Spectrophotometric Analysis of Optical Translucency, Opalescence, and Contrast of Leucite Ceramic for CAD-CAM Restoration as a Role of Ceramic Thickness

การวิเคราะห์สเปคตรัมแสงของความโปร่งแสง ความขุ่นใส และความคมเข้ม ของเซรามิกส์ชนิดลิวไซท์สำหรับการบูรณะด้วยแคทแคมอันเนื่องจากการความหนาของเซรามิกส์

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ABSTRACT

The esthetic success of CAD-CAM ceramic restorations depends on good color determination of ceramic restoration that directly related to their optical properties. This study determines the effect of CAD-CAM ceramic thickness on their optical parameters (translucency, opalescence, and contrast). Ceramic discs (∅ 8 mm) at thickness of 0.7, 1.0, 1.3, 1.6, 1.8, and 2.0 mm were prepared from Empress CAD® ceramic blocks shade A1, A2, A3, and A3.5 (15 discs for each group) and polished with 1 μm diamond abrasive in Ecomet®3. The CIE L*, a*, b*, and ΔE parameters of discs were determined upon black and white backings using a spectrophotometer (ColorQuest®XE) with D65 illuminant and 10 degree observer. The translucency parameter (TP), opalescence index (OI), and contrast ratio (C) were calculated and analyzed using ANOVA and regression analysis. The results revealed that changing in ceramic thickness affected to the optical parameter of ceramic tested in each shade ($P < 0.05$). As the ceramic thickness increased, a significant reduction in TP, OI and C values ($P < 0.05$) with extremely high correlation coefficients with TP as well as high correlation coefficient with OI and C.

บทคัดย่อ

ความสำเร็จของการบูรณะฟันด้วยวัสดุเซรามิกส์ชนิดแคทแคมขึ้นอยู่กับการเลือกสีของวัสดุเซรามิกส์เป็นสำคัญ อันมีความสัมพันธ์โดยตรงกับคุณสมบัติของวัสดุที่เกี่ยวข้องกับแสง การศึกษานี้เพื่อประเมินปัจจัย

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ขอความหนาของเซรามิกส์ที่ใช้ในการบูรณะต่อความโปร่งแสง ความขุ่นใส และความคมเข้ม โดยทำการเตรียมชิ้นเซรามิกส์ยี่ห้อเอมเพรสแคดสี A1, A2, A3 และ A3.5 ให้มีเส้นผ่าศูนย์กลาง 8 ม.ม. และมีความหนา 0.7, 1.0, 1.3, 1.6, 1.8 และ 2.0 ม.ม. แล้วทำการขัดด้วยผงขัดความละเอียด 1 ไมครอนด้วยเครื่อง Ecomet 3 แล้วทำการวัดค่าของสีได้แก่ CIE L*, a*, b* และ ΔE ด้วยฉากหลังสีขาวและสีดำ โดยใช้เครื่องสเปคโตรโฟโตมิเตอร์ที่กำหนดค่าความสว่างที่ D65 และมุมของการสังเกตที่ 10 องศา แล้วทำการคำนวณค่า ความโปร่งแสง ความขุ่นใส และความคมเข้ม รวมทั้งทำการวิเคราะห์ความแปรปรวนและการวิเคราะห์ความถดถอย ผลการศึกษาพบว่าการเปลี่ยนแปลงความหนาของเซรามิกส์ส่งผลต่อคุณสมบัติเชิงแสงของเซรามิกอย่างมีนัยสำคัญ ($P < 0.05$) โดยความหนาของเซรามิกส์ที่เพิ่มขึ้นจะสัมพันธ์กันอย่างยิ่งกับค่าความโปร่งแสง และในทำนองเดียวกันจะสัมพันธ์กับความขุ่นใสและความคมเข้มของเรามิกที่ลดลง

Key Words : Translucency, Opalescence, Contrast, CAD-CAM, Optical property
คำสำคัญ : ความโปร่งแสง ความขุ่นใส ความคมเข้ม แคทแคม คุณสมบัติเชิงแสง

Introduction

Computerized control machine helping dentist in designing and constructing the ceramic restorations, known as CAD-CAM (figure 1). The CAD-CAM technology has been developed for fabricating ceramic dental restorations because of its' consistent quality and precision achievement in this process, less labor intense as well as less expensive than conventional technique. (Fasbinder DJ, 2006, Willer J and Weber HP, 1998, Persson M and Bergman B, 1995)

