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Original Paper

The Influence of Zirconia Opaquer and Thickness of Monolithic Zirconia on the Final Shade

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Abstract

Statement of problem. Monolithic zirconia can be influenced by the underlying titanium base which alters the restoration shade and creates unsatisfactory optical results.

Purpose. The purpose of this in vitro study is to find out the influence of zirconia opaquer on the optical proportion of monolithic zirconia at different thicknesses.

Material and methods. Three experimental groups have been examined - monolithic zirconia, zirconia opaquer and titanium implant abutment (group A), monolithic zirconia and titanium implant abutment (group B) and monolithic zirconia only (group C). Experimental specimens with a thickness of 0.8 mm, 1.5 mm, 2 mm were designed for a titanium implant abutment and 12 monolithic zirconia specimens for each thickness in shade A2 were prepared for each group respectively. A digital spectrophotometer was used to record the components for color value, chroma and hue. The mean and standard deviation (SD) of these measurements were calculated for all groups. The data for three independent groups were analyzed using the Kruskal-Wallis test and compared pairwise using Dunn's post hoc test adjusted by the Bonferroni correction. The degree of statistical significance was considered $P<0.05$.

Results. Statistically significant differences were found in all components of color value (L), chroma (C), hue (H) and thickness across groups A, B and C. For 0.8 mm thickness, the post-hoc test showed no significant difference between group A and C for the L and H color components. However statistically significant differences were found between groups B and C for all color components L, C, and H. For 1.5 and 2 mm thickness, the post-hoc test shows no significant difference between group B and C in all color components L, C and H. Statistically significant differences were found between group A and C for all color components L, C and H.

Conclusions. By increasing the thickness of monolithic zirconia, better masking color effect of the metal abutment background can be achieved. Using the monolithic zirconia on thin thickness (less than 1 mm) alone, without zirconia opaquer or opaque cement, cannot optimally mask the metal abutment background color. However, using the zirconia opaquer on thin monolithic zirconia thickness (less than 1 mm) can positively affect the final shade by masking the metal abutment background. Monolithic zirconia in thickness 1.5 and 2 mm can alone mask the metal abutment background color, while using the zirconia opaquer here can negatively affect the final shade of the restoration.

Clinical Implications

In daily clinical cases we may encounter angulated or straight metal implant abutments with thin zirconia crowns that do not achieve an acceptable color match. The grey tone of the metal abutment can negatively reflect through the zirconia crown, resulting in suboptimal esthetic outcomes. This study demonstrates that applying zirconia opaquer on thin monolithic zirconia (less than 1 mm) over a metal implant abutment can positively influence the final shade by effectively masking the metal background. However, monolithic zirconia with a thickness of 1.5 mm or 2 mm can sufficiently mask the metal abutment on its own and the use of zirconia opaquer in these cases can negatively affect the final restoration shade.

Introduction

Obtaining an esthetic restoration on a dental implant can be challenging. For dental implants a metal abutment is often used providing retention for the tooth shaped restoration.(1-3) Several factors can affect the shade of the restoration material, such as the luting material, the abutment material, and the restoration thickness.(4-11) Monolithic zirconia has the benefit of esthetic appearance, but the structure underneath may affect how it looks esthetically. The appearance is reported to be different with different ceramic shades and cement colors.(5-7, 9, 11-13) An opaque white resin cement can mask the color of a titanium abutment, but it may alter the final shade of the ceramic restoration.(5, 11, 14) Previous studies have investigated a range of zirconia thicknesses from 1 to 2.5 mm and reported a decrease in color difference (ΔE) with increasing thickness.(10, 15)

However, a metal abutment is difficult to mask, especially under a highly translucent ceramic restoration.(9, 13) Therefore in addition to opaque cement, the opaquer – the material used for masking the abutment color from inside of a crown - (16) plays an important role in the development of the shade and the esthetic outcome.(4, 16-19) Considering that we have different types and shades, like for example gold and base metal (nickel-chromium), of the abutments in dentistry the optical effect and shade of each abutment type can affect the final shade of ceramic restoration .(5, 7, 9, 12, 13, 17)

