COMPARISON OF SHADE CHANGES ACCORDING TO DRY/WET CONDITION OF TEETH USING INTRA-ORAL COLORIMETER

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Objectives.

The purpose of this study was to compare the shade changes in wet and dry conditions of natural teeth using two different intra-oral colorimeters.

Materials and methods.

Twenty volunteer subjects have no restorations and fillings in the maxillary central incisors were involved in this clinical study. The color of tooth was measured by two different instruments that were a Shade Scan™ System and a VITA Easyshade®, Five times consecutive measurements were done for each subject with both instruments. Groups of measurement are an initial wet condition as control, dry in 5 minutes, 15 seconds after re-wetting with saliva, re-wetting after 5minutes and re-wetting after 30 minutes.

Using ShadeScan System™, tooth image was captured and converted to the mapping image of Vitapan 3D master. Three main shades were chosen from each subject and calculated the area in Global Lab Image software. Data were analyzed using paired T-Test and Wilcoxon Signed Ranked Test.

Using VITA Easyshade®, color differences(Δ E) between measurements were analyzed with one sample T-test.

Results.

Using ShadeScan System™, there were significant differences between control group and dry(P=.023), dry and re-wetting 15 seconds, 5 minutes, 30 minutes as well(P=.021, P=.017, P=.030) in comparison of primary shade. However, comparing three main shades, there was no significant difference between control and dry(P=.105).

Using VITA Easyshade®, color differences(Δ E) between control and dry, dry and re-wetting 30 minutes were statistically different(P=.002, P=.022).

Conclusion.

Primary shade could be changed in dry and wetting procedure in time, however there was no significant shade changes in overall.

Key Words

Shade taking, Dry shade, Colorimeter, ShadeScan System™, VITA Easyshade®

The esthetics of tooth color restorations depend on outline, surface texture, translucency, and color.[1] To obtain the successful clinical outcome for the esthetic prosthesis, proper shade selection is crucial.[2,3] In addition, shade selection for the tooth color restoration is the technique sensitive procedure.[4]

Some clinicians recommend to take the shade prior to clinical procedures.[5] Shade and surface texture are evaluated prior to tooth preparation. It is reported that "When teeth are dehydrate, air replaces the water between the enamel rods, changing the refractive index and making the enamel appear opaque white. ··· even though the enamel is highly translucent and is colorless···."[6]

However, many clinicians do the shade taking at the end of their clinical procedures, even followed by oral prophylaxis.[7] During the clinical procedures, teeth might be in dry or semi-dry condition for a while. For instance, impression making procedure needs to keep the teeth in dry condition for at least 5 minutes when poly vinyl siloxane that used most commonly. For temporary cementation, working field is isolated from the moisture to have proper properties of luting agents.

The purpose of this study was to compare the shade of the dry and re-wetting tooth surface in time.

MATERIALS AND METHODS

Twenty subjects were selected for this study. After examining the right and left central incisors in the maxilla of each subject, one sound tooth was selected, free from restorations and caries.

The teeth selected for measurement were brushed without toothpaste at least half hour before the measurements. In order to avoid the superficial staining, all subjects were restricted to foods and beverages except pure water while they were waiting for the measurements.

The color of tooth was measured by two different instruments that were an intra-oral colorimeter instrument (ShadeScan™ System, CYNOVAD, Montreal, Canada) (Fig. 1) and an intra-oral spectrophotometer (VITA Easyshade®, Vident, Brea, CA). (Fig. 2)

ShadeScan™ System has three sources of illumination. It makes possible to avoid other illumination source in the color measuring environment. To ensure measurement accuracy, a subject opened one' s mouth to provide a dark background and made sure illumination source project perpendicular to the tooth surface. In order to capture the proper image symmetrical and centered highlights form the reflected illumination should be positioned somewhere between the gingival third and the incisal third. VITA Easyshade® has the D65 light source. The aperture diameter of the measuring port of the spectrophotometer is 5mm.

