Influence Of Porcelain Thickness And Repeated Firings On The Color Of Metal - Ceramic Restorations - An In Vitro Study

Tulika Khanna*, Sandeep Gurav, Rudraprasad IV#, Nandeeshwar DB#**

*Reader, Dept of Prosthodontics, MGM Dental College and Hospital, Navi Mumbai. ** Ad-Hoc Lecturer, Tata Memorial Hospital, Mumbai.# Professor, Bapuji Dental College and Hospital Davangere.

Abstract: Background & Objectives: Color matching between ceramic restorations and natural teeth has been a major challenge in dentistry. Faults may occur during shade matching procedure in the dental clinic or in the laboratory at the time of fabrication of restoration. This study assessed the effect of porcelain thickness and repeated firing on the color of metal-ceramic restorations. Method: Thirty 12mm square samples of nickel chromium alloy were prepared and divided into three groups of 10 samples each. All samples were fired with opaque porcelain followed by dentin porcelain maintaining the dentin thickness to 1mm, 2mm and 3mm with silicon molds. The color of all the samples was measured with a spectrophotometer after 1st firing. Samples were subjected to repeated firing and color was again measured after 4th firing, 7th firing, 10th firing and 13th firing. The data was subjected to statistical analysis. Results: The results showed that increasing the thickness of porcelain resulted in significant increase in the Lightness (L*) and decrease in the Chroma (C*) of the samples. It also demonstrated that repeated firing did not cause significant color change (ΔE) on repeated firing of 1mm and 2mm, however, repeated firing of 3mm samples showed substantial color changes (ΔE) on repeated firing but this change was within acceptable limits of oral environment. Interpretation and Conclusion: The results of the study suggest that increased thickness of the dentin porcelain increases the Lightness (L*) thereby reducing the graying effect of the opaque layer. Therefore, maximum tooth reduction should be encouraged without violating the pulp integrity to provide enough space for the bulk of porcelain for better esthetic results. The results also show that repeated firing does not affect the color stability of the porcelain samples tested although significant color changes were seen with 3mm samples which were within acceptable limits of oral conditions. So, it can be inferred that repeated firing of the porcelain can be done to achieve correct contours and shape of the restorations. [Khanna T NJIRM 2016; 7(4): 132-139]

Key Words: Porcelain, Hue, Chroma, Lightness, Repeated firing

Author for correspondence: Dr.Sandeep Gurav, Department of Dental and Prosthetic Surgery, Tata memorial Hospital, Mumbai. 400012.e- mail: drsandeepgurav@gmail.com

Introduction: The introduction of the porcelain-fused-to-metal restoration, although providing significantly greater strength characteristics than any alternative, has presented a number of esthetic challenges to the dental profession.[1] Several factors affect the ability of a porcelain system to produce an acceptable match with corresponding shade guides. Porcelain type, underlying metal, batch, manufacturer, opaque thickness, surface texture, layering of porcelain, ceramic dentin thickness, repeated firing, external lighting source and observer's visual perception all contribute to perceptible differences between the resultant shade of dental porcelain and their respective shade tabs.[2] Many studies have been conducted showing that repeated firing of porcelain[3,4,5] does not cause any significant color change in the resultant restoration but noteworthy changes in color have been seen on increasing the thickness of porcelain.2,3,6,7 None of the study has shown whether repeated firing of this increased thickness of porcelain causes any evident color change.

Hence, this in-vitro study was planned to know if there existed any significant color change by repeated firing on the increasing thickness of porcelain and the influence of porcelain thickness on various dimensions of color of metal-ceramic restorations.

The objectives of the study were to evaluate the effect of different porcelain thicknesses on the color of metal-ceramic restoration and to evaluate the color change by repeated firing of dentin porcelain of different thicknesses.

Material and Methods: In the present study, 30 samples were prepared of nickel-chromium alloy which was divided into three groups of 10 samples. These samples received porcelain whose thickness was maintained as 1mm, 2mm and 3mm respectively for the three groups with the help of silicon molds. All the samples were fired for 1 time, 4 times, 7 times, 10 times and 13 times and their color measured with a CM-3600d spectrophotometer each time. The samples for this study were made in two stages.

Preparation Of Alloy Substructure: For standardizing the thickness of the alloy substructure, patterns for the substructure were fabricated from 1.5 mm thick modeling wax using routine casting procedure. The specimens were numbered for easy identification.