Different external and internal parameters influence color perception and in order to reduce multifactorial error, a spectrophotometer has been used to classify color numerically in several previous studies investigating factors affecting restoration shade. (5, 6, 8, 11, 12, 15, 17, 20-24) Spectrophotometry can differentiate color differences and achieves higher reproducibility than visual assessment.(12, 20, 22, 25, 26) The spectrophotometer program is based on the optical response of a standard observer, whereas the human eye provides inconsistent responses to hue, value, and chroma. Therefore, the spectrophotometer has been suggested to be used. (21, 27)

Computer-aided design and computer-aided manufacturing (CAD-CAM) technology now plays an important role in dentistry, with many restorative materials being developed to be compatible with the technology.(28-30) No studies on the effects of zirconia opaquer and zirconia thickness to mask the metal shade abutment when using CAD-CAM technology have been identified. Therefore, the purpose of the study is to find out the influence of zirconia opaquer on the optical proportion of monolithic zirconia at variable thickness. The null hypothesis was that zirconia opaquer and thickness of the monolithic zirconia restorations would not influence the final shade.

Material and Methods

The study was designed with the following three experimental groups: monolithic zirconia, zirconia opaquer and titanium abutment (group A), monolithic zirconia and titanium abutment (group B) and monolithic zirconia only (group C), see Figure 1. Experimental specimens with a thickness of 0.8 mm, 1.5 mm, 2.0 mm were designed for a titanium abutment (NeoBase® abutment; Neoss) and 12 monolithic zirconia (KATANA™ Zirconia YML; Kuraray Noritake Dental) specimens for each thickness in shade A2 were prepared for each group respectively, see Figure 2.