Five times measurements were done for each subject with both instruments. Meas-urements were repeated three times. Five times of measurements were grouped in initial wet condition (C), 5minutes dry (D), re-wetting for 15 seconds (S15), re-wetting for 5minutes (M05), and re-wetting for 30 minutes (M30). Seven comparisons were done for dry and re-wetting (C-D, C-S15, C-M05, C-M30, D-S15, D-M05, and D-M30).

First measurement was performed in condition of any kind of preparation. Subject was instructed to swallow the saliva in order to keep minimum moisture on the tooth surface. For the second measurement, selected tooth was dried by air syringe for about one minute and kept away from moisture using cotton rolls and gauze. Measurement was done after at least 5 minutes dry conditioning of selected tooth. Third measurement was performed in 15 seconds of re-wetting. Subject was instructed to rinse the mouth with water and swallow saliva to keep the minimum moisture over the examining tooth surface. Fourth and fifth measurement were done 5 minutes and 30 minutes after re-wetting conditioning of

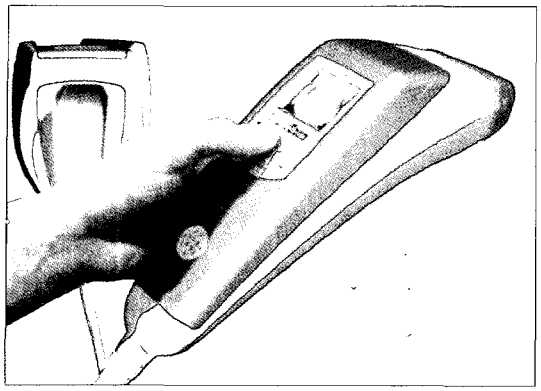

Fig. 1. ShadeScan™ System

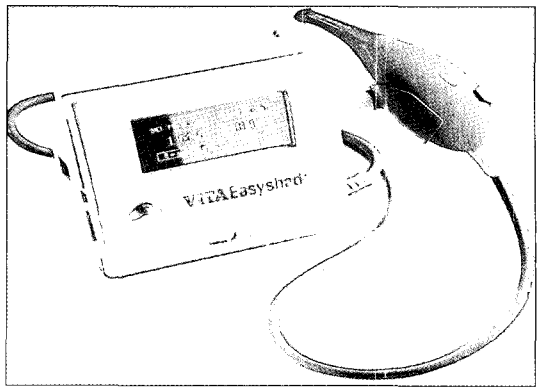

Fig. 2. VITA Easyshade®

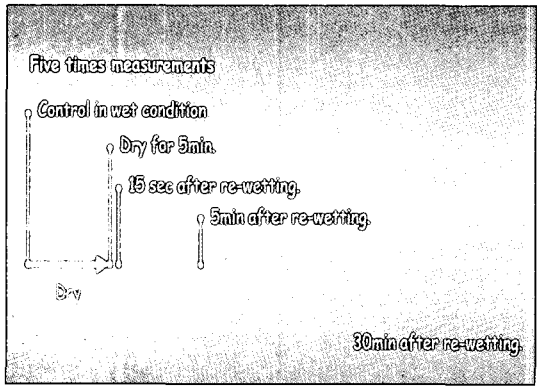

Fig. 3. Five times measurements

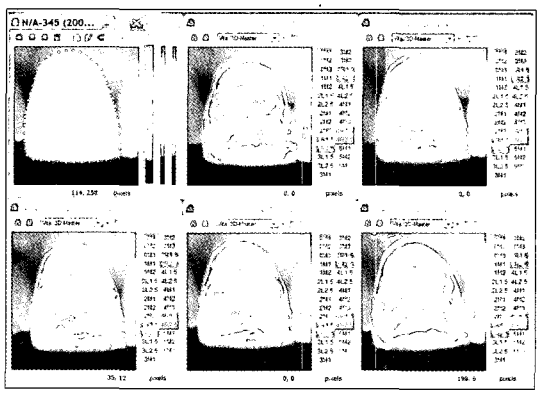

Fig. 4. Digitally mapped images based on Vitapan 3D-master® shade

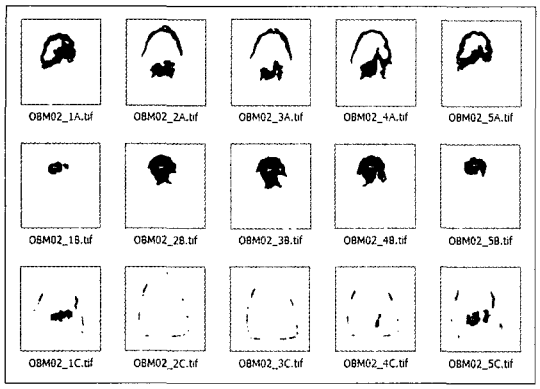

Fig. 5. Cropped images of three shades (in row) in five times measurements (in column)

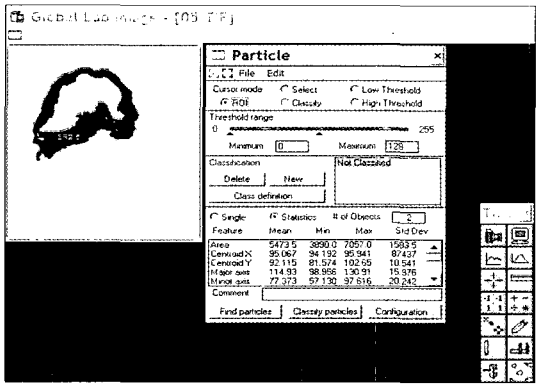

Fig. 6. Area measurements in graphic software

