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Digital analysis of the color of the heat-cured acrylic resin (using scanner)

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الخلاصة

هدف الدراسة : استعمال صورة السكانر للعينة لاجراء التحليل الرقمي للمعان وايجاد تاثير نوع وسماكة مادة قاعدة الطقم الأكريلية حرارية التصلب وغمرها في محاليل مختلفة على تغيير لونها . **المواد وطرائق العمل** : أستخدم نوعين لمادة قاعدة الطقم . ثلاثون عينة حضرت بابعاد متساوية لاختبار تغير اللون .وقد تم تحليل مقياس اللون لصورة العينة بواسطة برنامج الفوتوشوب 9. استخدم مقياس تغير اللون CIE Lab لتحليل تغير اللون . أحتسب مقدار تغير اللون لايجاد القيمة المقبولة سريريا لتغير اللون . احصائيا الاختبارات (ANOVA ,Student t- test ,Dunnett pairwise multiple comparison t-test , Duncan,smultiple range test) أجريت لأيجاد الفرق المعنوي بين القيم عند احتمالية $P \leq 0.05$ **النتائج** : أضهرت النتائج أن هناك فرق معنوي لقيمة اللمعان قبل وبعد صقل العينات لمادة الاكريلك ، كذلك هناك تاثير معنوي لنوع وسماكة المادة ونوع المحلول الذي غمرت فيه المادة على تغيير لونها والتي كانت سريريا غير مقبولة . أستنتج في هذه الدراسة أن السكانر يعطي صورة دقيقة يمكن قياس لمعانها وتغير لونها بواسطة نظام CIE Lab .

الكلمات المفتاحية : رقمي ، سكانر ، لون ، لمعان

ABSTRACT

Aim: Using scanner image to digitally analyze the brightness and the effect of the type the of material, thickness and immersion of material in different solutions on the color change of the heat-cured acrylic resin denture base material. **Materials and Methods:** Two types of heat-cured acrylic resin denture base material were used. Totally 30 samples were prepared for uniform dimension for each color test. Sample scanner imaged and color metric is analyzed with software program Adob Photoshop 9.0. The CommissionInte´rnationale de l'E´ clairage for characterizing color (CIE L*a*b*) color difference metrics were used for the performance analysis. Color change (ΔE) value calculated to determine clinically acceptable color change. Statistically ANOVA, Student's t–test , Dunnett pairwise multiple comparison t–test and Duncan's multiple range test were carried out to determine the significant differences at $p \leq 0.05$. **Results:** The results appeared that there is a significant differences of the brightness value before and after polishing of the acrylic resin samples. And statistically there is a significant effect of type, thickness, and immersion in different solution on the color change of the tested materials which is clinically not acceptable . **Conclusion :** The result appeared that scanner gives an accurate image to digitally evaluate brightness and color change of dental materials with CIE L*a*b*color system.

Key words : Digital, scanner color, brightness

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INTRODUCTION

Color is the quality which is modulated by a series of factors, environmental and individual, that the clinic must know [1,2].

There are generally three accepted dimensions of color in Munsell color system [3,4,5]: Hue : it is that quality by which one color family distinguished from another. Value :(brightness) this would be like the black and white image of the observed object. Chroma (Saturation): is that quality by which a strong color distinguished from a weak one.

The CIE L*a*b* which is a method developed in 1978 by the Commission Inte´rnationale de l'E´ clairage for characterizing color based on human perception [6], The basic CIE concept is that all colors can be matched by mixing relative amounts of the three light primaries: Red (X), Green (Y) , and Blue (Z) . These can then be transformed to *L**, *a** and *b** values [6,7]. *L** is a measure of lightness .The *a** values represent positions on a red-green axis. As a* becomes more positive in value, the color is more red; as a* becomes more negative in value, the color becomes more green. The *b** values represent positions on a yellow- blue axis. As b* becomes more positive in value, the color becomes more yellow; as b* becomes more negative in value, the color becomes more blue.

Color determination may be precisely performed with spectrophotometers, however this technique is time consuming and requires special devices[8].

In computing, a scanner is a device that optically scans images, printed text, handwriting, or an object, and converts it to a digital image. Common examples found in offices are variations of the *desktop (or flatbed) scanner* where the document is placed on a glass window for scanning [9].

