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An In-Vitro Study on the Influence of Ceramic Thickness in the Color of Titanium Ceramic Restoration

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ABSTRACT

Background: Various factors such as metal alloy, thickness of the opaque porcelain, different methods of condensation of ceramic, thickness of the dentine ceramic, different ceramic firing condition affect the color of final ceramic restoration. It is not considered significant while taking single variable into account but several subtle changes in these factors lead to discernible color change. Purpose: The aim of this study was to evaluate the influence of ceramic thickness over color of ceramic layered on the titanium casting. **Methods**: Ultra low fusing ceramics of different thickness (0.5mm,1mm,1.5mm and 2mm) was veneered over a metal substrate of pure titanium and spectrophotometric analysis of 20 such discs was done to determine parameters (CIELAB system). One-way ANOVA and multiple comparison results of ANOVA were performed for statistical analysis. **Results**: The different thickness of ceramic significantly influences the ΔE value. There was significant change in the L* value ($P<0.05$) with different thickness of titanium metal ceramic tabs. There was also significant difference in C*ab values with different thickness of ceramic. **Conclusions**: The thickness of the ceramic has significant effect in the L* value of the titanium ceramic restoration. The thicker restoration appeared darker than the thinner one. There was also significant effect in the color saturation or chroma with different thickness of ceramic. Chroma decreased with increased thickness. Color difference between groups were significant. Overall thickness had effect on the final color of the titanium ceramic restoration.

Keywords: color difference ΔE; commercially pure titanium; low fusing ceramic; spectrophotometer.

INTRODUCTION

Because of excellent cosmetic results, good biocompatibility and high mechanical strength, ceramic materials are extensively used in dentistry.[1] Incorporation of metal infrastructures also termed as "metalloceramic prostheses" have been most widely used type of restoration due to increased fracture resistance than that of ceramic only.[2-5] As the amount of dental reduction determines the space required for metal ceramic restoration, it is important to match the color of ceramic to its substrate background while constructing the restoration.[6]

Colorimeters and spectrophotometers are used in dentistry to determine, quantify and compare the color during industrial manufacture of materials. Their use have been extended in selection of color of teeth in mouth, transferring such information to a laboratory and thus minimizing subjective visual perception.[7] The results of comparison of these instruments was found accurate in some respect following comparison with their standard.[8]

The color difference of ceramics due to metal substrate was studied for gold and titanium alloy, gold, rexillium.[9-12] The transmission of light through dental ceramics results in visual difference owing to the reason that increased thickness causes fewer amounts of direct transmission and less light scattering.[13] The objective of this study was to find out the effect of different ceramic thickness on the different color parameters of the color of titanium ceramic restoration.

METHODS

This study was designed to evaluate the color difference with different ceramic thickness in a titanium metal substrate. Commercially pure titanium (Symbion, Japan) brand was selected to be casted. Ultra-low fusing ceramic (Duceratin®kiss, Dentsply) was selected to veneer with different thickness.

1. Preparation of specimen

20 disc-shaped wax patterns were carved out of modelling wax having 0.5 mm in thickness. The

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diameter was maintained 10mm. Each wax pattern was sprued with an inlay casting wax on one end of the disc. The wax pattern was aligned vertically which sprued to a horizontal bar.

For investing, investment stainless steel ring, 45 mm in diameter was used. The distance between the end of the ring and the highest part of the wax pattern was 6mm to allow gas to escape. The wax pattern was then invested with magnesia and alumina based investment material (Symbion, TC, Japan) following manufacturer's recommendations. The proper powder/liquid ratio of 450gm/63 ml was taken and hand mixed for 15 sec until a homogenous mix was obtained. The mixture was then vaccum mixed (Vacuum powder mixer, Whipmix, USA) for 120 sec. The mixed investment material was hand painted on each material using brush and then slowly poured into each ring while being vibrated and left to set for 90miutes as recommended by manufacturer. After complete setting, the glaze surface of the investment material was removed to allow gas escape. Then rubber sprue former was removed from each ring. The casting ring was heated in burnout furnace to 250°C with heating rate of 5°C /min and held constant for ninety minutes. The temperature was then increased to 900°C with same heating rate. Then it was kept for 30 minutes. Finally, the rings were cooled down slowly at a rate of 5°C/min to 430°C and were held at that temperature for 30 minutes. When the burnout cycle was completed, the casting rings were placed into the Ti casting machine (Symbion, Japan)(Figure 1). Once the start/stop button is pressed, the closed interconnected two-chamber