tooth with same instruction to the subject same as before. (Fig. 3)

Using ShadeScan™ System, measurements were saved as captured digital images through the ShadeScan™ Plus software provided by same manufacturer. Each digital image was converted to a mapping image based on VITAPAN 3D-Master® shade. (Fig. 4) From the digitally maped image, three main shades were selected from each subject. Primary, secondary, tertiary shades were based on the area of the digitally mapped image. Each selected shades were cropped using graphic software and generated to the individual graphic files in same dimension. (Fig. 5) These images were measured the area in software, Global Lab Image Ver.2.10 (Data Translation Inc. & Automatix Inc., Marlboro, Massachusetts.). (Fig. 6) Data were analyzed using paired T-test and Wilcoxon singed ranks test.

Using VITA Easyshade®, measurements were done on the middle third of teeth. Each measurement was converted to CIE Lab values. ΔE values were calculated among the 5 groups. The following equation was used for color difference calculations: $\Delta E=[(\Delta L^*)2+(\Delta a^*)2+(\Delta b^*)2]1/2$. Data were analyzed using one sample T-test.

RESULTS

Using ShadeScan™ System, Table I shows the area numbers of selected shades chosen for each subjects. In some subjects, even primary shade were not occupied so much area of total area.

In comparison of three main shades there were significant differences between C-S15 using paired T-test same as C-S15, C-M 05($P<.05$) Using Wilcoxon Signed Ranks Test, there were significant differences between C-S15, C-M05 and C-M30. ($P<.05$) From both analysis, there was no significant difference