Condensation Of Ceramic Over Metal Substructure:
Two layers of opaque porcelain were fired followed by dentin body porcelain to achieve thickness of 1mm, 2mm and 3mm by using the silicon molds. The opaque thickness varied between 0.2 to 0.3 mm. No attempt was made to standardize the opaque thickness on any sample by grinding due to potential harmful effect on bond both between the opaque porcelain and the metal and the bond between the opaque and dentin porcelain. The molds were prepared as per the procedure described in the previous studies[3,8]. Porcelain powder was applied on the metal substructure. The depth of the molds was such that the dentin thicknesses could be controlled at 1mm, 2mm and 3mm.(fig 1 and 2) The porcelain was applied in excess to compensate for the shrinkage which occurs during firing and then fired as recommended by the manufacturer.

Fig. 1: Silicone index for Ceramic thickness

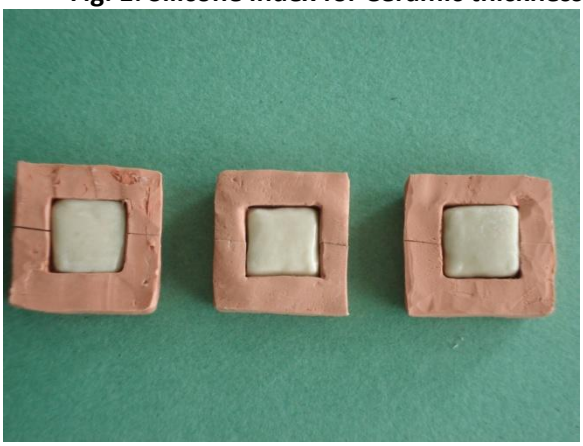
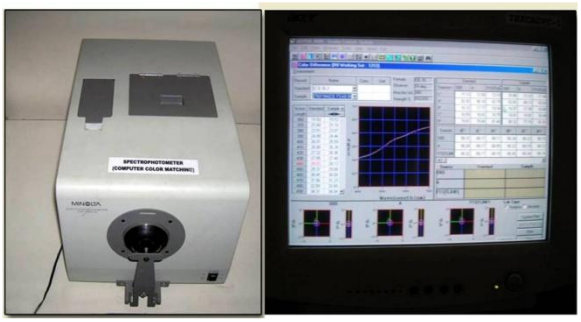


Fig 2: Porcelain fired samples of 1mm, 2mm and 3 mm thickness

The thickness of each sample was then measured nine times along its length with an electronic digital caliper and corrected as necessary until the desired thickness of dentin was achieved (1 mm, 2 mm and 3mm). The samples were ultrasonically cleaned for 5 minutes and then glazed. The samples were subjected to repeated firing to check their color stability. All samples were fired for a total of 13 times and their noted after 1st firing, 4th firing, 7th firing, 10th firing and 13th firing.
Color Evaluation Of Samples By Spectrophotometer: The samples were individually analyzed with a CM 3600d-Spectrophotometer. (Fig 3)

Fig 3: CM 3600d- spectrophotometer with computer analyser



All data was recorded and expressed in Munsell color notation (Hue, Value, Chroma) and CIE notation (L*, a*, b*)

The color difference (ΔE) of the samples on repeated firing was calculated using the following formula. The color of the samples after 1st firing was taken as baseline and color after repeated firing was compared to this.

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

Where ΔL, difference in the Lightness (L*) of two samples.
Δa, difference in the a* value (chroma on red-green axis) of two samples
Δb, difference in the b* value (chroma on yellow-blue axis) of two samples
Statistical Analysis:
Descriptive data are presented as mean and standard deviation and were used for analysis. One-way ANOVA (Analysis of Variance) was used for multiple group comparisons followed by Post Hoc Tukey's Test for pair wise comparison.

Results: The present study spectrophotometrically evaluated the color change (ΔE) seen when porcelain samples of different thickness were fired repeatedly. It also assessed the changes occurring in various

dimensions of color on varying the porcelain thickness.

Table no. 1 and graph no.1 show changes occurring in the Hue (H*) of the samples as their thickness increased. It also represents the changes in the Hue as the samples of the respective thicknesses were fired repeatedly. The data shows an increase in the Hue as the thickness of the samples were increased. The samples of 1mm showed the Hue of 78.90 ± 0.24 which increased to 79.35 ± 0.78 at 2mm and 79.47 ± 0.59 at 3mm after 1st firing. This increase in Hue however, was found to be statistically insignificant (p>0.05). Likewise, at all the further firings a trend of increase in the Hue was seen in the samples as their thickness were increased but of little significance.

