Research into the Colors of Denture Base Resin

—Influence of Differences in Shade and Thickness—

by

*Toshiki ICHIWATA, Koichiro UEDA, Tomotaka TAKEDA,
Hiromi GOTO, Masayuki SHIRANE, Akihisa NAKAMURA,
Toshikazu IBONAI, Eiichi MORITA, Yoshinori SATOH,
and Katsuzo OHKI*

I. Introduction

The color of denture base resin greatly influences the aesthetic element, an important purpose of making prostheses.

Particularly for removable partial dentures, when an artificial tooth is put into the patient's mouth, it is very important to match as best you can the color of the patient's gingiva and the color of the denture base, because the two are adjacent in the patient's mouth. This is why denture base resin is manufactured in various shades, from which the dentist can select the one he/she thinks the best. The selection of shades, therefore, depends heavily on the dentist's subjective point of view.

Numerous reports have been made of research into the colors of artificial teeth [2,3] and gingiva [4,5,6,7,8,9] conducted by the visual color-comparison method, color spectrometry or by directly reading the tristimulus values; but research into the color of the denture base resin itself has been regrettably scanty.

To investigate the factors influencing the color of denture base resin, the authors made test pieces differing in shade and thickness and conducted experiments by means of a colorimeter which directly reads the color values.

II. Materials and Methods

1) Materials

The brand names, shade numbers and batch numbers of the denture base resin used in the present experiment are given in Table 1, Fig. 1. Since Shade No. 5 is clear, we omitted it from the experiment.

2) Test Pieces

First, four pieces of glass were made, each 17 mm long, 27 mm wide and with different thicknesses of 1.9, 2.0, 2.8, and 3.7 mm. These were invested in flasks, cured according to the conventional method, left for 24 hours, and then were taken out of the flasks.

The four test pieces were treated with water-proof paper ranging from No. 240 to No. 1200, and were made, by the method [2] of IBUSUKI et al., into four different sizes, each 15 mm long and 25 mm wide but having a thickness of 0.9, 1.8, 2.7 and 3.6 mm.

一和田寿樹, 植田耕一郎, 武田友孝, 後藤ひろみ, 白根雅之, 中村昭久, 伊保内利一, 森田栄一, 佐藤吉則,
大木一三: *Department of Removable Partial Denture Prosthodontics, Nihon University School of
Dentistry, Tokyo (Director: Prof. Katsuzo OHKI).*

Table 1

Material	Acrylic resin	
Trade name	ACRON	
Manufacturer	G-C DENTAL INDUSTRIAL CORP.	
Shade and Batch No.	powder	
	1. CLEAR PINK	030621
	2. LIGHT PINK	280621
	3. PINK	280231
	4. DARK PINK	170531
	6. NATURAL LIGHT PINK	070811
	7. NATURAL DARK PINK	FL20
	8. LIVE PINK	231221
	9. PALE PINK	030621
	liquid	280231

Fig. 3 Color (Lightness, saturation)

One hundred and sixty test pieces of five different kinds of shade and thickness were thus made.

The test pieces were kept in water for one week, and then the water on their surface was wiped off, and their color was examined. The color of the test pieces was examined at three locations on each piece, and the measurements at the 15 locations were all taken into consideration.

3) Color System

As a color system, the CIE 1976 (L^* a^* b^*) uniform perception color space was used—that is, the L^* a^* b^* color system. (Figs. 2 and 3)

L^* indicates the lightness index number, and a^* and b^* are the chromaticity index numbers. Chromaticity index numbers a^* and b^* are defined as the properties of colors when hue and saturation are considered simultaneously. a^* in the a^* b^* coordinate plane indicates redness in the positive direction, and b^* shows yellowness in the positive direction. The greater the value of each—that is, the greater the distance from the origin—the greater is the saturation. The colorimeter is said

to perceive lightness, hue and saturation, and the difference in color nearly coincides with the difference in color sense [13].

4) Measuring Equipment

The measuring equipment used was a reflector-use, CIE color system digital colorimeter using the vertical reflection, diffuse illumination method (manufactured by Minolta Camera Co., CHROMA METER II (Reflectance) (Figs. 4 and 5). In this equipment, a pulsed Xenon lamp is used as a light source, and 6 silicon photo cells (for the double-beam feedback system) as the receptors. This instrument can measure the color of a circular area 8 mm in diameter.

