;
❑d. Always very precise.

3. What is the color temperature of the Smile Lite lamp?

❑a. 1000 K;
❑b. 65000 K;
❑c. 10000 K;
❑d. 5500 K.

4. Please select the true statement:

❑a. The Vita Easyshade V spectrophotometer measures the reflected light;
❑b. For visual shade selection, the standardized light conditions are not important;
❑c. The VITA Easyshade spectrophotometer is not able to measure color parameters like L*a*b or L*c*h;
❑d. The color difference is measurable with the Vita Easyshade spectrophotometer.