The aim of this study was using scanner image to digitally analyze the brightness and the effect of the type the of material, thickness and immersion of material in different solutions on the color change of the heat-cured acrylic resin denture base material.

MATERIALS AND METHODS

Two types of pink color heat-cured acrylic resin denture base materials (Major prodotti, Italy and RESPAL, Italy) were used. The samples were prepared follow the recommended manufacturers powder/ liquid ratio. Curing was carried out by using conventional water bath method in which placing flask in a thermostatically controlled water bath for curing cycle 1.5 hours at 74^oC followed by 30 minutes at 100^oC [10]. Samples were finished with (#320, #400, #600) grit sandpaper at standard speed of 300rpm. Machine polished with pumice[11]. All prepared samples were stored in distilled water at 37^oC for 48 hours for conditioning before testing [12].

Ten samples were prepared to the uniform size in dimension 15±1 mm ×15±1 mm ×1±0.1 mm (length, width and thickness respectively). To evaluate the brightness and the effect of the type of the materials on color change samples were divided into two groups:

Group A: Five samples of (Major prodotti) type .To evaluate brightness before and after polishing Group A was subclassified as :

Group(A1) : Five samples of (Major prodotti) before polishing .

Group (A2*)*: Five samples of (Major prodotti) after polishing .

Group B: Five samples of (RESPAL) heat-cured acrylic resin after polishing .

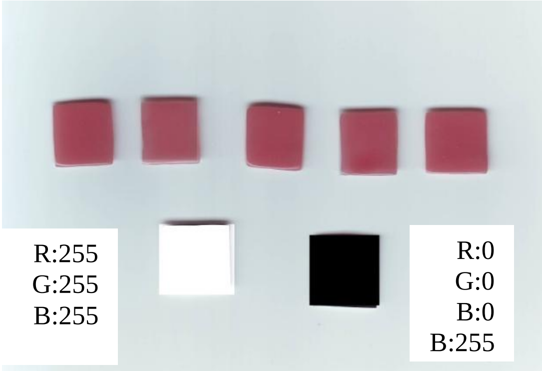
Twenty samples of heat-cured acrylic resin(Major prodotti) were prepared to a uniform size in dimension 15±1 mm ×15±1 mm ×2±0.1 mm (length width and thickness respectively) . Samples were divided into four groups .Five samples for each group:

Group C (Control group): to evaluate the effect of thickness on the color change in comparison with Group (A2), and the immersion in different solution in Groups D,E and F Group D : Samples immersed in distilled water at (37 ^oC) for one month period. Group E : Samples immersed in disinfection solution as a denture cleanser (0.05 % sodium hypochlorite solution at room temperature 21^0 C±1), for 10 minutes[13,14], then immersed in distilled water, this procedure repeated every day for one month period . Group F : Samples immersed in coffee (CAFÉ PELE / Brazil) at (30 gm)of coffee dissolved in (1 litter) of boiling distilled 37 ^oC for one month period .The solution replaced every day[15].

Measurements were repeated 3 times for each sample and the mean of L*,a* and b* were calculated .

Methods for measurement brightness and color change:

Samples were scanner imaged using flat-bed scanner (CanoScan LiDE 25, Canon, Vietnam). The images were digitized, with an input resolution of 600 pixels per inch. Color analyzed using commercial graphic software program Adob Photoshop 9.0. In order to reduce variations, a flat homogeneous, non reflective black and white reference patches were inserted into the images to provide references with respect to which the images may be normalized and standardized [6] as shown in Figure (1) These black and white reference patches are intended to define the respective minimum and maximum Red, Green, and Blue (RGB) values for each image ,which are(255, 255, 255) for white patches and(0, 0, 0) for black patches. To standardize the measured samples the Red, Green, and Blue values were obtained for each images**.**



R: red G: green B: blue
Figure (1):Standardization color samples with White and black patches

The brightness value of the samples was assessed with Hue, Saturation and Brightness color system (HSB) [3,4]. Brightness measurements were repeated 3 times for each sample and the means were calculated .