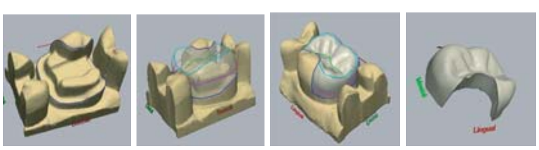

Figure 1 CAD-CAM restoration technique

The goal of CAD-CAM ceramic restoration is to restore missing tooth structure functionally as well as esthetically within an appropriate treatment time, usually consumes one appointment (1991, Crawford, 1991). Achieving aesthetic ceramic restoration appears to be a complex process that requires careful control of the form, texture, and optical properties of the ceramic material used for restoration fabrication. Carefully control variations of these factors results in predictable aesthetic appearance of the restoration that leading to patient satisfaction (Jorgenson MW and Goodkind RJ, 1979, Davis LG et al., 1998, ÕBrien WJ, 1985, Ashworth P and PSpriggs L, 1996). The dentist needs to fabricate ceramic restoration that has color match to the adjacent natural tooth structure. It is crucial for dentist to carefully match the color of tooth that need to be restored and select the most suitable ceramic blank to fabricate the ceramic restoration (Miller LL, 1987(Special issue), Culpepper WD, 1970, Meijering AC et al., 1997). Generally, the dentist selects the ceramic blank that has the color match with the shade guide used during shade selection process. Since the commercially ceramic blanks for CAD-CAM are available in different sizes that are appropriate for each restoration such as for crown, bridge, veneer, It's extremely hard for dentist to select a predictable ceramic blank for CAD-CAM machine to mill down the ceramic blank to the size of each dental restoration. Usually, the ceramic dental restorations have the thickness range from 0.7 to 2.0 mm., and some of them may have the thickness out of this range. Thus, the ceramic may change in color after the ceramic blanks were milled down. If this kind of situation occurs, the color of the final restoration may differ from the time prior selection. Even through, there are many techniques and instruments to help dentist for selection of the appropriate tooth color such as spectrophotometer or colorimeter (Judd DB and G), error still be difficult to eradicate because the color of ceramic blank and the color of the ceramic restoration after ceramic milling may be different. The thickness of the porcelains can significantly affect the overall color of the restoration produced (Wyszecki, Jorgenson MW and Goodkind RJ, 1979, Douglas RD and M., 1999, Dozic A et al., 2003). The color of dental cement used to cement restoration as well as the color of the dentine or dentine substitute are extremely influenced on the final appearance of all-ceramic (Jorgenson MW and Goodkind RJ, 1979, Vichi A et al., 2000, Barath VS et al., 2003).

Prediction the color of the restoration in order to fabricate restoration that closely color match with the adjacent teeth have investigated (Miyagawa Y and Power JM, 1983, Saunderson JL, 1942, Nagai SI and Sawafuji F, 1993). The color of the final restoration shall be possible if the optical properties of ceramic, cement, dentine or dentine substitute are precisely evaluated (O' Keefe KL and Pease PL, 1991, Wyszecki, Wayne D and McAree, 1985, Grajower R et al., 1982). There are 3 main optical parameters affect ceramic color in this study, translucency parameter, opalescence index and contrast ratio. Translucency parameter (TP) means the color difference between the color of material over a white background and a black background. It is almost important value that plays a decisive role in light transmission phenomena. In case where there is little or no existing tooth structure to provide a reflected or transmitted color of dentine, called "through and through restoration" are especially difficult and extremely challenged to dentist to provide naturally looking restoration (O' Keefe KL and Pease PL, 1991, Kamishima N et al., 2005, Heffernan MJ and SA, 2002). In this case, translucency material, like ceramic, may provide relatively poor color matches. Ceramic used for anterior restoration must be translucent in order to assemble the appearance of natural tooth. The enamel of natural tooth can reflect light blue-gray hue and provide clearly visible halo at the incisal edge of the teeth which is call "halo effect" (Chizick KM, 1994). Ceramic materials used for dental restoration must be capable of demonstrating halo effect at different levels which are measured in terms of opalescence index (OI). More specifically, a grayish shade is often visible against the surrounding tooth structure, because the rather translucent material is probably effect by the darkness of the oral cavity (Lee YK and JM, 2004, Kingery WD et al., 1976, Holloway JA and RB, 1997). Opalescence is another associated factor that related to the particular light diffraction of the very fine particles in the combination of ceramic (Lee YK et al., 2006, Vanini L, 1996, Chizick KM, 1994). In addition material are capable of reflect the spectrum of light at the different degree. The different degree of materials to reflect the spectrum of light results in the contrast of materials. The contrast of material can be measured based upon the ratio of the reflectance of ceramic material upon a black backing and upon a white backing which can be defined as contrast index (C). Modern dental ceramic provide chemical composition that result in a restoration that behave of better light translucency, opalescence effect and contrast ratio that provide lifelike restoration (Antonson SA and Anusavice KJ, 2001, Seghi RR et al., 1989, Chu FC et al., 2004). In clinical practice the correct choice of the CAD-CAM block may cause problems because the thickness of the restoration and the translucency of the ceramic material influence the final color decisively and found that the mismatching color occurs because the shade of the porcelain restoration is significantly affected by the thickness of the porcelain (Sven Reich and Hornberger H, 2002, Jorgenson MW and Goodkind RJ, 1979, Wyszecki, Douglas RD and M., 1999). From this point of view, the translucency parameter (TP), opalescence index (OI) and contrast ratio (C) of the ceramic must be considered as critical properties of material. The purpose of this present study was to evaluate the inherent color of CAD-CAM ceramic related to the translucency, opalescence index and contrast ratio of this material at various thicknesses.

