Original Article

The Translucency Effect of Different Colored Resin Cements used with Zirconia Core and Titanium Abutments

N Capa, C Celebi, A Casur, I Tuncel[1], A Usumez[2]

Department of Prosthodontics, Faculty of Dentistry, Yeditepe University, [1]Department of Prosthodontics, Faculty of Dentistry, Bezmialem Vakıf University, [2]Private Practitioner, Dentalpuls Clinics, Istanbul, Turkey

Abstract

Purpose: The purpose of this study was to evaluate the effect of the different color of resin cements and zirconia cores on the translucency parameter (TP) of the restoration that simulates the implant-supported fixed prosthesis using titanium base on the bottom. **Materials and Methods:** Zirconia core plates (Zr-Zahn) were prepared in A2 shades (n = 11). Resin cement plates (3M ESPE) were prepared in A2, A1, translucent (TR) shades (n = 11). The initial color measurements and were measured on zirconia core plates, and resin cements plates using a spectrophotometer. Then, the resin cement plates were placed below the zirconia core plates, and the second measurements were done. The final measurements were done after placing the titanium discs in the bottom. The data were analyzed with two-way analysis of variance and Tukey honestly significant differences tests (α = 0.05). **Results:** The highest TP values were recorded for A1-colored resin specimens and the lowest for zirconia core plates in the first measurement ($P < 0.05$). The addition of zirconia core decreased the TP values in all tested resin cement groups ($P < 0.05$). The highest TP value was recorded for A1-colored resin cement with zirconia core plates and the lowest for A2 and TR with zirconia core plates after second measurements ($P < 0.05$). The addition of titanium decreased the TP of the zirconia core plate and resin cement combination ($P < 0.05$). **Conclusions:** The addition of a zirconia core under the resin cement dramatically reduced the TP values, and the presence of a titanium layer decreased the TP value and caused a darker appearance.

Keywords: *Resin cement, titanium, translucency, zirconia*

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Introduction

There are several materials used to make fixed prostheses such as all ceramic, zirconia, and metalceramic mixtures. All these prostheses have different physical, mechanical, and esthetic properties. One of the critical success factors in the rehabilitation of a lost tooth in the anterior region is the color.[1-4] Color is the major consideration from an esthetic point of view since it gives the prosthesis an appearance that matches the adjacent teeth which makes it look very natural. With the correct color match, an outstanding esthetic result can be achieved. Technically, the color of the prosthesis depends on variations in ceramic materials as well as the metallic or zirconia core material. The characteristic colors of the prosthetic materials are affected by their translucency.[1,5-9]

The translucency parameter (TP) can be explained as the state of a material that allows some light to pass through it and which will result in opacity if no light is passed and transparency if all available light is passed through it.[1,10,11] Although allceramics are translucent, metalceramics are opaque. In addition, zirconia ceramics are semi-translucent, which means that the color of the underlying tooth or abutment and/or the thickness and color of the luting agent have an influence on the final color.[6] The increase of the TP in zirconia core material will increase its translucency which will, in turn, enhance its esthetic properties. However, this material should

Address for correspondence: Dr. A Usumez, Dental Plus Clinics, Incirli Street, No:73, Bakırköy/Istanbul, Turkey.
E-mail: asli_u@hotmail.com

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be used with caution when used in discolored teeth, natural teeth with metallic posts, and implanted metallic abutments. With increased translucency, masking ability will decrease, and the color of the metal abutment will be more visible from the surface of the restoration.[2,4,12]

The color of the luting cement affects the final color of the restoration, as with zirconia ceramic restoration, due to its semi-translucency qualities.[6] Manufacturers suggest that zirconia ceramic restorations can be cemented successfully with either conventional or adhesive cements. Since both types of luting cements have different optical properties, their translucency values may also differ. When the zirconia ceramic material is more translucent, the resin cement under the material becomes more noticeable. The different colors of the luting cement will affect its TP. The effect of the luting cement on the final color of the restorations has not been fully researched as of this date.[13] Several studies have evaluated the masking ability of various luting cement materials used with full ceramic restorations. Still, there is not enough research on their influence on the final color, due to their translucency when used with zirconia ceramic.[1,3,7,9,12,14]