(CIE L*a*b*) color difference metrics were used for the performance analysis. Samples scanner imaged were digitally analyzed to obtain the baseline L*, a*, b* values. The total color change (Δ E) of each samples was calculated for each sample at each evaluation using the formula[2,6,10,16] :

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

$$\Delta E = [(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2]^{1/2}$$

In principle, when no color difference will be detected after its exposure to the testing environment ($\Delta E=0$) [7]. Delta E value of (3.7) or less is considered to be clinically acceptable in vitro study and of (6.8) is considered to be clinically acceptable in vivo study [6,7] .

Statistical analysis was carried out using ANOVA, Student's t–test, Dunnett pairwise multiple comparison t–test to determine the significant differences at $p \leq 0.05$ for L*, a*, b* and brightness values.

RESULTS AND DISCUSSION

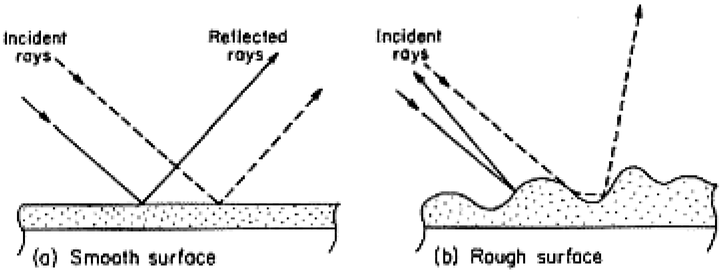
The (CIE L*a*b*) system for measuring chromacity was chosen to record color differences because it is well suited for determination of small color differences[17].

The results in Table (1) showed Student's t–test for the effect of polishing on the brightness of acrylic resin denture base materials. The results show that Group (A 1) has brightness value (79.00) which is higher than that of Group (A2) which is (65.00).That mean the rough surface has a higher brightness value than smooth surface. This result can be explained according to Snell's laws (Snell's laws: The angle of the reflected ray is the same as that of the incident ray) in that a ray of light arriving on a perfectly smooth surface is reflected in a single direction called *specular* direction. When the surface is rough, it is scattered in every direction of the space with an intensity varying according to the direction of incidence, the direction of reflection, and the roughness profile. This scattered light is called *diffuse reflection* and it results from the surface roughness, so that the surface appears equally bright from all viewing directions[18]Figure (2)[19].

Table (1): Student's t–test for the effect of polishing on the brightness of acrylic resin denture base materials

Group	No.	Mean	$\pm$ SD	t–value	d.f.	*p*–value
Group(A1)	5	79.00	1.225	22.136	8	0.000*
Group(A2)	5	65.00	0.707			

* means significant difference existed at 5% level of significance.
Group(A1):Samples of (Major) acrylic resin before polishing
Group(A1):Samples of (Major) acrylic resin after polishing



(specular reflection) (diffuse reflection)

Figure (2): Light reflection(19)

(a) from smooth surface (specular reflection) and (b) rough surface (diffuse reflection). In both cases the angle of incidence equals the angle of reflection at the point that the light ray strikes the surface.

The results of the Student's t–test in Table (2) showed that there is a significant differences for the all color metric(L*a*b*) of the different types of heat-cured acrylic resin denture base materials. Group(A 2) Major type has L*a*b*values (51.40, 30.60, 6.60) respectively, Group B PERSAL type has L*a*b*values (68.00, 16.80, 16.80). Major type has L*and a* values higher than of PERSAL type , but has lower b*. That mean Major type is darker and more reddish but less yellowish than PERSAL type .This result come in agreement with the result of Ahmet *et al* (17) in that these differences may be related to the type of staining agent of the material.

Table (2): Student's t–test for the effect of the type of heat–cured acrylic resin denture base materials on the color change (L*a*b*values)

Color Metric+	Material Type	No.	Mean	± SD	t–value	d.f.	*p*–value
L*	Group (A2)	5	51.40	0.548	–41.50	8	0.000*
	Group B	5	68.00	0.707			
a*	Group (A2)	5	30.60	0.894	13.158	8	0.000*
	Group B	5	16.80	2.168			
b*	Group (A2)	5	6.60	0.548	9.00	8	0.000*
	Group B	5	16.80	0.707			

+ L*: lightness; a*: red-green axis; b*: yellow–blue axis.
Group (A2): Major; Group B: PERSAL.
* Means significant difference existed at 5% level of significance.