Table 1: Comparison of H* value (Hue) for different porcelain thickness

No. of firings		H*1	H*2	H*3	F** Value	Significance
1st firing	Mean	78.90	79.36	79.47	2.65	p>0.05 NS
	SD	0.24	0.78	0.59		
4th firing	Mean	78.78	79.48	79.58	0	p>0.05 NS
	SD	0.48	0.81	0.58		
7th firing	Mean	78.89	79.61	79.67	0	p>0.05 NS
	SD	0.46	0.84	0.57		
10th firing	Mean	79.09	79.73	79.74	3.35	p>0.05 NS
	SD	0.45	0.84	0.56		
13th firing	Mean	79.19	79.83	79.81	2.85	p>0.05 NS
	SD	0.56	0.85	0.55		

NS= Not Significant
H*1 = Hue at 1mm porcelain thickness
H*2 = Hue at 2mm porcelain thickness
H*3 = Hue at 3mm porcelain thickness
** Oneway ANOVA Test

Graph no.1 -Hue (H*) of the porcelain at thickness 1mm, 2mm and 3mm seen after repeated firing.

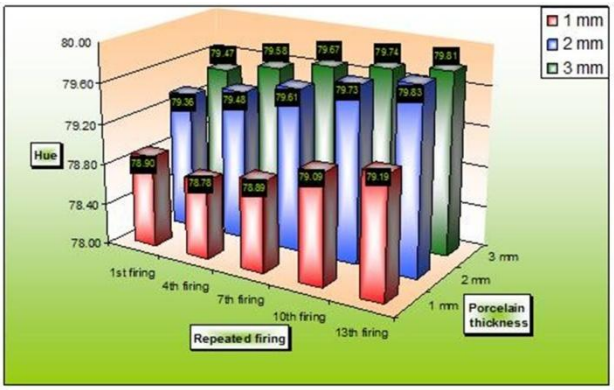
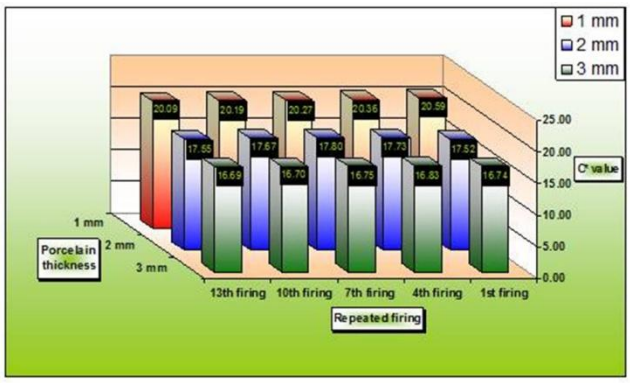


Table no. 2 and graph no. 2 represents the variations in the Chroma (C*) of the samples of different thickness and the changes that occurred in the Chroma after these samples were subjected to repeated firing. It was observed from the data that as

Graph no. 2 - Chroma (C*) of the porcelain at thickness 1mm, 2mm and 3mm seen after repeated firing.



the thickness of the samples increased, there was a statistical significant (p<0.01) decrease in their Chroma (C*). At 1st firing, the Chroma of 1mm samples was 20.59 ± 1.77 which decreased to 17.52 ± 1.90 at 2mm and further to 16.74 ± 0.43 at 3mm.

When this data was subjected to Tukey's Test for pair wise comparison, it was seen that a significant decrease ($p<0.01$) in Chroma was seen when samples of 1mm and 2mm and samples of 1mm and 3mm were compared. Same trend of significant decrease in C* value between 1mm and 2mm and between 1mm and 3mm was seen when the samples were examined for Chroma (C*) after 4th, 7th, 10th and 13th firing.