The TP is most commonly used to measure the translucency of dental materials and is calculated directly from the color difference of specimens when measured on a black and a white background.[15-20] The color of the background substrate influences the final color of the ceramic specimen because of its translucency.[12] A TP value of zero corresponds to a completely opaque material. An increasing TP value indicates an increasing translucency. As a result of the higher TP value, the material is more translucent (TR).[9-11,21]

Color difference and TP are measured with a spectrophotometer which provides light. That light penetrates into the material that is measured, travels through the material, and is reemitted or absorbed. Some of the photons that are reemitted follow pathways leading outside of the window area, and this results in a mathematical measurement that corresponds to a visual perception as color.[2,6,22-24]

The purpose of this study was to measure the TP of the resin cement that is used to lute the zirconia core onto the gray-colored metallic abutment using spectrophotometer. The first research hypothesis tested was that there are no differences in the TP values of different colored resin cements. The second hypothesis tested was that the addition of a zirconia core does not affect the TP values. The third hypothesis tested was that there are no differences in the final color of the restoration when a zirconia core was cemented with different colored resin cements on gray-colored titanium abutments.

Materials and Methods

The yttrium partially stabilized green-stage zirconium dioxide block (ICE Zirkon, Zirkonzahn GmbH, Gais BZ, Italy, Lot: ZB0061D) was sliced by a precise cutting machine (Mecatome T1800, Presi, Grenoble, France) using a diamond wafering blade (Isomet, Buehler Co., Lake Bluff, IL, USA) into rectangular plate slices 0.5 mm thick, and all slices were carefully measured using a digital caliper (500-784, Mitutoyo Co., Kawasaki, Japan) to ensure similar thicknesses.

Eleven zirconia (Zr) core plates (10 mm in width, 5 mm in length and 0.5 mm in thickness) were fabricated, and each sample was colored with A2 shades of coloring liquid (Color Liquid for ICE Zirkon, Zirkonzahn GmbH, Gais BZ, Italy, Lots: CB0382B, CB00025B, CA9257A, CB0242B, CB0254B) according to the Vita Classic Shade Guide: A2, (VitaZahnfabrik, H Rauter GmbH and Co., BadSackingen, Germany). Each sample was immersed in the coloring liquid using plastic tweezers, held for 3 s, as recommended by the manufacturer, and then, dried under a heating lamp (Zirkonlampe 250, Zirkonzahn GmbH, Gais BZ, Italy) for 30 min. After coloring, all samples were sintered at 1,500°C in a sintering furnace (Zirkonofen 600 V/2, Zirkonzahn GmbH, Gais BZ, Italy) following the protocol. The temperature was raised to 1,500°C for 3 h and maintained for 2 h before cooling.

Resin cement plates; (RelyX-U200 or RelyX-Ultimate; 3M-ESPE, St. Paul, MN, USA) 10 mm in width, 5 mm in length, and 0.4 mm ± 10 μm in thickness were prepared in A1, A2, or shades (n = 11). Silicone molds were used for the production of the resin cement plates to maintain the same plate size. After calibrating the desired thickness, the two resin cements were mixed according to the manufacturers' instructions, applied in the silicone molds, and covered with a Mylar matrix (no. 687, Hawe Neos, Bioggio, Switzerland). To obtain a homogeneous and standardized cement thickness, 500 gr pressure was applied on the samples for 2 min. Polymerization was done by light curing for 40 s (Optilux 501, Kerr Corporation, Orange, CA, USA). The thickness of the plates was checked using a digital micrometer (Mitutoyo Manufacturing Company Ltd., Kawasaki, Japan). The accuracy of the micrometer was ±10 μm. Each finished plate was measured 3 times, and the mean thickness was calculated and standardized.