The results in Table (3) showed a descriptive statistics for the effect of thickness of the materials and immersion in different solutions on color change. Group A(2)has L*a*b*values (51.40, 30.60, 6.60). Group C has L*a*b* values (42.00,40.80,10.00) . So increase in thickness of material (Group C) make the material more darker , reddish and yellowish. This result come in agreement with the result of Koishi *etal* (20) in that the thickness and smoothness affect the color. This result can be explained in that denture plastics ,ceramics, and resin composites used in dentistry are translucent materials .The color of thinly applied translucent material might be influenced by background .The most dramatic change observed is the increase in opacity as the thickness increases. With regard to the L*a*b* values, the translucent material transmits light and tends to be influenced by the background color ,thin translucent material exhibited a higher L* value and increased thickness of the material cause decrease in the L* values(20,21).

Group D has L*a*b*values (40.40, 41.20, 14.60), Group C has L*a*b* values (42.00,40.80,10.00) .That mean the material when immersed in distilled water for one month period become darker (L* value 40.40) of Group D is less than that of Group C (42.00), and more reddish (a* value 41.20) of Group D is higher than that of Group C (40.80), and more yellowish (b* value14.60) of Group D is higher than that of Group C (10.00). This result can be explained in that methyl/ethyl methacrylate–based and bisacryl methacrylate–based may undergo color change when subjected to the oral environment. The degree of color change can be affected by water sorption. Water accumulation and photo-oxidation have been reported to be responsible for internal color change. Water plays an important role in chemical degradation processes such as oxidation and hydrolysis and the subsequent change of the optical properties of the provisional materials[7].

Group E has L*a*b*values (38.40, 40.80, 14.60). Group C has L*a*b* values (42.00,40.80,10.00) .That mean the material when immersed in disinfection solution for one month period become darker, and more yellowish than Group C, but they have same a* value.

Group F has L*a*b*values (38.80, 39.80, 13.80). That mean the material when immersed in coffee for one month period become darker, less reddish and more yellowish than Group C. This result come in agreement with result of Arthur *etal* [7] . The discoloration might b due to both surface adsorption and absorption of colorants.

Table (3): Descriptive statistics for the effect of thickness of the acrylic resin denture base materials, immersion in distilled water, disinfection solution and coffee on color change(L*a*b*values)

Group	Color Metric[+]	No.	Min.	Max.	Mean	± SD
Group C (Control) 2mm thickness	L*	5	41	43	42.00	0.707
	a*	5	40	41	40.80	0.447
	b*	5	10	10	10.00	0.000
Group A2 (Thickness) 1mm thickness	L*	5	51	52	51.40	0.548
	a*	5	30	32	30.60	0.894
	b*	5	6	7	6.60	0.548
Group D (Immersion in Distilled Water)	L*	5	39	42	40.40	1.140
	a*	5	40	42	41.20	1.095
	b*	5	14	15	14.60	0.548
Group E (Immersion in Disinfection Solution)	L*	5	38	39	38.40	0.548
	a*	5	40	42	40.80	1.095
	b*	5	13	15	14.60	0.894
Group F (Immersion in Coffee)	L*	5	38	40	38.80	0.837
	a*	5	39	40	39.80	0.447
	b*	5	13	15	13.80	0.837

[+] L*: lightness; a*: red-green axis; b*: yellow–blue axis.
Min.: Minimum; Max.: Maximum

The results of (ANOVA) in Tables (4) showed that there is significant differences for the all color metric L*a*b* between the different groups A(2),C, D ,E and Group F.

Table (4): Analysis of variance (ANOVA) for the effect of thickness of the acrylic resin denture, immersion in distilled water, disinfection solution and coffee on color change(L*a*b*values)

Color Metric+	S.O.V.	S.S.	d.f.	M.S.	F–value	*p*–value
L*	Between Groups	569.600	4	142.400	229.677	0.000*
	Within Groups	12.400	20	0.620		
	Total	582.000	24			
a*	Between Groups	409.360	4	102.340	142.139	0.000*
	Within Groups	14.400	20	0.720		
	Total	423.760	24			
b*	Between Groups	249.440	4	62.360	148.476	0.000*
	Within Groups	8.400	20	0.420		
	Total	257.840	24			

+ L*lightness; a*: red-green axis; b*: yellow–blue axis.
* Means significant difference existed at 5% level of significance.