Table2: Comparison of C* value (Chroma) for different porcelain thickness

No.of firings		C*1	C*2	C*3	F** Value	Significance	Significant Groups***
1st firing	Mean	20.59	17.52	16.74	17.9	p<0.01 S	C*1 &C*2, C*1 &C*3
	SD	1.77	1.90	0.43			
4th firing	Mean	20.36	17.73	16.83	18.1	p<0.01 S	C*1 &C*2, C*1 &C*3
	SD	1.82	1.41	0.51			
7th firing	Mean	20.27	17.80	16.75	19.1	p<0.01 S	C*1 &C*2, C*1 &C*3
	SD	1.77	1.31	0.52			
10th firing	Mean	20.19	17.67	16.70	19.4	p<0.01 S	C*1 &C*2, C*1 &C*3
	SD	1.75	1.28	0.53			
13th firing	Mean	20.09	17.55	16.69	17.8	p<0.01 S	C*1 &C*2, C*1 &C*3
	SD	1.76	1.38	0.52			

S = Significant
C*1 = Chroma at 1mm porcelain thickness
C*2 = Chroma at 2mm porcelain thickness
C*3 = Chroma at 3mm porcelain thickness
** Oneway ANOVA Test
*** Tukey's Test

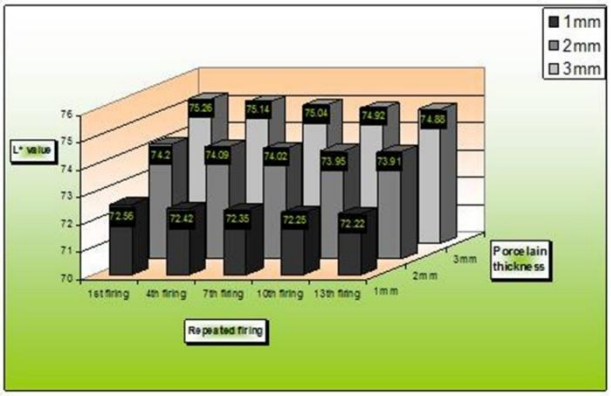
Table3: Comparison of L* value (lightness) for different porcelain thickness

No. of firings		L*1	L*2	L*3	F** Value	Significance	Significant Groups***
1st firing	Mean	72.56	74.20	75.26	17.72	p<0.01 S	L*1&L*2, L*1&L*3
	SD	1.02	0.97	1.06			
4th firing	Mean	72.42	74.09	75.14	19.35	p<0.01 S	L*1&L*2, L*1&L*3
	SD	0.95	0.97	1.02			
7th firing	Mean	72.35	74.02	75.04	19.59	p<0.01 S	L*1&L*2, L*1&L*3
	SD	0.91	0.96	1.02			
10th firing	Mean	72.25	73.95	74.92	20.05	p<0.01 S	L*1&L*2, L*1&L*3
	SD	0.90	0.90	1.04			
13th firing	Mean	72.22	73.91	74.88	19.67	p<0.01 S	L*1&L*2, L*1&L*3
	SD	0.91	0.91	1.05			

.S = Significant
L*1 = Lightness at 1mm porcelain thickness
L*2 = Lightness at 2mm porcelain thickness
L*3 = Lightness at 3mm porcelain thickness
** Oneway ANOVA Test
*** Tukey's Test

Table no. 3 and graph no.3 signifies the changes in the Lightness (L*) which reveals that there is statistical significant increase ($p<0.01$) in the Lightness (L*) of the samples when the samples of 1mm, 2mm and 3mm thickness were compared with each other. . At first firing, the samples of 1mm showed the Lightness (L*) value of 72.56 ± 1.02 which increased to 74.20 ± 0.97 at 2mm and at 3mm it further increased to 75.26 ± 1.06.

Graph no. 3 Lightness (L*) of the porcelain at thickness 1mm, 2mm and 3mm seen after repeated firing.



When the data was subjected to Tukey's Test for pair wise comparison, it revealed a significant increase in L* value between 1mm and 2mm samples and between 1mm and 3mm samples. Same trend of increase in L* value between 1mm and 2mm and between 1mm and 3mm was seen when the samples were examined for Lightness(L*) after 4th, 7th, 10th and 13th firing.

Graph no. 4 -Total color change (ΔE) seen for porcelain of different thickness as they were subjected to repeated firing.