Material and methods

A. Sample preparation

Ceramic disk specimens of 8 mm in diameter and at the thickness of 0.7, 1.0, 1.3, 1.6, 1.8 and 2.0 mm. were prepared from Empress CAD®(IvoclarVivadent Liechtenstein) block of four shades (A1, A2 A3 and A3.5) using diamond blade cutting instrument (Isomet4000®, Buehler, Illinois, USA) at a speed of 2,500 rpm with high water coolant. The discs were then polished with polishing solution immersed with fine (1 microns diameter) diamond powder (Metadi, Buehler, Illinois USA). All disc specimens were immersed in the distilled water prior to optical color evaluation.

B. Optical evaluation

Spectrophotometer (ColorQuest XE®, Hunter Associates Laboratory, Inc. Virginia, USA) was used to determine the optical color parameters. A small area of aperture of 4 mm. in diameter was used to facilitate the precise spectrum directly on the disc specimen in order to eliminate the edge loss effect during optical measurement. The spectrophotometer was calibrated prior to perform measurements with standard white tile (Hunter Associates Laboratory, Inc. Virginia, USA.) with the standard light source; D65 illuminant and 10 degree observer. The optical parameters in term of CIELAB (Commission Internationale de I'Eclairage) (1976) were determined for each sample. The color data values determined from these measurements for each shade in each thickness. All the ceramic samples were placed and measured against both white and black background. In order to maintain the same position of each specimen during measurement period, the repositioning clear jig was used to maintain the central position. The color parameters were Lw, Lb, aw, ab, bw, bb, Yw and Yb.

Translucency parameter (TP) was calculated using equation 1 (Lee YK et al., 2005):

TP= [(Lw*- Lb*)2 + (a*w-a*b)2 + (bw*-b*b)2]1/2..................Equation. 1

Opal index (OI) was calculated using equation 2, where a*b, b*b was the value measured for the black background, and a*w, b*w was the value for the white background (Lee YK, 2007a):

O I = [(a * w - a * b) 2 + (b * w - b * b) 2] 1/2 ....Equation. 2

Contrast ratio (C) was calculated using equation 3, where Yb was the value for the black background, YW for the white background, and L for thickness, as follows (Antonson SA and Anusavice KJ, 2001):

C= 1-(1-Yb/YW)1/L ....Equation. 3

C. Statistic analysis

Analysis of variance (ANOVA) using statistical software (SPSS, version 11.5, Chicago) was performed to find out the significant difference of color parameters at significant level of $P < 0.05$. Linear regression analysis was performed to calculate the correlation coefficients (R2) for each parameters and thickness for each shade.

Results

The results of the optical parameters of CAD-CAM ceramic tested were reported in terms of the mean and standard deviation of translucency parameter (TP), opalescence index (OI), and contrast ratio (C) as shown in Table 1 and graph in figures 2-4. The translucency parameter (TP), opalescence index (OI), and contrast ratio (C) tend to reduce as the thickness of ceramic restoration increase. An analysis of variance (ANOVA) were evaluated and indicated that there were significant difference of translucency parameter (TP), opalescence index (OI), and contrast ratio (C) due to the variation of shade of ceramic block ($P < 0.05$), ceramic thickness ($P < 0.05$) and their interaction ($P< 0.05$) as shown in the tables 2, 3, and 4. This indicated that the ceramic shade and the ceramic thickness influence significantly to the translucency parameter (TP), opalescence index (OI), and contrast ratio (C) at 95% level of confidence. The Tamhane multiple comparison of the translucency parameter (TP), opalescence index (OI), and contrast ratio (C) as a function of thickness for each shade were shown in tables 5, 6, and 7.