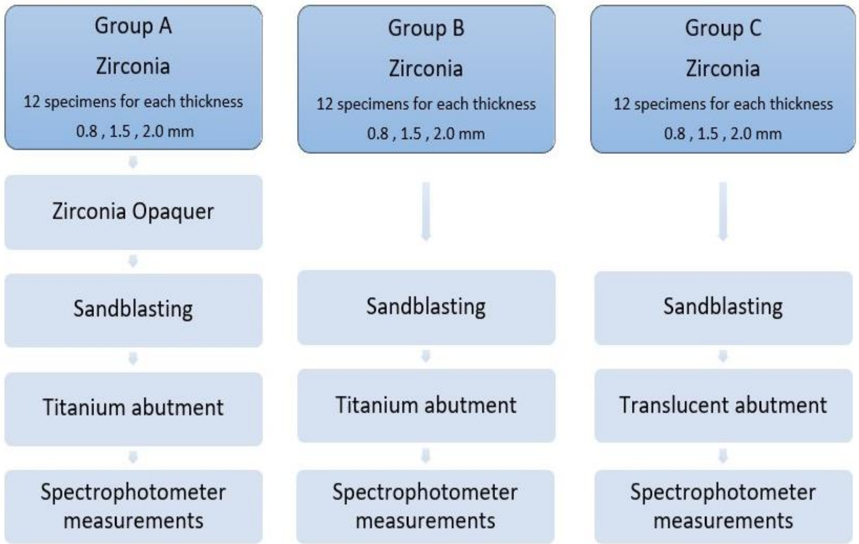

Figure 1. Laboratory Study Outline

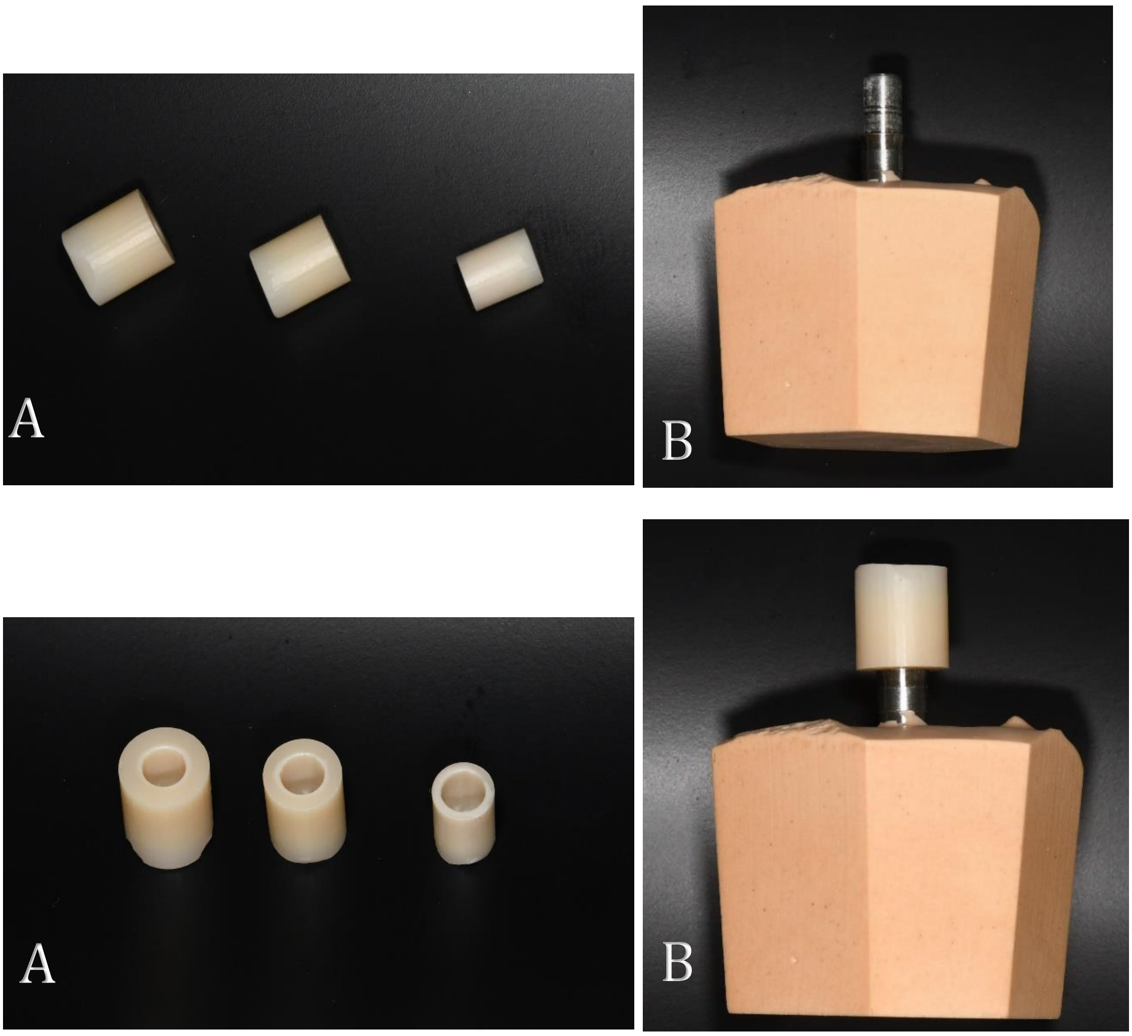

Figure 2. Photographed materials. A, zirconia specimens 0.8, 1.5 and 2.0 mm. B, zirconia specimen on titanium abutment

In group A an opaquer (Esthetic colorant OPAQUE; Kuraray Noritake Dental) was applied with 3 consecutive brush strokes on each thickness of zirconia before sintering, according to the manufacture instruction. After sintering, sandblasting, according to the manufacture instruction, before the specimens were placed directly on the titanium abutment without any separating medium. For group B the same procedure as in group A took place, but without the opaquer. In Group C, which consisted only of zirconia specimens, the specimens were sandblasted and placed on a translucent plastic abutment stick. The groups and respective treatment were outlined in Figure 1.

A digital spectrophotometer (VITA Easy shade® V) was used to record the components of color value, chroma and hue in the Commission International De L'éclairage (CIELab) color coordinates system. For each specimen the measurements were repeated three times in a dark room. The positioning of the spectrophotometer in relation to the specimens were standardized for all measurements. Three component of any color which are value, chroma and hue.[(31)] Each measurement variable can be explained as follows: L (VALUE, lightness) lighter (+) or darker (-), C (CHROMA, saturation) higher saturation (+) or lower saturation (-), H (HUE) more yellowish (+) or reddish (-) than the VITA classical A2 shade.