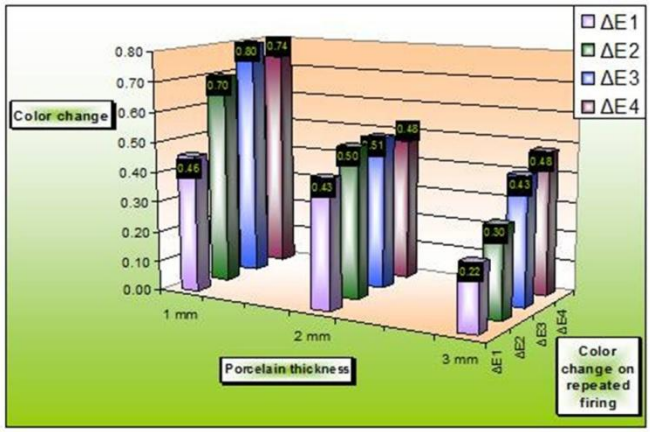


Table no. 4 and graph no.4 explains the total color change (ΔE) seen in samples of different porcelain thickness as they were subjected to repeated firing. It was seen that when samples of 1mm and 2mm were fired repeatedly for 4 times, 7 times, 10 times and 13 times, no significant ($p>0.05$) color change was seen.

Table 4: Total color change (ΔE) of different porcelain thickness after repeated firing

Porcelain Thickness		4^{th} firing (ΔE1)	7^{th} firing (ΔE2)	10^{th} firing (ΔE3)	13^{th} firing (ΔE4)	F* Value	Signi-ficance	Significant Groups**
1 mm	Mean	0.46	0.70	0.80	0.74	1.26	p>0.05 NS	--
	SD	0.37	0.44	0.46	0.44			
2 mm	Mean	0.43	0.50	0.51	0.48	0.32	p>0.05 NS	--
	SD	0.18	0.19	0.26	0.20			
3 mm	Mean	0.22	0.30	0.43	0.48	4.57	p<0.05 S	ΔE3 - ΔE1, ΔE4 -ΔE1
	SD	0.15	0.13	0.21	0.20			

NS= Not Significant
S = Significant
ΔE1 – Color change in samples between 4^{th} firing and 1^{st} firing
ΔE2 – Color change in samples between 7^{th} firing and 1^{st} firing
ΔE3 – Color change in samples between 10^{th} firing and 1^{st} firing
ΔE4 – Color change in samples between 13^{th} firing and 1^{st} firing
* Oneway ANOVA Test
** Tukey's Test

However, when 3mm samples were fired repeatedly for 4 times, color change (ΔE1) was found to be 0.22 ± 0.15 which increased to 0.30 ± 0.13 (ΔE2) after 7th firing. Till 7th firing, the color change (ΔE) of these samples was not statistically significant. However, on further firing, the 3mm samples showed significant color change ($p<0.01$) of 0.43(ΔE3) after 10th firing which increased to 0.48 ± 0.20 (ΔE4) after 13th firing.

Table no. 5 shows mean and standard deviation of total color change (ΔE) seen at repeated firing for different porcelain thickness. It was observed that there was no significant color change ($p>0.05$) seen in any porcelain thickness after 4th firing. Significant color difference (ΔE) was seen after 7th and 10th firing but further firing to 13th time did not show any noteworthy color changes. On subjecting the data to Tukey's Test for pair wise comparison, it became evident that color change was seen when samples of 1mm were compared with samples of 3mm after 7th and 10th firing. The results of the present study can be summarized as follows.

Increasing porcelain thickness resulted in significant increase in lightness (L*) and significant decrease in chroma (C*) of the porcelain samples.

Repeated firing of porcelain did not have significant effect on the Hue, Chroma and Value of the porcelain of any thickness used in the study.
Total color change (ΔE) due to repeated firing was not significant for 1mm and 2mm samples; however, significant ΔE values were observed with repeated firing of 3mm samples.

Table 5: Total color change (ΔE) after repeated firing of different porcelain thickness

No.of firings		1mm	2mm	3mm	F* Value	Significance	Significant Groups**
4th firing (ΔE1)	Mean	0.46	0.43	0.22	2.63	p>0.05 NS	-----
	SD	0.37	0.18	0.15			
7th firing (ΔE2)	Mean	0.70	0.50	0.30	4.87	p<0.05 S	1mm - 3mm
	SD	0.44	0.19	0.13			
10th firing (ΔE3)	Mean	0.80	0.51	0.43	3.54	p<0.05 S	1mm - 3mm
	SD	0.46	0.26	0.21			
13th firing (ΔE4)	Mean	0.74	0.48	0.48	2.5	p>0.05 NS	------
	SD	0.44	0.2	0.2			

NS= Not Significant
S = Significant
ΔE1 – Color change in samples between 4th firing and 1st firing
ΔE2 – Color change in samples between 7th firing and 1st firing
ΔE3 – Color change in samples between 10th firing and 1st firing
ΔE4 – Color change in samples between 13th firing and 1st firing
* Oneway ANOVA Test
** Tukey's Test

Discussion: The dental profession has long been confronted with the problem of matching the color of artificial tooth substances to the natural dentition. The selection or modification of color for a ceramic restoration is complex and requires careful consideration.[9]

For the ease of understanding, discussion has been divided in two parts. Effect of porcelain thickness on the three dimensions of color. Color change seen after repeated firing of porcelain with different thickness.