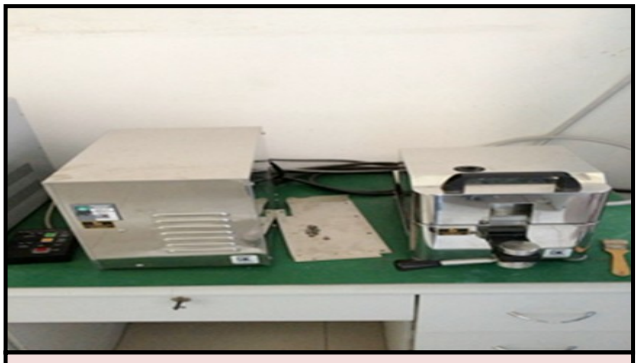

Figure 1. Titanium casting machine.

system of the casting machine allows melting and casting to take place under vacuum with inert gas. After casting was completed, the casting rings were immediately quenched in tap water.

2. Finishing of metal disc

Cutting off the sprues using thin cutting disc separated the recovered metal specimens. After separation, the metal specimens were carefully inspected for discrepancies. The metal specimens were then burnished with tungsten carbide bur at low speed (<10000rpm) and flattened the surface by grinding and polishing on coarse, medium and fine grained alumina polishing strip in the same direction. In the process, specimen thickness was maintained to 0.4 ± 0.05mm with an electronic digital caliper. Then all the specimens were sandblasted by the 100-µm aluminum oxide particles for 20 seconds. The specimens were passivized rinsing in running water and ultrasonically cleaned in distilled water for five minutes, repeating the process for 3 times. After cleaning the specimens were fully dried using a paper.

3. Application of porcelain

After all 20 metal disc (Figure 2) were prepared, they were randomly divided into 4 groups (A, B, C and D) each having five samples. Shade A2 of commercially used low fusing ceramic was selected

Figure 2. Finished metal discs with thickness of 0.4.

(Duceratin®kiss, Dentsply). A thin layer of bonding agent supplied with the ceramic material was applied to the discs. The bonding agent was dried in the muffle entrance and then fired in a furnace (Dentsply) following the firing cycles recommended by manufacturer. Subsequently a wash layer of the opaque porcelain was applied and fired, followed by a second layer that masked the metal color according to the manufacturer's instructions. The opaque layer was maintained to 0.3mm, which was verified by electronic digital calipers.

Body porcelain was then mixed with its designated liquid and the slurry was applied using a bristle brush. The body porcelain was condensed by blotting with a tissue. Each specimen was fired in a furnace. Consequent application of second body porcelain layer was done to achieve required thickness.

After dentin body, the specimen were flattened and smoothened using a different grit of water sand paper. Overall thickness of the specimen was maintained to group A 1.2mm, group B to 1.7mm, group C to 2.2mm and the group D to 2.7mm. Finally all the specimen were glazed and made ready for spectrophotometric analysis (Figure 3).

Figure 3. Finished metal ceramic tabs.

4. Measurement of the color of specimen

Clinical spectrophotometer (Crystaleye, Olympus, Japan) (Figure 4) was used to analyze the color of

Figure 4. Clinical spectrophotometer.

specimens. Each specimen was measured three times taking the mean value. Colorimetric parameter were recorded as CIEL*,a*,b* values, C*ab representing as chroma and ΔE representing the color difference between two specimens. The statistical analysis was performed using the analysis of variance (ANOVA) and Multiple comparison results of ANOVA test.