The initial TP measurements were done individually on the zirconia core plates and the resin cement plates using a spectrophotometer (CM 2600d, Konica Minolta Inc., Tokyo, Japan). Then, the resin cement plates were placed under the zirconia core plates, and second

measurements were taken. Before the measurements, the airspace between the zirconia and resin cement plates was minimized by smoothing the interacting surfaces. Four resin cement plate groups made of two resin cements (RelyX-U200 or RelyX-Ultimate) were created, and each group consisted of two colors (RelyX-U200, Shades: A2, TR; RelyX-Ultimate, Shades: A1, TR).

Each resin cement plate was used as a background for the zirconia plates without additional adhesive during the TP measurements. These measurements were performed by positioning the flat surface of the spectrophotometer against the center of the flat zirconia surface of each cement plate's assembly. The final measurements were done after placing the titanium disks (5 mm in diameter, 3 mm in height) at the bottom of the plates to simulate implant abutments. This three-layered assembly mimics the final restorations.

The TP values were calculated directly from the color difference of specimens measured on a black background and a white background. All of the values were calculated as mean ± standard deviation. The data were analyzed with the analysis of variance and Tukey honestly significant differences test (α = 0. 05).

Results

In the first measurement, the highest TP values were recorded for A1-colored resin specimens and the lowest for the zirconia core plates ($P < 0.05$). There were no statistically significant differences between the two different TR-colored resin cements ($P > 0.05$) and the A1- and A2-colored resin cements ($P > 0.05$). However, the TP values of A1 colored specimens were higher than the TR ones ($P < 0.05$). The TP values of all groups tested are shown in Table 1.

The addition of the zirconia core decreased the TP values in all tested resin cement groups ($P < 0.05$). In the second measurements, the highest TP value was recorded for the A1-colored resin cement and the lowest for the A2 and Ultimate-TR with the zirconia core plates ($P < 0.05$). There were no statistically significant differences between the A1 and U200-TR colors in zirconia groups ($P > 0.05$); however, there were statistically significant differences between the A1and Ultimate-TR colors ($P < 0.05$).

The addition of titanium decreased the TP of the zirconia core plate and resin cement combinations ($P < 0.05$). There were no statistically significant differences in TP values among the different colored resin cements when titanium was added as the base material ($P > 0.05$).

Discussion

This study evaluated the effect of different colors of resin cements (self-adhesive and adhesive resin cement) and zirconium cores on the final color of the restoration that simulates the implant-supported fixed partial dentures using a titanium base. There were statistically significant differences in TP values among the different colored resin cements. On the basis of these data, the first research hypothesis that there are no differences in TP values of different colored resin cements was rejected. The addition of the zirconia core dramatically reduced the TP values, so the second hypothesis that the addition of a zirconia core does not affect the TP values was also rejected. The final TP value of the restoration was measured with the addition of a gray-colored titanium abutment in the third measurements. The addition of titanium decreased the TP of the zirconia core plate and resin cement combinations. Therefore, the third hypothesis that there are no differences in the final color of the restoration when the zirconia core was luted with different colored resin cements on gray-colored titanium abutments was accepted.

For a single crown, studies have shown that the metal or zirconia core must be at least 0.5 mm or 0.7 mm thick in areas of high stress.[4,24,25] In parallel with those studies, a 0.5 mm zirconia core thickness was used in the present study. The use of disc-shaped specimens allowed for better control of the thickness of the different layers. The flat surface obtained also allowed the spectrophotometer to measure more precisely and that resulted in more reliable color measurements.[4,26,27]

Zirconia has been reported to possess the highest mechanical properties among dental ceramics.[25,26,28] Although there is no consensus, it is accepted that the highly dense microstructure of zirconia commonly results in a rapid reduction in translucency. Baldissara *et al*.[14] recently compared the translucency of several zirconia cores and demonstrated that they all allowed light to pass through the material to some degree.[29] In