Table I. Calculated area of selected shades using ShadeScan™ System

Subject	C	D	S15	M05	M30	C	D	S15	M05	M30	C	D	S15	M05	M30	Vita 3D Master		
	Primary Shade (1°)					Secondary Shade (2°)					Tertiary Shade (3°)					1°	2°	3°
1	13025	11576	13411	12832	13048	4390	1618	2370	2060	4026	2630	5483	4533	5335	3894	1M2	2L1.5	2M1
2	9864	6299	8328	10081	9037	2849	6228	4194	5050	3378	2776	5931	7611	5627	2310	2M3	2M1	1M2
3	15030	14375	16076	18014	15441	4831	7354	7015	6982	6245	2616	4285	3878	2929	2005	1M2	2M1	1M1
4	15327	10152	16662	18176	16018	6192	6968	7201	5625	6782	4644	5712	6547	5851	5202	1M2	1M1	2M1
5	11527	10221	15447	14179	12915	3250	2039	2520	2445	2838	2417	3876	4144	3740	3101	1M2	2R1.5	3M2
6	9529	6108	6939	9649	9540	6398	9885	10378	7040	6897	2766	1875	1644	3254	2981	2M3	1M2	2M2
7	3009	4373	3242	3537	3220	2029	2550	2512	2888	2272	3130	2175	2711	4434	3264	2M1	2M2	2M3
8	5867	5182	5748	5054	6003	5244	4393	4097	3948	5026	4357	6022	6975	7989	3997	3M1	1M2	2R1.5
9	10397	9946	8916	9492	8534	5665	4444	5469	5368	5905	1173	3832	3734	3538	2316	1M2	2M1	1M1
10	4253	6740	5519	5590	4619	4063	2694	2651	2834	4832	2159	3971	4562	3797	2758	1M2	2R1.5	2M1
11	7473	10486	12161	8633	6557	4436	6466	5318	5856	4480	2041	1480	1458	1615	2087	1M2	2M1	1M1
12	12502	12706	12092	13287	12327	5601	5611	5227	4829	5628	3945	5973	3673	5183	4563	1M2	2M1	1M1
13	7394	6623	8666	8174	7585	6654	7226	7715	7075	7157	1411	1384	2039	2061	1427	1M2	2M1	1M1
14	7146	10372	5814	6270	6254	7681	5238	8482	9260	8735	3107	5399	5232	5109	3389	1M1	1M2	0M3
15	13092	13401	12944	13091	12853	7756	8815	7685	7540	8264	2995	1590	3785	2736	2850	1M2	2M1	1M1
16	9066	5836	5782	4894	7238	2465	4675	4222	7737	3646	2910	3567	3585	3749	3094	4R2.5	4M3	3R1.5
17	13612	12065	11779	13673	14103	7130	8370	7730	7355	7250	1489	2516	3644	2292	1771	1M2	1M1	0M3
18	13619	10030	12429	12631	13501	6440	8818	6119	7603	6920	2980	5590	5070	4272	3123	1M2	2M1	1M1
19	5328	8408	6319	5599	5141	4023	5953	6105	4550	4813	2497	4877	4422	4157	2912	2M3	2M1	2M2
20	9903	7314	8461	8987	9005	7317	6835	7387	6846	7469	2073	6985	8047	7925	3509	1M2	1M1	0M3

Table II. Three main shades

Paired Samples Test

	Paired differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 CONTROL - DRY	-412.88	2137.25	275.92	-964.99	139.23	-1.496	59	.140
Pair 2 CONTROL - S15	-780.38	1773.76	228.99	-1238.59	-322.17	-3.408	59	.001
Pair 3 CONTROL - M05	-692.98	1466.30	189.30	-1071.77	-314.20	-3.661	59	.001
Pair 4 CONTROL - M30	-166.32	1032.62	133.31	-433.07	100.44	-1.248	59	.217
Pair 5 DRY - S15	-367.50	1637.29	211.37	-790.46	55.46	-1.739	59	.087
Pair 6 DRY - M05	-280.10	2024.76	261.40	-803.15	242.95	-1.072	59	.288
Pair 7 DRY - M30	246.57	2075.53	267.95	-289.60	782.73	.920	59	.361

Test Statistics[c]

	DRY-CONTROL	S15-CONTROL	M05-CONTROL	M30-CONTROL	S15-DRY	M05-DRY	M30-DRY
Z	-1.620[b]	-2.967[b]	-3.210[b]	-2.348[b]	-1.818[a]	-.398[a]	-1.067[b]
Asymp. Sig. (2-tailed)	.105	.003	.001	.019	.069	.691	.286

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon signed Ranks Test

Table III. Primary shade

Paired Samples Test

	Paired differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 CONTROL - DRY	1371.30	2328.21	520.60	281.66	2460.94	2.634	19	.016
Pair 2 CONTROL - S15	152.50	2196.75	491.21	-875.61	1180.61	.310	19	.760
Pair 3 CONTROL - M05	-73.50	1634.09	365.39	-838.28	691.28	-.201	19	.843
Pair 4 CONTROL - M30	-6.85	753.62	168.51	-359.55	345.85	-.041	19	.968
Pair 5 DRY - S15	-1218.80	2091.41	467.65	-2197.61	-239.99	-2.606	19	.017
Pair 6 DRY - M05	-1444.80	2484.17	555.48	-2607.43	-282.17	-2.601	19	.018
Pair 7 DRY - M30	-1378.15	2487.90	556.31	-2542.52	-213.78	-2.477	19	.023