The previous studies show definite effect of porcelain thickness on color of porcelain to varying degree. A study[3] was done using 3 porcelain systems and 3 thicknesses (1mm, 2mm, and 3mm) and their color was analyzed with spectrophotometer using Munsell System. It was observed that Hue of any porcelain

system was not significantly affected on increasing porcelain thickness. Another study[7] evaluated the effect of porcelain thickness (0.5, 1 and 1.5mm) and underlying metal on the color of metal-ceramic restorations. It was found that for shades A3 and C4, the Hue shifted toward yellow-red between 0.5 and 1mm dentin porcelain thickness whereas no change was seen in the Hue for shade B1. The present study was in correlation with the previous studies[3,7] where no significant difference in the Hue of the samples was observed at any thickness.

A study[3] has analyzed the effect of porcelain thickness on the Chroma of samples of varying thickness (1mm, 2mm and 3mm).The result of the study showed insignificant difference in the Chroma of samples regardless of their thickness. Another study[7] has shown significant increase in Chroma on increasing the porcelain thickness with shade A3 but with shade B1 and C4 no substantial change. The results of the present study are in contradiction to the study done by Jorgenson et al[3] but in correlation with Jacobs et al.[7] The data of the present study shows that there is significant decrease in the C* value ($p<0.01$) of samples as their thickness was increased. At 1st firing, the Chroma of 1mm samples was 20.59 ± 1.77 which decreased to 17.52 ± 1.90 at 2mm and further to 16.74 ± 0.43 at 3mm. When this data was subjected to Tukey's Test for pair wise comparison, it was seen that a significant decrease in Chroma was seen when samples of 1mm and 2mm and samples of 1mm and 3mm were compared. Same trend of significant decrease in C* value between 1mm and 2mm and between 1mm and 3mm was seen when the samples were examined for Chroma (C*) after 4th, 7th, 10th and 13th firing. In the present study, this significant decrease in the Chroma of the samples can be explained by the fact that as Chroma being inversely proportional to Lightness[10], so as the Lightness of samples has increased in the present study on increasing the thickness, their Chroma has shown a significant reduction.

A study[3] has shown that the Lightness (L*) of samples increases by the thickness of porcelain. Another study[7] has shown the Lightness of samples of shade A3 and C4 but with shade B1, there was little change in Lightness. The result of the present study was in agreement with previous study[3]. In the present study, there was statistical significant increase in the Lightness (L*) of the samples ($p<0.01$) when the samples of 1mm, 2mm and 3mm were compared with each other. At first firing, the samples of 1mm showed the Lightness (L*) of 72.56 ± 1.02 which increased to 74.20 ± 0.97 at 2mm and at 3mm it further increased to 75.26 ± 1.06. When the data was subjected to Tukey's Test for pair wise comparison, it revealed a significant increase in L* value between 1mm and 2mm samples and between 1mm and 3mm samples. Same trend of increase in L* value was seen when the samples were examined for Lightness(L*) after 4th, 7th, 10th and 13th firing.

Though the translucency of dental porcelain is much higher than that of natural teeth, this effect is countered by the placement of opacifying compounds in the opaque layer. As the thickness of the porcelain increases, this opacification or decreasing of the value is counteracted. Increasing the value is accomplished by the effect of greater translucency with increased thickness of porcelain. Lambert's and Beer's laws of light and absorption can also be applied to explain the increase in Lightness (L*) of porcelain with increased thickness. Lambert's law states that equal amounts of absorption result when light passes through equal thickness of material. Therefore, if the thickness of the porcelain increases, more light will be absorbed in the porcelain layer and less in the opaque layer. The result is an increase in value. Beer's law states that equal amounts of absorption result when light passes through equal amounts of absorbing material. Thus the increased thickness of porcelain, which means increased units of porcelain colorants, will absorb more incident light than thinner layers. This means that less incident light will be absorbed by the opaque layer with increased thickness of porcelain. The resultant effect is increasing the value.[3]