RESULTS

The mean values of L*, a* and b* for different groups are presented in Table 1, 2 and 3 respectively.

Table 1. Mean and standard deviation of L*.

Thick-ness	Sample					Mean ±SD	p value
	1	2	3	4	5		
A (1.2 mm)	74.21	73.95	74.49	73.87	74.01	74.10±0.248	<0.001
B (1.7 mm)	72.25	72.11	71.41	71.90	72.18	72.02±0.403	
C (2.2 mm)	71.13	70.61	71.75	69.81	70.12	70.68±0.778	
D (2.7 mm)	68.52	67.54	67.72	69.18	68.57	68.30±0.672	

Table 2. Mean and standard deviation of a*value.

Thick-ness	Sample					Mean ±SD	p value
	1	2	3	4	5		
A (1.2 mm)	2.94	2.18	3.34	2.97	2.44	2.57±0.360	0.001
B (1.7mm)	2.24	3.28	2.92	3.09	3.13	2.93±0.407	
C (2.2mm)	3.15	3.48	3.29	3.48	3.27	3.33±0.143	
D (2.7 mm)	2.21	2.34	2.72	1.64	1.68	2.11±0.458	

Taking the value of a* and b* into the formula $C^*ab=[(a^*)^2+(b^*)^2]^{1/2}$, the C*ab value was obtained. The mean values of C*ab for different groups are presented in Table 4.

The comparison among the group of the specimens with different thickness of dentin porcelain showed that values of L* decreased with increase in thickness of ceramic. The difference between them was statistically significant (P<0.05) (Table1 & 5).

Table 3. Mean and standard deviation of b*value.

Thickness	Sample					Mean ±SD	p value
	1	2	3	4	5		
A(1.2mm)	23.34	24.49	23.48	22.88	23.33	23.50±0.59	<0.001
B(1.7 mm)	21.12	21.94	22.37	21.15	20.07	21.33±0.88	
C(2.2 mm)	20.09	20.49	21.65	20.03	21.49	20.75±0.77	
D(2.7mm)	18.54	17.74	19.13	18.05	17.70	18.23±0.60	

Table 4. Mean and standard deviation of C*ab value.

Thickness	Sample					Mean ±SD	p value
	1	2	3	4	5		
A (1.2 mm)	23.52	24.58	23.71	23.02	23.45	23.66±0.56	<0.001
B (1.7 mm)	21.23	22.18	22.55	21.37	20.31	21.52±0.87	
C (2.2 mm)	20.33	20.78	21.89	20.38	21.73	21.02±0.74	
D (2.7mm)	18.67	17.89	19.32	18.12	17.11	18.22	

There was significant difference in the a* value of group A-group C, group B-Group D and Group C – Group D (P<0.05)(table5) but difference between Group A-Group B, Group A-Group D, Group B-Group C was not statistically significant (P>0.05) (Table 5).

Table 5. Multiple comparison results of ANOVA for L, a*, b* and C*ab.

L value	B	C	D
A	<0.05	<0.05	<0.05
B		<0.05	<0.05
C			<0.05
a* Value	B	C	D
A	>0.05	<0.05	>0.05
B		>0.05	<0.05
C			<0.05
b* Value	B	C	D
A	<0.05	<0.05	<0.05
B		>0.05	<0.05
C			<0.05
C*ab Value	B	C	D
A	<0.05	<0.05	<0.05
B		>0.05	<0.05
C			<0.05

Significant difference in the b*value of all specimen (P<0.05) was observed except in between group B and Group C (P>0.05)(table 5). Also, there was significant difference in C*ab values between all groups (P<0.05) except between Group B and Group C (P>0.05) (Table 5).