All measurements were statistically analyzed by one examiner who did not take part in any of the laboratory procedures. The software used was the Statistical Package for the Social Sciences (SPSS) version 24 (SPSS Inc.,IL). The data were tabulated, and from these measurements mean and standard deviation (SD) were calculated. The performed tests, for three independent groups, were the Kruskal-Wallis test, and pair-wise comparison using Dunn's post hoc test adjusted by the Bonferroni correction. The degree of statistical significance was considered $P < 0.05$.

Results

The mean ±SDs for color component value (L), chroma (C) and hue (H) for each group A, B and C and thickness are presented in Table 1. Statistically significant differences were found with all components of color L, C and H and thickness across groups A, B and C.

Table 1. Comparison of color components value (L), chroma (C) and hue (H) for each group and thickness

Thickness	Group A mean ±SD	Group B mean ±SD	Group C mean ±SD	*P*-value*	Pairwise comparisons	*P*-value**
0.8 mm						
L	-0.77 ±0.32	2.93 ±0.5	0.47 ±0.47	<.001	A-B	.000
					A-C	.104
					B-C	.002
C	-0.24 ±1.43	-0.79 ±0.32	2.27 ±1.12	<.001	A-B	1.000
					A-C	.001
					B-C	.000
H	6.48 ±0.69	7.12 ±0.25	6.64 ±0.39	.001	A-B	.007
					A-C	1.000
					B-C	.004
1.5 mm						
L	2.48 ±0.42	1.72 ±0.36	1.80 ±0.16	<.001	A-B	.000
					A-C	.000

					B-C	1.000
C	1.06 ±0.35	-0.05 ±0.40	-0.24 ±0.20	<.001	A-B	.000
					A-C	.000
					B-C	1.000
H	3.89 ±0.34	5.02 ±0.38	5.50 ±0.18	<.001	A-B	.003
					A-C	.000
					B-C	.059
2 mm						
L	1.78 ±0.53	1.08 ±0.25	0.99 ±0.25	<.001	A-B	.004
					A-C	.000
					B-C	1.000
C	-0.03 ±0.45	-0.63 ±0.27	-0.55 ±0.26	<.001	A-B	.000
					A-C	.009
					B-C	1.000
H	4.67 ±0.42	5.27 ±0.36	5.23 ±0.32	<.001	A-B	.001
					A-C	.004
					B-C	1.000

L, Value; C, Chroma; H, hue; SD, standard deviation.

* Kruskal-Wallis, ** Dunn's post hoc test adjusted by the Bonferroni correction.

For 0.8 mm thickness the results show that group A (with opaquer) has improved the final shade in color components L and H to be closer to group C. The post-hoc test shows no significant difference between group A and C with L and H color components. In contrast to comparison group B and C in which statistically significant differences were found for all color components L, C and H.

For 1.5 and 2 mm thickness the results shows that group A (with opaquer) are lighter and more saturated in comparison with group C, and group B mean numbers are closer to Group C. The post-hoc test shows no significant difference between group B and C in all color components L, C and H. Statistically significant differences were found between group A and C for all color components L, C and H.

Discussion

The result of this in vitro study showed that the zirconia opaquer and thickness of the monolithic zirconia restorations significantly influenced the final shade; therefore, the null hypothesis was rejected.