The result of Tamhane multiple comparison of the translucency parameter (TP) indicated that all subgroups are significant to this values when the thickness changed except for A1, A2, A3 and A3.5 in the thickness of 0.7 mm., A1, A2, A3 and A3.5 in the thickness of 1.0 mm., A1, A2, A3 and A3.5 in the thickness of 1.3 mm., A1, A2, A3 and A3.5 in the thickness of 1.6 mm., A1 and A2 in the thickness of 1.8 mm., A3 and A3.5 in the thickness of 1.8 mm., A3 and A3.5 in the thickness of 2.0 mm. were found not significant different.

The result of Tamhane multiple comparison of opalescence index (OI) indicated that all subgroups are significant to this values when the thickness changed except for A3 and A3.5 in the thickness of 0.7 mm., 1.0 mm., 1.3 mm., 1.6 mm. and 1.8 mm., between A2 and A3 in the thickness of 1.6 mm., A1, A2, A3 and A3.5 in the thickness of 2.0 mm. were found not significant different.

The result of Tamhane's multiple comparison of contrast ratio (C) indicated that all subgroups are significant to this values when the thickness changed except for A1 and A2, A3 and

A3.5 in the thickness of 0.7 mm., A1 and A2 in the thickness of 1.0 mm., A3 and A3.5 in the thickness of 1.3 mm., A1 and A2, A3 and A3.5 in the thickness of 1.6 mm., A3 and A3.5 in the thickness of 2.0 mm. were found not significant different.

The regression analysis were performed for translucency parameter (TP), opalescence index (OI), and contrast ratio (C) and indicated that correlation coefficient (R2) as a function of ceramic thickness were demonstrated in table 8. The correlation coefficient of translucency parameter (TP) as a function of thickness was extremely high where as high correlation coefficient with opalescence index (OI) and contrast ratio (C) were indicated. The correlation of translucency parameter (TP), opalescence index (OI), and contrast ratio (C) as a function of porcelain thickness exhibit the linear characteristic as show in the figures 5-7. This indicated that as the porcelain thickness increased, the translucency parameter (TP), opalescence index (OI), and contrast ratio (C) reduced arithmetically.

Table 1 indicated mean and sd of translucency parameter (TP), opalescence index (OI), and contrast ratio (C) of ceramic for each shade and thickness

Shade	Thickness (mm.)	TP		OI		C	
		mean	sd	mean	sd	mean	sd
A1	0.7	16.858	0.459	5.121	0.343	0.629	0.025
	1.0	13.360	1.032	4.644	0.195	0.576	0.022
	1.3	10.699	0.825	4.318	0.319	0.536	0.019
	1.6	8.610	0.747	4.037	0.285	0.529	0.016
	1.8	7.242	0.358	3.823	0.278	0.508	0.016
	2.0	5.678	0.354	3.191	0.201	0.496	0.014
A2	0.7	18.023	0.833	5.627	0.208	0.648	0.019
	1.0	14.294	0.543	5.501	0.130	0.598	0.013
	1.3	11.296	0.743	5.316	0.200	0.574	0.021
	1.6	9.280	0.632	4.911	0.241	0.551	0.020
	1.8	8.094	0.389	4.45	0.204	0.542	0.014
	2.0	6.465	0.540	3.56	0.299	0.450	0.024
A3	0.7	16.858	0.459	6.364	0.192	0.680	0.012
	1.0	13.360	1.032	6.218	0.294	0.632	0.027
	1.3	10.699	0.825	6.094	0.409	0.602	0.024
	1.6	8.610	0.747	5.419	0.333	0.574	0.025
	1.8	7.242	0.358	4.973	0.308	0.567	0.012
	2.0	5.678	0.354	3.783	0.310	0.557	0.025
A3.5	0.7	17.133	0.481	6.357	0.290	0.671	0.012
	1.0	13.955	0.502	6.267	0.125	0.614	0.013
	1.3	10.844	0.243	6.02	0.240	0.595	0.006
	1.6	8.683	0.283	5.499	0.388	0.584	0.009
	1.8	7.174	0.456	4.581	0.416	0.582	0.015
	2.0	5.760	0.261	3.849	0.336	0.571	0.011