Table 1: The translucency parameters values of all groups tested

Study groups	U200-TR	U200-A2	Ultimate-TR	Ultimate-A1	Zirconia
Materials	$28.32+1.98^{a}$	$30.90+2.82^{a,b}$	$29.31+4.26^{a}$	$32.97+3.27^{b}$	$12.54+0.69^{c}$
Cement + zirconia	$6.48+0.98^{A,B}$	$6.21+0.38^{B}$	$6.21+0.44^{B}$	$7.02+0.76^{A}$	
Cement + zirconia + titanium	$0.12+0.05^{D}$	$0.48+0.39^{D}$	$0.30+0.20^{D}$	$0.52+0.77^{D}$	

Groups in the same row with the different letters show statistically significant differences ($P<0.05$)

the present study, the thickness of zirconia was 0.5 mm, and the TP value was 12.54. Because some light passes through the zirconia ceramic, it is more likely to give the restoration a natural appearance.

Optical effects of luting cements on the final restoration color were evaluated in many studies.[4,29,30] Several of those studies showed that this effect was not significant, but several others suggested that the type or color of the luting cement exerted a significant effect on the final color of the restorative materials.[4,12,31] Resin luting cements are used to improve mechanical properties by bonding the crown to the prepared tooth and modifying the final restoration color and masking the underlying color.[4,13,32] In the current study, different colored resin cements affected the TP values when they were combined with the zirconia core; however, they were not effective when used together with a titanium-based material. The different colored resin cements used were not effective in masking the underlying titanium color. The presence of the titanium layer decreased the TP value, meaning that the titanium caused a darker appearance. This result is in accordance with the previous studies that showed the reflection of incident light by a dark metallic structure.[33-35]

In addition, it has been reported that chromatic luting cements have the ability to mask the underlying tooth color.[36] However, to date, there are no published standards for resin cement shade classification.[11] In fact, it has been reported that resin cement systems of the same shade exhibit different color parameters.[37] Chang *et al*.[32] studied the optical effect of composite resins on ceramic crowns and noted that there are no industrial standards for resin shade classification. The results of the present study show that cements of the same shade in different systems exhibit different color parameters. In terms of opacity or translucency, in the CIELAB system, the white opaque and TR shades do not match. Similarly, A1 and A2 shades had different L*, a*, and b* values in each system. Such lack of consistency in shade classification can create problems in color matching. The authors advise clinicians to harmonize the opacity and color of cements to create an optimum esthetic outcome. By mixing cements, a clinician may be able to adjust the color of the restoration.[32] The most important factor is to know the coloration results of ceramic-resin combinations.[37]

A previous study showed that the size and number of particles can also influence the values of Delta E, Delta L*, Delta a* and Delta b* as well as the translucency of composite resins.[38] Joiner[39] pointed out the importance of optical properties such as translucency and opacity since they are indicative of the quality and quantity of the reflected light. A light reflection difference could result in a statistically significant difference in translucency.[2] The results of the current study showed no statistically significant differences in the TP values of two different TR resin cements. In addition, there were also no significant differences in the A1- and A2-colored resin cements. This could be the result of them having almost the same amount of filler contents.

Resin cement thickness has a significant effect on TP values. In the current study, to compare the effect of zirconia core material on TP values, the thickness of resin cement used was 0.4 mm which is thicker than that used in clinical conditions. However, the present study has several limitations, making it difficult to compare results directly with clinical studies. First, veneering material was not applied and not tested in the study. Second, only one core thickness (0.5 mm) of zirconia was tested. Third, the resin cement thickness was 0.4 mm, which is much thicker than the cement layer typically used in clinical applications. Future investigations should be performed with different core and veneering porcelain thicknesses for greater clinical relevance.