The measurement was conducted by placing test pieces on a standard white board under a standard source C., and the L^* a^* b^* values were recorded directly by a digital printer.

III. Results

The results of measuring Shades No. 1 to No. 4 are given in Table 2, Fig. 6, and those of Shades No. 6 to No. 9 in Table 3, Fig. 7. For Shade No. 1, the greater the thickness, the lower was the value of L^* or the degree of lightness.

Measuring a^* and b^* for Shade No. 1 showed that the saturation of the test piece 1.8 mm in thickness was the greatest among the four.

As for hue, as the thickness increased, a change from reddish-yellow to red and to reddish-purple was observed. A similar tendency was observed with the other shades.

Table 4 shows differences in L^* a^* and b^* against differences in thickness when 1.8 mm is taken as standard, for Shades No. 1 to N. 4—that is ΔL^* , Δa^* and Δb^* . Table 5 likewise shows the results for Shades No. 6 to No. 9. Table 6 shows the color difference in ΔE_{ab} against a thickness of 1.8 mm for each shade. The values shown in parentheses are the values converted into NBS units, as in Table 7. Table 7 suggests how the color differences are observed by the eye.

Table 2. Shade No. 1-4 (L^* a^* b^*)

	mm	L^*	a^*	b^*
S-No. 1	0.9	65.2	19.1	20.3
	1.8	56.4	24.8	18.4
	2.7	52.5	23.4	14.8
	3.6	51.6	23.2	12.9
S-No. 2	0.9	63.3	20.6	15.9
	1.8	54.8	24.4	12.7
	2.7	51.3	23.5	9.7
	3.6	50.8	22.1	8.2
S-No. 3	0.9	64.0	23.1	18.8
	1.8	51.1	30.4	16.0
	2.7	48.6	28.3	13.3
	3.6	47.7	27.2	11.6
S-No. 4	0.9	67.1	18.7	15.5
	1.8	50.1	30.2	14.4
	2.7	47.3	28.3	11.7
	3.6	46.2	27.1	10.5

Fig. 1 Shade guide

Fig. 2 CIE 1976 (L^* , a^* , b^*)—Space

Fig. 4 Chroma meter II (Reflectance) (Minolta Camera Co., Ltd.)

Fig. 5 Chroma meter II (Reflectance) (Minolta Camera Co., Ltd.)

Fig. 6 Shade No. 1-4 ($L^*a^*b^*$)Table 3 Shade No. 6-9 ($L^*a^*b^*$)

	mm	L^*	a^*	b^*
S-No. 6	0.9	66.7	14.7	10.1
	1.8	56.5	19.2	10.0
	2.7	51.9	19.8	7.4
	3.6	48.7	19.4	6.0
S-No. 7	0.9	62.7	19.8	10.2
	1.8	53.2	22.8	8.7
	2.7	48.9	22.6	7.2
	3.6	46.6	21.8	5.3
S-No. 8	0.9	66.6	16.6	12.5
	1.8	55.8	21.4	12.9
	2.7	49.5	24.2	10.8
	3.6	46.8	22.5	7.4
S-No. 9	0.9	72.2	9.7	11.1
	1.8	59.4	17.9	13.0
	2.7	53.4	17.7	9.9
	3.6	49.7	17.6	8.4

Table 8 gives the results of a two-way dispersion analysis of L^* , with shade and thickness as factors ($\alpha=5\%$).

For Shades No. 1 to No. 4, no influence was observed of differences in shade, but the influence of differences in thickness was observed. In Shades No. 6 to No. 9, on the other hand, the influence of differences both in shade and thickness was observed.