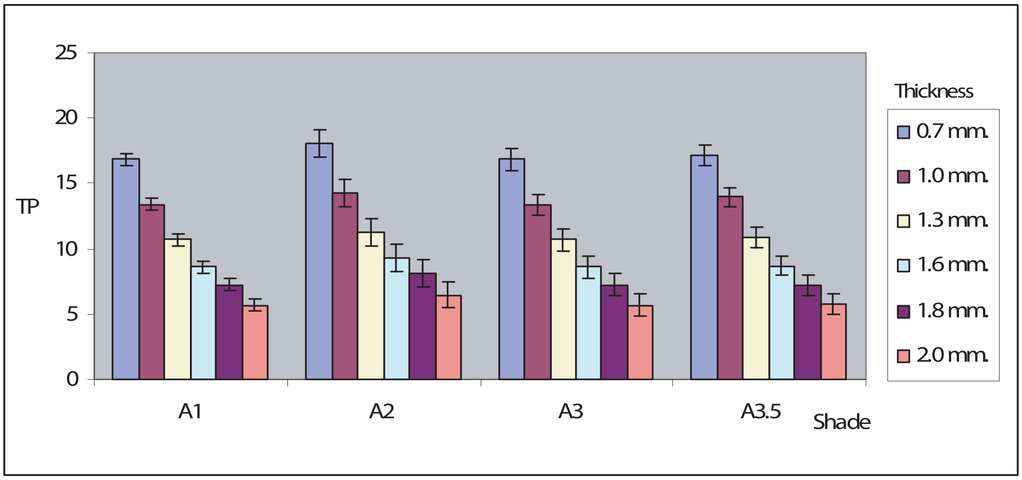

Figure 2 Bar graph of translucency parameter (TP) value of shade A1, A2, A3 and A3.5