Many studies[3,4,5] previously done have demonstrated that repeated firing does not cause appreciable color change of porcelain. Jorgenson [3] has shown no significant changes in the Hue, Value and Chroma of 2mm porcelain samples when repeatedly fired for 2 times, 5 times and 10 times. Barghi N [4] has shown that there were no obvious color changes seen after first firing and only slight changes were observed in the color of samples with different combinations of opaque and dentin porcelain from 5th through 9th firing O'Brien WM[5] has compared the color change (ΔE) between 3rd firing and 6th firing. In their study, the mean ΔE for Jelenko was found to be 1.45, for Will-Ceram it was 1.43, for Vita it was 0.58 and for

Ceramco it was found to be 0.54. This color change was not found to be significant with any of the porcelain systems. When compared by brand, Vita and Ceramco showed less color change as compared to Jelenko and Will-Ceram. The results of the present study are in accordance with all the mentioned studies[3,4,5] which shows no significant color change (ΔE) on firing the samples of 1mm and 2mm for upto 13 times; however, significant color difference (ΔE) were seen with 3mm samples at 10th and 13th firing. When 3mm samples were fired repeatedly, color change increased after 7th firing. Till 7th firing, the color change (ΔE) of these samples was not statistically significant. On further firing, the 3mm samples showed significant color change (ΔE3) of 0.43 ± 0.21 after 10th firing which increased to 0.48 ± 0.20 (ΔE4) after 13th firing. So, it can be inferred that repeated firing of thicker samples of porcelain may show significant changes in the total color of porcelain.

The present study did not show any significant changes in the Hue, Chroma and Value of the samples of 1mm, 2mm and 3mm samples which were fired for 1 time, 4 times, 7 times, 10 times and 13 times.

Conclusion: Within the limitations of this study, it was concluded that Thickness of porcelain significantly affects the color of the porcelain fused to metal restorations. Increased thickness of the dentin porcelain significantly increased the Lightness (L*) of the samples and showed significant reduction in the Chroma (C*) of the samples.

Repeated firing did not significantly affect the color stability of the porcelain samples tested although samples with 3mm thickness showed significant amount of color change (ΔE) on firing for 10 times and 13 times. However, this color change was found to be within acceptable limits of oral conditions (ΔE > 3.7).

References:

1. Seghi RR, Johnston WM. Spectrophotometric analysis of color differences between porcelain systems. J Prosthet Dent 1986;56(1):35-40.
2. Douglas RD, Pryzybylaska M. Predicting porcelain thickness required for dental shade matches. J Prosthet Dent 1999;82:143-149.
3. Jorgenson MW, Goodkind RJ. Spectrophotometric study of five porcelain shades relative to the dimensions of color, porcelain thickness, and repeated firings. J Prosthet Dent 1979;42(1):96-105.
4. Barghi N. Color and glaze: Effects of repeated firings. J Prosthet Dent 1982;47(4):393-95.
5. O'Brien WM, Kay KS, Boenke KM, Groh CL. Sources of color variation on firing porcelain. Dent Mater 1991;7:170-173.
6. Barghi N, Lorenzana RE. Optimum thickness of opaque and body porcelain. J Prosthet Dent 1982;48(4):429-431.
7. Jacobs SH, Goodacre CJ, Moore BK, Dykema RW. Effect of porcelain thickness and type of metal ceramic alloy on color. J Prosthet Dent 1987;57(2):138-142.
8. Obregon A, Goodkind RJ, Schwabacher WB. Effects of opaque and porcelain surface texture on the color of ceramometals restorations. J Prosthet Dent 1981;46(3):330-340.
9. Groh CL, O'Brien WJ, Boenke KM. Differences in color between fired porcelain and shade guides. Int J Prosthodont 1992;5(6):510-514.
10. Fondriest J. Shade Matching in Restorative Dentistry: the Science and Strategies. Int J Periodont Rest Dent 2003;23(5):468-479.

Conflict of interest: None
Funding: None
Cite this Article as: T Khanna, S Gurav ,Rudraprasad , Nandeeshwar Influence of Porcelain Thickness & Repeated Firings On The Color Of Metal - Ceramic Restorations Natl J Integr Res Med 2016; 7(4): 132-139