Fig. 7 Shade No. 6-9 ($L^*a^*b^*$)Table 4 Shade No. 1-4 ($\Delta L^* \Delta a^* \Delta b^*$)

	mm	ΔL^*	Δa^*	Δb^*
S-No. 1	0.9	8.8	-5.7	1.9
	1.8	—	—	—
	2.7	-3.9	-1.4	-3.6
	3.6	-4.8	-1.6	-5.5
S-No. 2	0.9	8.5	-3.8	3.2
	1.8	—	—	—
	2.7	-3.5	-0.9	-3.0
	3.6	-4.0	-2.3	-4.5
S-No. 3	0.9	12.9	-7.3	2.8
	1.8	—	—	—
	2.7	-2.5	-2.1	-2.7
	3.6	-3.4	-3.2	-4.4
S-No. 4	0.9	12.0	-11.5	1.1
	1.8	—	—	—
	2.7	-2.8	-1.9	-2.7
	3.6	-3.9	-3.1	-3.9

Table 5 Shade No. 6-9 (ΔL^* Δa^* Δb^*)

	mm	ΔL^*	Δa^*	Δb^*
S-No. 6	0.9	10.2	-4.5	0.1
	1.8	—	—	—
	2.7	-4.6	0.6	-2.6
	3.6	-7.8	0.2	-4.0
S-No. 7	0.9	9.5	-3.0	1.5
	1.8	—	—	—
	2.7	-4.3	-0.2	-1.5
	3.6	-6.6	-1.0	-3.4
S-No. 8	0.9	10.8	-4.8	-0.4
	1.8	—	—	—
	2.7	-6.3	2.8	-2.1
	3.6	-9.0	1.1	-5.5
S-No. 9	0.9	12.8	-8.2	-1.9
	1.8	—	—	—
	2.7	-6.0	-0.2	-3.1
	3.6	-9.7	-0.3	-4.6

Table 6 Shade No. 1-4, 6-9; ΔE_{ab}^*

(NBS Unit)

Thickness mm	Shade No.							
	1	2	3	4	6	7	8	9
0.9	10.7 (9.8)	9.8 (9.0)	15.1 (13.9)	20.6 (19.0)	11.1 (10.2)	10.1 (9.3)	11.8 (10.9)	15.3 (14.1)
1.8	—	—	—	—	—	—	—	—
2.7	5.5 (5.1)	4.7 (4.3)	4.2 (3.9)	4.3 (4.0)	5.3 (4.9)	4.6 (4.2)	7.2 (6.6)	6.8 (6.3)
3.6	7.5 (6.9)	6.4 (5.9)	6.4 (5.9)	6.3 (5.8)	8.8 (8.1)	7.5 (6.9)	10.6 (9.8)	10.7 (9.8)

Table 7 Degrees of Color Difference
(Textile Terms)

Degree of Color Difference	NBS Unit
Just detectably different (trace)	0.0-0.5
Slightly different (slight)	0.5-1.5
Moderately different (noticeable)	1.5-3.0
Appreciably different (appreciable)	3.0-6.0
Very different (much)	6.0-12.0
A different color (very much)	12.0 and over

 ΔE_{ab}^* is expressed in NBS (National Bureau of Standard) units by multiplying by 0.92.Table 8 ANOVA TABLE (Shade No. 1-4; L^*)

Factor	S.S.	D.F.	M.S.	F-value	P
T	711.0458	15			
A	39.2143	3	30.7140	3.5800	0.0596
B	638.9707	3	212.9902	58.3343	0.0000
E	32.8607	9	3.6511		

A: Shade B: Thickness.

Table 9 ANOVA TABLE (Shade No. 6-9; L*)

Factor	S.S.	D.F.	M.S.	F-value	P
T	934.8312	15			
A	71.9385	3	23.9795	16.1213	0.0005
B	849.5058	3	283.1686	190.3739	0.0000
E	13.3869	9	1.4874		

A: Shade B: Thickness.

IV. Summary

Much research has been done of color science relative to dentistry, but the amount of research applied to denture base resin is very small—there are only three papers, by KANEKO et al. [4,5], IBUSUKI et al. [10], and POWERS and J.M. [11,12] and most of these used the Munsell color comparison method. Therefore, the authors did experiments using measuring equipment which can produce objective results, and obtained the following conclusions:

1. The lightness of the resin decreased with increasing thickness.
2. The color saturation of the resin was greatest when the thickness was 1.8 mm.
3. A tendency for the hue to change from reddish-yellow to red and to reddish-purple was observed with increasing thickness.
4. For the lightness of the resin, no influence was observed of the change in Shades No. 1 to No. 4. However, lightness was influenced by differences in the thickness of Shades No. 1 to No. 4, and also by differences in the shade as well as the thickness of Shades No. 6 to No. 9.

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