Conclusions

Within the limitations of the study, the following conclusions were drawn:

1. Different colored resin cements showed different TP values in the same thickness
2. The addition of a zirconia core under the resin cement dramatically reduced the TP values
3. The presence of a titanium layer decreased the TP value and caused a darker appearance. The TP values of different colored resin cements are not significant factors in determining the final shade of zirconia cores in implant-supported fixed prosthesis.

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Conflicts of interest

There are no conflicts of interest.

References

1. Pecho OE, Ghinea R, Ionescu AM, Cardona Jde L, Paravina RD, Pérez Mdel M. Color and translucency of zirconia ceramics, human dentine and bovine dentine. J Dent 2012;40 Suppl 2:e34-40.
2. Spyropoulou PE, Giroux EC, Razzoog ME, Duff RE. Translucency of shaded zirconia core material. J Prosthet Dent 2011;105:304-7.
3. Tuncel I, Eroglu E, Sari T, Usumez A. The effect of coloring liquids on the translucency of zirconia framework. J Adv Prosthodont 2013;5:448-51.
4. Capa N, Tuncel I, Tak O, Usumez A. The effect of luting cement and titanium base on the final color of zirconium oxide core

material. J Prosthodont 2017;26:136-40.
5. Cekic-Nagas I, Egilmez F, Ergun G, Kaya BM. Light transmittance of zirconia as a function of thickness and microhardness of resin cements under different thicknesses of zirconia. Med Oral Patol Oral Cir Bucal 2013;18:e212-8.
6. Vichi A, Louca C, Corciolani G, Ferrari M. Color related to ceramic and zirconia restorations: A review. Dent Mater 2011;27:97-108.
7. Choi YJ, Razzoog ME. Masking ability of zirconia with and without veneering porcelain. J Prosthodont 2013;22:98-104.
8. Farhan D, Sukumar S, von Stein-Lausnitz A, Aarabi G, Alawneh A, Reissmann DR, *et al.* Masking ability of bi- and tri- laminate all-ceramic veneers on tooth-colored ceramic discs. J Esthet Restor Dent 2014;26:232-9.
9. Kursoglu P, Karagoz Motro PF, Kazazoglu E. Translucency of ceramic material in different core-veneer combinations. J Prosthet Dent 2015;113:48-53.
10. Powers JM. Restorative Dental Materials. 12th ed. St. Louis: Mosby; 2006. p. 35-42.
11. Pérez MM, Ghinea R, Ugarte-Alván LI, Pulgar R, Paravina RD. Color and translucency in silorane-based resin composite compared to universal and nanofilled composites. J Dent 2010;38 Suppl 2:e110-6.
12. Vichi A, Ferrari M, Davidson CL. Influence of ceramic and cement thickness on the masking of various types of opaque posts. J Prosthet Dent 2000;83:412-7.
13. Dede DÖ, Armaganci A, Ceylan G, Cankaya S, Celik E. Influence of abutment material and luting cements color on the final color of all ceramics. Acta Odontol Scand 2013;71:1570-8.
14. Baldissara P, Llukacej A, Ciocca L, Valandro FL, Scotti R. Translucency of zirconia copings made with different CAD/CAM systems. J Prosthet Dent 2010;104:6-12.
15. Johnston WM, Ma T, Kienle BH. Translucency parameter of colorants for maxillofacial prostheses. Int J Prosthodont 1995;8:79-86.
16. Johnston WM, Reisbick MH. Color and translucency changes during and after curing of esthetic restorative materials. Dent Mater 1997;13:89-97.
17. Heffernan MJ, Aquilino SA, Diaz-Arnold AM, Haselton DR, Stanford CM, Vargas MA. Relative translucency of six all-ceramic systems. Part I: Core materials. J Prosthet Dent 2002;88:4-9.