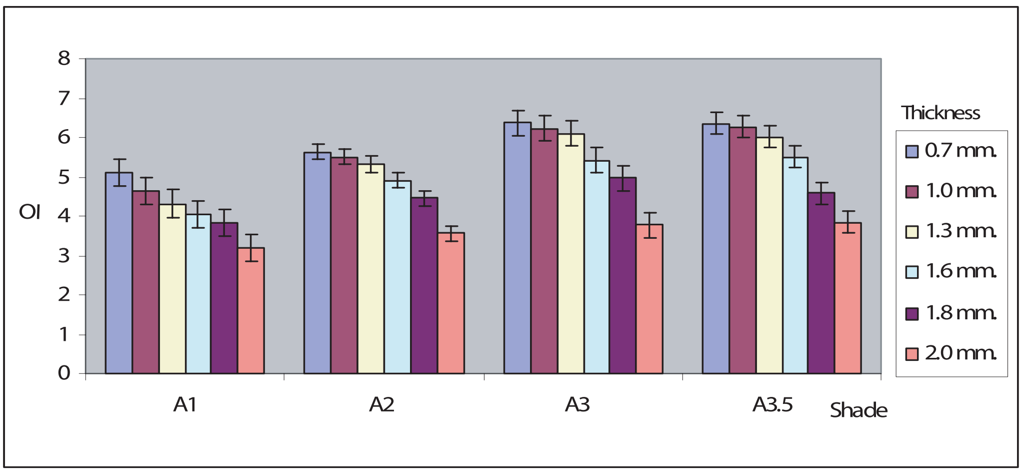

Figure 3 Bar graph of opalescence index (OI) value of shade A1, A2, A3 and A3.5

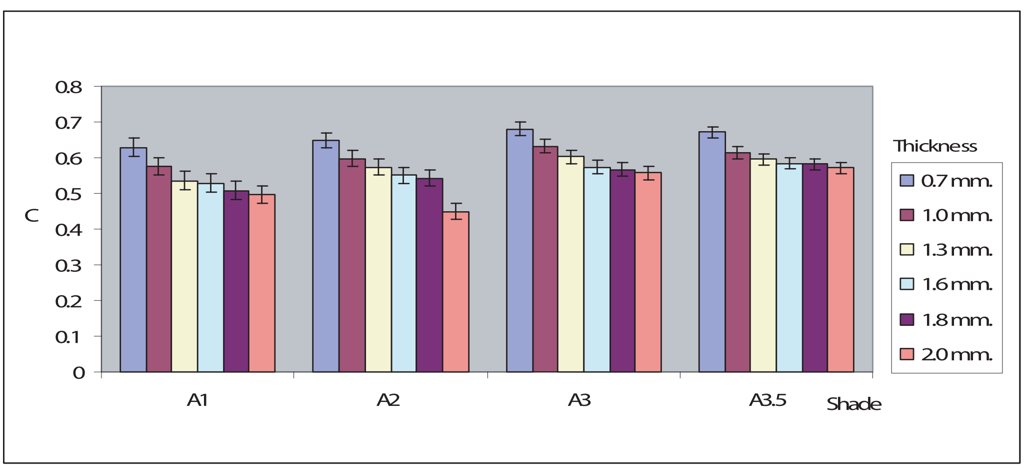

Figure 4 Bar graph of contrast ratio (C) value of shade A1, A2, A3 and A3.5

Table 2 ANOVA of translucency parameter (TP) of ceramic as a function of shade, thickness and their interaction

Source	SS	df	MS	F	P value
COLOR	121.300	3	40.433	95.627	0.000
THICKNESS	5312.681	5	1062.536	2512.953	0.000
COLOR * THICKNESS	14.116	15	0.941	2.226	0.006
Error	142.069	336	0.423		
Total	49391.296	360			

NB : SS : Sum of the square df : degree of freedom MS : mean square

Table 3 ANOVA of opalescence index (OI) of ceramic as a function of shade, thickness and their interaction

Source	SS	df	MS	F	P value
COLOR	98.433	3	32.811	489.464	0.000
THICKNESS	236.467	5	47.293	705.506	0.000
COLOR * THICKNESS	12.358	15	0.824	12.290	0.000
Error	22.524	336	0.067		
Total	9453.326	360			

NB : SS : Sum of the square df : degree of freedom MS : mean square

Table 4 ANOVA of contrast ratio (C) as a function of shade, thickness and their interaction

Source	SS	df	MS	F	P value
COLOR	0.296	3	0.099	473.765	0.000
THICKNESS	0.486	5	0.097	467.351	0.000
COLOR * THICKNESS	0.019	15	0.001	6.038	0.000
Error	0.070	336	0.000		
Total	124.601	360			

NB : SS : Sum of the square df : degree of freedom MS : mean square

Table 5 Tamhane's multiple comparison of translucency parameter of thickness as a function of shade

Shade / Thickness (mm.)	A1	A2	A3	A3.5
0.7	•—	—• •—	—• •—	—•
1.0	•—	—• •—	—• •—	—•
1.3	•—	—• •—	—• •—	—•
1.6	•—	—• •—	—• •—	—•
1.8	•—	—• •—	—• •—	—•
2.0			•—	—•

NS= non significant between dot (•) groups

Table 6 Tamhane's multiple comparison of opalescence index of thickness as a function of shade

Shade / Thickness (mm.)	A1	A2	A3	A3.5
0.7			•—	—•
1.0			•—	—•
1.3			•—	—•
1.6		•—	—• •—	—•
1.8			•—	—•
2.0	•—	—• •—	—• •—	—•

NS= non significant between dot (•) groups

Table 7 Tamhane's multiple comparison of contrast ratio (C) of color thickness as a function of shade

Thickness (mm.) \ Shade	A1	A2	A3	A3.5
0.7	•	•	•	•
1.0	•	•		
1.3			•	•
1.6	•	•	•	•
1.8				
2.0			•	•

NS= non significant between dot (•) groups

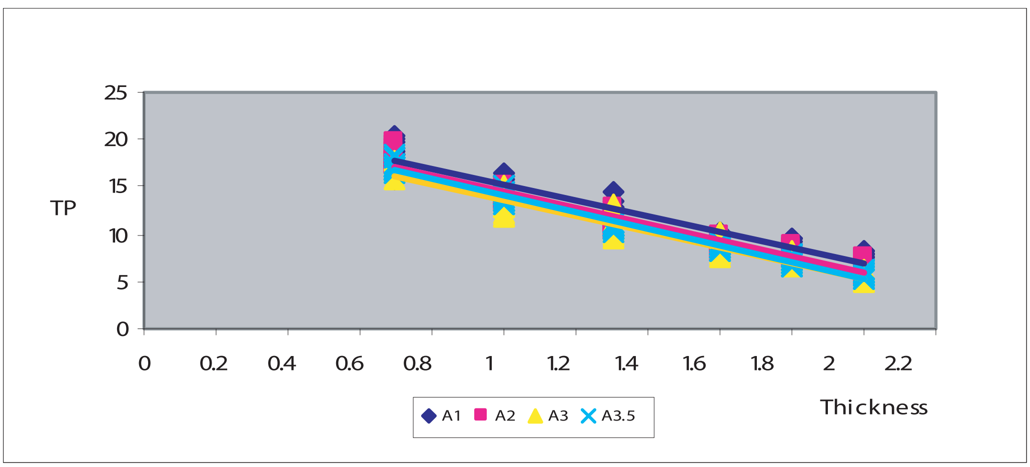

Figure 5 demonstrated translucency parameter (TP) value for each ceramic shade as a function of thickness