Test Statistics[c]

	DRY-CONTROL	S15-CONTROL	M05-CONTROL	M30-CONTROL	S15-DRY	M05-DRY	M30-DRY
Z	-2.277[a]	-.560[b]	-.560[b]	-.448[b]	-2.315[b]	-2.389[b]	-2.165[b]
Asymp. Sig. (2-tailed)	.023	.575	.575	.654	.021	.017	.030

a. Based on negative ranks.

b. Based on positive ranks.

c. Wilcoxon signed Ranks Test

Table IV. Color difference data using VITA Easyshade®

Subject	C-D	C-S15	C-M5	C-M30	D-S15	D-M5	D-M30
1	2.7	2.4	2.6	1.3	1.1	4.9	3.3
2	4.9	1.4	3.8	1.0	4.1	2.1	4.0
3	2.3	2.0	1.4	0.9	2.6	1.6	2.2
4	3.8	2.3	3.0	1.8	4.2	1.6	3.7
5	2.5	2.3	5.0	1.1	2.2	2.7	2.2
6	2.7	0.6	1.6	1.3	2.5	3.2	3.4
7	4.3	3.7	4.1	1.0	0.7	1.4	4.0
8	3.4	3.0	4.0	3.5	0.6	1.1	2.9
9	1.5	1.1	1.2	0.5	1.1	1.9	1.4
10	2.7	2.7	2.1	0.7	2.3	1.3	2.1
11	1.6	1.9	1.6	1.7	2.1	2.5	1.3
12	5.4	5.8	5.8	1.8	0.9	2.4	4.8
13	4.9	3.1	6.3	4.1	2.2	2.2	1.3
14	3.8	3.5	3.3	3.9	0.4	1.8	0.4
15	2.5	2.3	4.2	1.1	0.6	2.6	2.6
16	1.4	1.3	1.7	4.8	1.7	2.2	4.3
17	5.1	7.1	5.9	2.2	3.0	1.4	4.7
18	9.1	5.1	9.1	1.8	4.6	0.9	10.5
19	1.0	0.7	0.6	0.3	1.5	1.3	1.2
20	5.6	5.4	6.7	2.3	0.5	1.7	3.6

Table V. one sample test result using VITA Easyshade®

One-Sample Test

	Test Value = 2					
					95% Confidence Interval of the Difference	
	t	df	Sig.(2-tailed)	Mean Difference	Lower	Upper
C-D	3.628	19	.002	1.560	.660	2.460
C-S15	2.236	19	.038	.885	5.647E-02	1.714
C-M05	3.404	19	.003	1.700	.655	2.745
C-M30	-.510	19	.616	-.145	-.740	.450
D-S15	-.192	19	.850	-5.500E-02	-.656	.546
D-M05	.199	19	.844	4.000E-02	-.381	.461
D-M30	2.497	19	.022	1.195	.193	2.197

even in C-D and D-M30. (P>.05) (Table II)

However, in comparison with primary shade, there were significant differences between C-D, D-S15, D-M05, D-M30 from both paired T-test & Wilcoxon Signed Ranks Test(P<.05). In addition there was no significant difference between C-S15, C-M05, C-M30 using both analysis. (P<.05) (Table III)

Using VITA Easyshade®, Table IV shows the color difference between two measurements. A ΔE value of less than 1 is considered excellent color match between two objects . If the color difference is $1<\Delta E<2$, the match is clinically acceptable. If the color difference is greater than 2, the match is considered clinically unacceptable.[8] Therefore test value for T test was set for 2. Table IV shows the color difference between each two measurements.