Regarding thin zirconia thickness, previous studies have reported that when the ceramic thickness increases, the influence of the underlying structure on the final color decreases.[8, 12, 13] It has been reported that monolithic zirconia restoration has a better masking effect than the lithium disilicate restoration and it can mask the underlying background color on an even thinner thickness.[32] Regarding the masking ability, it is critical when translucent ceramics along with dark/discolored backgrounds are used.[15] Therefore, on this study we used monolithic zirconia restoration because it was previously reported that it has a better masking effect thanks to its polycrystalline structure with no glass content which increases opacity so it could mask the metal background.[32-34] The titanium background reduces the transmission and reflection of incident light, resulting in a darker appearance.[9] Earlier investigations have concluded that for the ceramic's final shade, as seen in the background, zirconia was preferable to titanium.[9, 12, 35, 36]

The present study shows that the zirconia restoration of 0.8 mm cannot mask the color of the underlying metal, and this corresponds to Malkondu "*et al*" [37] achieving a more optimal color for specimens with zirconia thickness of 1 mm- the color difference ($\Delta E=2.23$) rather than 0.6 mm ($\Delta E=3.53$). The zirconia opaquer used in the present study had positively affected the final shade on the 0.8 mm zirconia specimens. Masking the underlying metal background abutment color and the results for each value and hue were the closest to the zirconia specimens without any background effect (group C). In general, the opaquer has been reported to possibly affect the final shade when applied on different backgrounds.[38] However, in this study (Ozcelik "et al"2008) the opaquer was applied directly on the metal background.

Increasing the zirconia restoration thickness can have a better masking effect.[23] A 1 mm thick zirconia ceramic has been advised for acceptable masking ability ($\Delta E<5.5$), while for achieving ideal masking ability, the zirconia thickness should be increased to 1.6 mm ($\Delta E<2.6$).[39] This corresponded to the present study showing that the zirconia restoration in thickness 1.5 mm and 2 mm without zirconia opaquer (group B) has been masking the metal background color and being closest to group C. In addition, it shows in the present study that using the zirconia opaquer in zirconia thicknesses of 1.5 mm and 2 mm can affect the final shade negatively, as it may be brighter and more saturated. Therefore, it is suggested that the zirconia thickness alone can mask the metal color background when its thickness is more than 1 mm without any need of zirconia opaquer. This corresponds to a previous study that shows that the zirconia thickness is more critical when it is less than 1 mm.[39] When discolored or when using metal backgrounds, zirconia thickness should be increased. As a guideline, a background ceramic color harmony is suggested for monolithic zirconia restorations. [40]

Another factor that can affect the final shade is using an opaque cement to mask the metal background which was not evaluated on this study. According to the present study, it seems that the zirconia opaquer and zirconia thickness are enough to mask the metal background, considering having satisfying results with zirconia opaquer on thin zirconia thickness 0.8 mm. So, using the opaque cement can negatively affect the final shade and produce an unsatisfying result. This was documented in the previous study showing that an opaque white cement can mask the color of a titanium abutment but may also alter the final shade of the ceramic restoration.[6] In addition, it has been reported that the luting cement cannot mask the shade of the underlying structure with a ceramic thickness of less than 1.5 mm.[41, 42] According to present study and other studies [12, 15, 23, 39, 40] monolithic zirconia restoration alone at thickness 1.5 mm can mask the underlying metal color.

This in vitro study simulated the clinical situation of an implant-supported restoration using zirconia restoration shade A2 on metal implant abutment. Therefore, this study was limited to only 1 shade. Further studies should investigate the various shades of zirconia on the final shade of the restorations.

Considering the increase in use of dental implants, it is, in this in vitro study, worth determining the effect of the masking ability of monolithic zirconia on metal implant abutments. Further clinical studies can be suggested to clinically evaluate the color masking optical effect of zirconia: zirconia opaquer and the thickness of the monolithic zirconia restorations on the final shade and comparing these lab results with the future clinical ones.

Conclusions

Based on the findings of this in vitro study, the following conclusions were drawn:

1. By increasing the thickness of monolithic zirconia, a better masking effect of the metal abutment background color is achieved.

2. The use of monolithic zirconia with thin thickness (less than 1mm) and alone without zirconia opaquer or opaque cement cannot mask the metal abutment background color optimally.

3. Using zirconia opaquer on thin monolithic zirconia thickness (less than 1mm) can positively affect the final shade in order to mask the metal abutment background.

4. Monolithic zirconia in thickness 1.5 mm and 2 mm can on its own mask the metal abutment background color, and using the zirconia opaquer here can negatively affect the final shade of the restoration.

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