The results of Dunnett pairwise multiple comparison t–test in **Table (5)** show there is significant differences in all color metric L*a*b* for the effect of thickness of material on color change between control Group C (2mm thickness) and Group A(2) (1mm thickness) of same type.

The results of the effect of immersion in distilled water for one month period in Group D on color change showed that there is significant differences for L*and b* values between Group C and D, but it is not for a* value.

The results of the effect of immersion in disinfection solution for one month period in Group E on color change showed that there is significant differences for L*and b* values between Group C and E, but it is not for a* value.

The results of the effect of immersion in coffee solution for one month period in Group F on color change that showed that there is significant differences for L*and b* values between Group C and F, but it is not for a* value.

Table (5): Dunnett pairwise multiple comparison t–test for the effect of thickness of the acrylic resin denture, immersion in distilled water, disinfection solution and coffee on color change(L*a*b*values)

Color Metric+	(I) Group	(J) Group	Mean Difference (I–J)	*p*–value
L*	A	C	9.40	0.000*
	D	C	–1.60	0.015*
	E	C	–3.60	0.000*
	F	C	–3.20	0.000*
a	A	C	–10.20	0.000*
	D	C	0.40	0.868
	E	C	0.00	1.000
	F	C	–1.00	0.222
b	A	C	–3.40	0.000*
	D	C	4.60	0.000*
	E	C	4.60	0.000*
	F	C	3.80	0.000*

+ L*lightness; a*: red-green axis; b*: yellow–blue axis.
Group C (Control),2mm thickness ; Group A ,1mm thickness ;
Group D (Immersion in Distilled Water) ; Group E (Immersion in Disinfection Solution) ; Group F (Immersion in Coffee)
* Means significant difference existed at 5% level of significance.

Table (6) showed that the color change (DE) value between the tested groups. The results showed the value of (DE) between Group A (2) and B was (21.89) which is more than (3.7). That mean this value is perceptible which can be detected by naked eye and it is clinically not acceptable. This result come in agreement with the result of Ahmet *etal* [17].

Table (6): Value for color change (DE) clinically acceptable(in vitro study) for acrylic resin denture base materials and porcelain

Material Type	Variable Group	DE *	Clinical Acceptance
Acrylic Material	(A2) vs B	21.89	Not Acceptable
	C vs (A2)	14.28	Not Acceptable
	C vs D	4.89	Not Acceptable
	C vs E	5.84	Not Acceptable
	C vs F	4.97	Not Acceptable

* DE ≤ 3.7 is regarded as and clinically acceptable.

Group (A2): Acrylic (Major) 1 mm thickness ; Group B: Acrylic (PERSAL) 1mm thickness; Group C: Acrylic (Major) (2 mm thickness) ; Group D : Acrylic (Major) Immersion in distilled Water ; Group E: Acrylic (Major) Immersion in disinfection Solution ; Group F: Acrylic (Major) Immersion in Coffee .

The values of (DE) between Group C and other groups (Group (A2),D,E and F) are shown in Table (11) . (DE) between Group C and Group (A2) was(14.28) , between Group C and Group D was (4.89) . Between Group C and Group E DE value was(5.84) and (DE) value between Group C and Group F was(4.97). All these values were more than 3.7 which are clinically not acceptable. This result come in agreement with the result of Nur *etal* [10]. The acrylic denture base material is unstable color material. Discoloration of denture base polymer may be caused by the penetration of colored solution during exposure to oral fluid and denture cleanser [7,22].

With limitation of this study , scanner gave an accurate image to digitally evaluate brightness and color change of dental materials with (CIE L*a*b*) system. Modern scanners typically use a charge-coupled device (CCD) or a Contact Image Sensor (CIS) as the image sensor. Images to be scanned are placed face down on the glass, an opaque cover is lowered over it to exclude ambient light, and the sensor array and light source move across the pane, reading the entire area. An image is therefore visible to the detector only because of the light it reflects. There is no requirement for standardizing the light environment of a dental operatory[9] .

CONCLUSION

The results appeared that scanner image can be used to digitally evaluate brightness and color change of dental materials with(CIE L*a*b*) system. The result appeared that the higher brightness value the more surface roughness of the heat-cured acrylic resin denture base material . The result appeared that type , thickness and immersion in different solution have statistically a significant effect on color change of heat-cured acrylic resin denture base material which is clinically not acceptable .

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