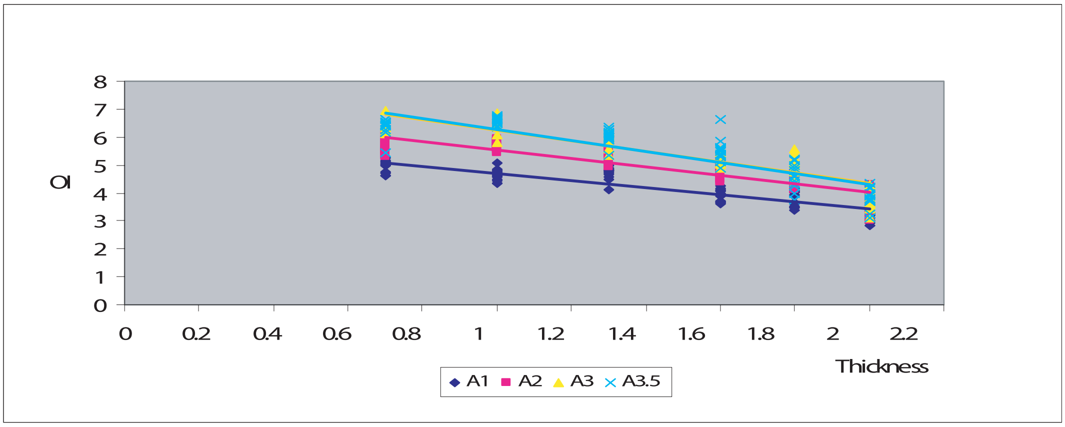

Figure 6 demonstrated opalescence index (OI) value for each ceramic shade as a function of thickness

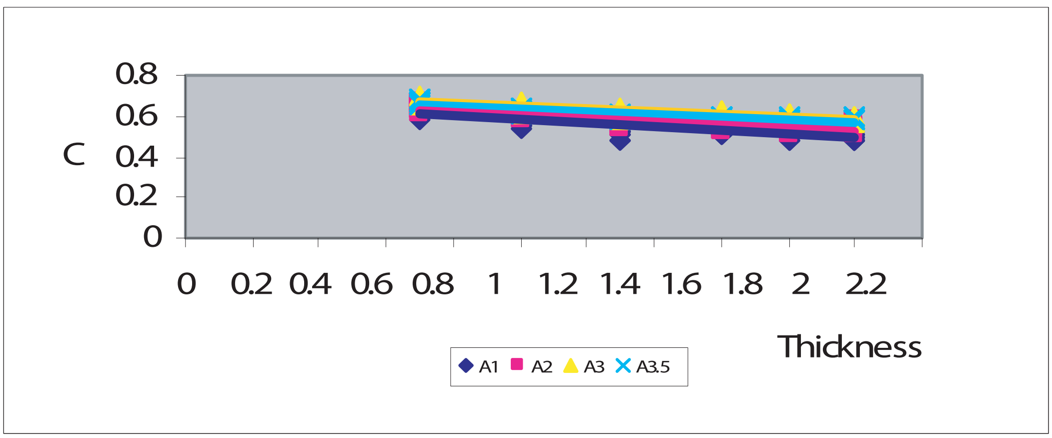

Figure 7 demonstrated contrast ratio (C) value for each ceramic shade as a function of thickness

Table 8 indicated correlation coefficient (R2) of translucency parameter (TP), opalescence index (OI), and contrast ratio (CI) on a function of thickness at various ceramic shade

	optical parameters tested		
Shade	**TP**	**OI**	**C**
A1	0.935	0.775	0.781
A2	0.959	0.780	0.764
A3	0.960	0.780	0.801
A3.5	0.983	0.777	0.756

Discussion

Aesthetic of ceramic restoration are influenced by the optical properties of ceramic material used for restoration fabrication by CAD-CAM technique. Factors that affect to the optical properties of ceramic result in disturbance of aesthetic restoration. This study proved that the ceramic thickness has significant influenced to optical properties of ceramic material tested which were translucency parameter, opalescence index, and contrast ratio.