Then the color difference between each group ΔE was calculated using the formula;

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

The result of ΔE between group A and group B was 2.92, group A and Group C was 5.31, group A and group D was 7.90, group B and group C was 2.17, group B and group D was 5.09 and group C and group D was found to be 3.33.

DISCUSSION

In dentistry, color selection is the most commonly done by visual perception. This method is based on standard scales that are consisting of charateristic samples of the average of the colors present in the human dentition. Visual comparison with natural dentition is done by using shade guide. [14] Color selection using scales depends on various factors such as subjective interpretation, fatigue, age, stress, illumination of eyes to light, inappropriate positioning of object and illuminating influence of environment etc.[15] Instrumental accuracy has been well established and found to be free from many such variables.[7,8] In our study clinical spectrophotometric study was done for all the discs and repeatability was assured.

There are various factors influencing the final shade of the metal porcelain restoration. It has been found that the composition of metal substrate underlying the ceramic restoration has significant effect on the color of metal ceramic restoration. Color difference for metal substrate was studied by various authors.[9-12,16-18] The study done by Stevenson B et al found high gold samples were significantly lighter than nickel-chrome backed samples .[10]

Influence of commercially pure titanium and Ti-Al -4V on final shade of low fusing porcelain was studied and compared them with three conventional metal ceramic systems in which the difference from the shade tabs were 5.79 for Ti-Al-4V and 12.58 for pure titanium.[19]

The composition and manufacturing process of porcelain also has direct influence on the optical outcome of ceramic material. The study conducted by Seghi et al found that different brands significantly differed from each other within each color parameter[14].

Resin cement has also affected the color of ceramic veneer in incisal region,[20] whereas color of composites has not affected resultant color.[21] Thus in order to mask the discolored tooth, 0.8mm of ceramic thickness was recommended.[22] In present study, the consideration was solely on the metal-ceramic restoration, thus role of cement was neglected.

The study on effect of thickness of ceramic material on the color of metal ceramic restoration has been carried out by various authors. Broadbelt et al,[13] illustrated that transmission of light is affected by ceramic thickness. the amount of direct transmission and light scattering decreased as a thickness increased . Dagg[23] and vichi et al[24] found statistically significant color difference between ceramic tabs of varying thickness.

Terada et al[16] tested several different base metal and precious alloys with different thickness and found that regardless of alloy type, as ceramic thickness increased, the l*decreased ,a* and b* increased.

The present study found a significant decrease in the L* value (p<0.05) as the thickness of the specimen increased. There was a decrease in the brightness as the thickness increased from 0.5 to 2mm. This is in agreement with the studies done by Terada[16], brewer[25] and Jorgenson and Goodkind.[26]

Among all groups except 1mm and 1.5mm b* value had significant difference. There was a decrease in the b* values as the thickness of the specimen increases, which corresponds to the study done by Brewer et al.[25] Which also does agree with the study in which increased thickness had increased reddish-bluish appearance.[27]

The chroma had significant decrease ($p<0.05$) as the thickness was increased in our study. There was significant difference in chroma between all specimens except between 1mm and 1.5mm group. This finding was in contradiction to that of Jacobs et al.[28]

In our study, significant color difference was observed in ceramic tabs of varying thickness. The difference was lowest between near thickness group and as the thickness increased, the color difference also increased. This is in agreement with the study done by Dagg et al and Vichi et al. they also stated that if ceramic was 2mm thick the coping under the ceramic had no effect on the final shade.[23,24] However it was noted that the difference in color was dependent on tooth regions, such as cervical or incisal.[29]

CONCLUSION

This study showed significant change in the L* value of the specimens with different thickness. As the thickness of the ceramic tabs increased the L* value i.e. brightness decreased. There was also significant change in the chroma i.e., the color saturation decreased with increase of thickness of specimen. There was significant color difference between groups of different thickness. The thickness of ceramics had significant influence in the final color of the titanium metal ceramic restoration.

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Conflict of interest: None

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