18. Bagis B, Turgut S. Optical properties of current ceramics systems for laminate veneers. J Dent 2013;41 Suppl 3:e24-30.
19. Wang F, Takahashi H, Iwasaki N. Translucency of dental ceramics with different thicknesses. J Prosthet Dent 2013;110:14-20.
20. Ahn JS, Lee YK. Difference in the translucency of all-ceramics by the illuminant. Dent Mater 2008;24:1539-44.
21. Raptis NV, Michalakis KX, Hirayama H. Optical behavior of current ceramic systems. Int J Periodontics Restorative Dent 2006;26:31-41.
22. Da Silva JD, Park SE, Weber HP, Ishikawa-Nagai S. Clinical performance of a newly developed spectrophotometric system on tooth color reproduction. J Prosthet Dent 2008;99:361-8.
23. Bolt RA, Bosch JJ, Coops JC. Influence of window size in small-window colour measurement, particularly of teeth. Phys Med Biol 1994;39:1133-42.
24. Vichi A1, Fazi G, Carrabba M, Corciolani G, Louca C, Ferrari M. Spectrophotometric evaluation of color match of three different porcelain systems for all-ceramic zirconia-based restorations. Am J Dent 2012;25:191-4.
25. McLaren EA, White SN. Glass-infiltrated zirconia/alumina-based ceramic for crowns and fixed partial dentures. Pract Periodontics Aesthet Dent 1999;11:985-94.
26. Seghi RR, Johnston WM, O'Brien WJ. Performance assessment of colorimetric devices on dental porcelains. J Dent Res 1989;68:1755-9.
27. Wee AG, Kang EY, Johnston WM, Seghi RR. Evaluating porcelain color match of different porcelain shade-matching systems. J Esthet Dent 2000;12:271-80.
28. Niu E, Agustin M, Douglas RD. Color match of machinable lithium disilicate ceramics: Effects of cement color and thickness. J Prosthet Dent 2014;111:42-50.
29. Aboushelib MN, Dozic A, Liem JK. Influence of framework color and layering technique on the final color of zirconia veneered restorations. Quintessence Int 2010;41:e84-9.
30. Ilie N, Stawarczyk B. Quantification of the amount of blue light passing through monolithic zirconia with respect to thickness and polymerization conditions. J Prosthet Dent 2015;113:114-21.
31. Azer SS, Ayash GM, Johnston WM, Khalil MF, Rosenstiel SF. Effect of esthetic core shades on the final color of IPS empress all-ceramic crowns. J Prosthet Dent 2006;96:397-401.
32. Chang J, Da Silva JD, Sakai M, Kristiansen J, Ishikawa-Nagai S. The optical effect of composite luting cement on all ceramic crowns. J Dent 2009;37:937-43.
33. Uzun G, Keyf F. Effect of different cement colors on the final color of IPS empress ceramic restoration. Biotechnol Biotechnol Equip 2007;21:4-10.
34. Nakamura T, Saito O, Mizuno M, Kinuta S, Ishigaki S. Influence of abutment substrates on the colour of metal-free polymer crowns. J Oral Rehabil 2003;30:184-8.
35. Jalali H, Alizadeh ES, Sadighpour L, Shabestari GO, Fard MJ. The effect of background and ceramic thickness on the color of an all-ceramic restorative system. J Calif Dent Assoc 2010;38:179-86.
36. de Azevedo Cubas GB, Camacho GB, Demarco FF, Pereira-Cenci T. The effect of luting agents and ceramic thickness on the color variation of different ceramics against a chromatic background. Eur J Dent 2011;5:245-52.
37. Turgut S, Bagis B. Effect of resin cement and ceramic thickness on final color of laminate veneers: An *in vitro* study. J Prosthet Dent 2013;109:179-86.
38. Lee YK. Influence of filler on the difference between the transmitted and reflected colors of experimental resin composites. Dent Mater 2008;24:1243-7.
39. Joiner A. Tooth colour: A review of the literature. J Dent 2004;32 Suppl 1:3-12.