The translucency of dental porcelain is largely dependent on light scattering (Brodbelt RH et al., 1980). If the majority of light passing through a ceramic is intensely scattered and diffusely reflected, the material will be opaque. If only part of the light is scattered and most is diffusely transmitted, the material will appear translucent (Kingery WD et al., 1976). In this present study, the translucency values identified the difference between the shades of ceramic material. As the ceramic thickness increased, the translucency of ceramic are reduced which result in low translucency of ceramic material. This indicated that the thicker the material the greater the opacity supported by the study of Kingery and Bowen (Kingery WD et al., 1976). Moreover, some study explain that thin material compose of less particle per unit volume than the thicker and consequently exhibit less scattering and decreased opacity (Clarke FJ, 1983). Considering the ceramic material used for anterior restoration must be translucent in order to assemble the appearance of natural tooth (Lee YK, 2007b).

A quantitative measurement of translucency was made by comparing reflectance of light (ratio of the intensity of reflected radiant flux [light] to that of the incident radiant flux) (1999;81: 39-110.) through the test specimen over a backing with a high reflectance to that of low reflectance or high absorbance. This procedure produce a contrast ratio (C) (Kingery WD et al., 1976). The contrast ratio is one of the most widely use methods to compare relative translucency of dental porcelain (Seghi RR et al., 1989). This ratio tends toward unity for opaque materials and toward zero for transparent materials (Kingery WD et al., 1976). Previous study show that, as contrast ratio decreased, the translucency of the ceramic specimen increases (Anusavice KJ et al., 1998). Thus these values depend on translucency value. High R2 values were obtained from this study indicated a better fit of the contrast ratio versus thickness data produced a straight linear support by the previous study of Antonson and Anusavice, 2001 (Antonson SA and Anusavice KJ, 2001).

The result of the present study of opalescence index related to the ceramic thickness found that increased of the thickness, decreased of the opalescence index support by the study of Rasetto et al (Rasetto FH et al., 2004) and also found that high correlation depicted between ceramic thickness and opalescence index. The opalescence of porcelain mimic the natural dentition, Leinfelder (KF, 2002) stated that opalescence augments the "vitality of a restoration" while Chizick (Chizick KM, 1994) and Yamamoto (Yamamoto M, 1895) compared the opalescence of teeth to that of the opal minerals or gems. Naturally, the physic of transmission of light through translucent material explain the opalescence, or opal effect which when white light (containing all wavelengths) strike the outer surface of an object, it may be absorbed call Absorbed light, reflected call Diffusely reflected light and Specularly reflected light, recently transmitted light enter the material, and some of this light cause opalescence (Young HD. Optics and modern physics. New York: McGraw-Hill, 1968:46: 96-101).While Chizick and Yamamoto (Chizick KM, 1994, Yamamoto M, 1895) described that the color of an object with fine internal phase is different when viewed in ambient (reflected) light, when viewed from the same side as the light source is placed, such as normal the blue light is preferentially deviated from straight line transmission through the material, unlike the longer, red-orange wavelengths. Therefore, more blue light than other colors of light will emerge from the front surface; The result is the blue-violet light is reflected back to the eye. This difference in color, depending on the position of the light source relative to the eye, is the opal effect or opalescence. Moreover, for all ceramic, translucent (enamel) porcelain has the design result of the human eye perceive the restoration as translucency by simulating the optical properties, such as opalescence, similar to those of natural teeth as light pass through small phase of dental porcelain, the various phase cause opalescence (Flannery JE and Wexell DR. Opal glases. In:Boyd DC, 1986).

The present study also compared those three parameters (TP, OI and C) of four shades group in equal thickness. The result demonstrated that some of these parameters in the same thickness for different shade are not significantly different. Thus, replacing one shade to another shade in the equal thickness of tooth preparation situation might be not affect the final shade or seem to be clinically acceptable of some restoration in final shade perceived base on this present study. This might be explain that not only the match of some optical properties for color to match with the adjacent teeth (Miyagawa Y and Power JM, 1983, Saunderson JL, 1942, Nagai SI and Sawafuji F, 1993). But the final color of the final restoration shall be closely match if the optical properties of ceramic, cement, dentine or dentine substitute are precisely evaluated in these proportion (Õ Keefe KL and Pease PL, 1991, Wyszecki, Wayne D and McAree, 1985, Grajower R et al., 1982).

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