There were significant differences between C-D, C-S15, C-M05, and D-M30(P<.05, one sample T test). However, C-M30, D-S15, and D-M05 were no significant different. (P<.05, one sample T test) (Table V)

DISCUSSION

Shade selection for the restorations is based on visual comparison of the remaining teeth with the aid of commercially available shade guides as the color standard.[9] However, available shades in the shade guides are not logically distributed and not consistent with the color of natural teeth.[10-12]

To solve this problem, intra-oral colorimeters were introduced. Reliability of instruments has been reported recently.[13,14] However, color has the nature of human perception and is impossible to calculate or measure as numbers.[15] Moreover, the repeatability of instruments was criticized.[16]

This vivo experiments had some limitations. Using VITA Easyshade®, the aperture diameter of the instrument was 5mm, so measurements were in limited area. Using Shade Scan System™, when area was calculated, locational changes of shades were not considered. The shades that had small area were excluded; even the shades were appeared, disappeared and changed through the dry and re-wetting condition.

In comparison of three chosen shades, there were significant differences in C-S15, C-M05. This result showed that shade could be changed in time of re-wetting. Nevertheless, there was no significant difference in C-D and D-M30. this result might be affected by the some of chosen shade which were not statistically changed in comparison. However, the results of VITA Easyshade® and primary shade comparison of ShadeScan System™ had similar conclusions that C-D and D-M30 were statistically different and C-M30 was no significant difference.

CONCLUSIONS

Using ShadeScan System™, there were significant differences between control group and dry(P=.023), dry and re-wetting 15 seconds, 5 minutes, 30 minutes as well (P=.021, P=.017, P=.030) in comparison of primary shade. However, comparing three main shades, there was no significant difference between control and dry(P=.105).

Using VITA Easyshade®, color differences(Δ E) between control and dry, dry and re-wetting 30 minutes were statistically different(P=.002, P=.022).

Primary shade could be changed in dry and wetting procedure in time, however there were no significant shade changes in overall.

REFERENCES

1. Seghi RR, Johnston WM, O' Brien WJ. Spectrophotometric analysis of color differences between porcelain system. J Prosthet Dent 1986;56:35-40.
2. Davision SP, Myslinski NR. Shade selection by color vision-detective dental personnel. J Prosthet Dent 1990;63:97-101.
3. Paravian RD. Evaluation of a newly developed visual shade matching apparatus. Int J Prosthodont 2002;15:528-34.
4. McPhee ER. Light and color in dentistry. Part I nature and perception. J Mish Dental Assoc 1978;60:565-72.
5. Preston JD. Perspectives in dental ceramics-Proceedings of the fourth international symposium on ceramics. Quintessence, 1988;279-84.
6. Winter R. Visualizing the natural dentition. J Esthet Dent 1993;5:102-17.
7. Shillingburg HT. Fundamentals of Fixed Prosthodontics. 3rd ed. Quintessence. 1997.
8. O' Brien WJ, Groh CL, Boenke KM. A new small-color-difference equation for dental shades. J Dent Res 1990;69:1762-4.
9. Van der Burgt JP, ten Bosch JJ, Borsboom PC, Plasschaert AJ. A new method for matching tooth colors with color standards. J Dent Res 1985;64:837-41.
10. Shotwell JL, Johnston WM, Swarts RG. Color comparisons of denture teeth and shade guides. J Prosthet Dent 1986;56:31-4.
11. Schwabacher WB, Goodkind RJ. Three-dimensional color coordinates of natural teeth compared with three shade guides. J Prosthet Dent

1990;64:425-31.
12. Wozniak WT. Proposed guidelines for the acceptance program for dental shade guides. Chicago: American Dental Association, 1987:1-2.
13. Eldiwany MS, Paravina RD, and Powers JM. Performance assessment of a new intra-oral spectrophotometer. IADR, 2004.
14. Wee A, Valentine CE, and Beck FM. Reliability of the ShadeScan for three different shade guides. IADR, 2004.
15. Hunt R, Measuring Colour, Fountain Press. 1998.
16. Tung FF, Goldstein GR, Jang S, and Hittelman E. The repeatability of an intraoral dental colorimeter. J Prosthet Dent 2002.

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