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Review Article

Effect of Ceramic Thickness and Cement Color on Final Shade of All Ceramic Restorations: A Systematic Review

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Abstract: One important aspect of dental restorations is esthetic. Although ceramic restorations are usually undertaken for esthetic reasons, several factors can affect their results. This study was undertaken to systematically review articles addressing the effect of ceramic thickness and luting cement color on the final restoration color. This systematic review was based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines. The study question was determined according to PICO (population, intervention, comparison and outcome). The issue under study was the effect of ceramic thickness and cement shade on the final color of ceramic crowns or veneers. A literature search was done in the PubMed and Medline databases using relevant keywords for the period from 2006 to 2016 and was limited to articles in the English language. The articles were selected based on inclusion and exclusion criteria and were evaluated qualitatively. The internet search resulted in 109 articles. Following application of inclusion and exclusion criteria, 17 studies were included in the systematic review. IPS Empress was the most assessed ceramic. It was found that the effect of ceramic thickness and cement shade on restoration color differed among studies because of the use of different ceramics and cements. This review showed that the thickness of the ceramic and the cement shade can affect the optical properties and color of all-ceramic restorations. Several factors influence the effect of the ceramic thickness and cement shade on restoration color.

Keywords: All-ceramic restoration, Color, Porcelain veneer, Luting cement.

INTRODUCTION

The goal of esthetic dentistry is to restore natural tooth form, biocompatibility and appearance. Patient satisfaction is primarily dependent on the color, surface properties, contour and translucency of the prosthetic tooth [1] The use of esthetic and tooth-colored restoration has increased in recent years [2]. Studies show that metal ceramic restorations have a survival rate of 94% over 10 years [3]; however, they are usually not able to distribute the reflected light properly, which reduces the esthetic of the work [4]. All-ceramic restorations were introduced to meet esthetic requirements. They are an esthetic and biocompatible alternative for metal-based restorations [3]. Studies have shown that ceramic systems can better match the shade [5] and that their marginal accuracy is similar to that of metal-based restorations [6]. An important aspect of dental treatment during restorative procedures is consideration of the esthetic quality of the work. Color science is a crucial means to achieving this aim; therefore, color is an important aspect of current dentistry [7]. Spectrophotometers, spectroradiometers and colorimeters are used for shade selection which was previously performed in a subjective manner [8, 9]. The colorimeter can report color in the form of standard CIELAB parameters quantitatively.

The CIELAB (Commission International de l'Eclairage) system was introduced in 1978 and is commonly used in dental research. The L* parameter represents lightness (0-100). The a* and b* parameters represent greenness-redness and blueness-yellowness, respectively, and can be measured quantitatively. The color difference (ΔE) between two objects or in one object before and after an experimental process can be used to determine change in color [10]. ΔE values have been investigated in several studies. Some showed that $\Delta E < 2.7$ is not detectable by the human eye and $\Delta E <$

5.5 is acceptable in clinical practice [11, 12]. Others described a ΔE of less than 1 unit as undetectable and suggested ΔE = 3.7 as the perception threshold of color mismatch in the oral cavity [13, 14].

The final color of all-ceramic restorations is influenced by different factors. It has been demonstrated that porcelain layering technique [15], dental ceramic type and primary shade [16], ceramic brand [13], thickness of veneering ceramic [11], and firing temperature and conditions [17] all affect the final appearance of a restoration. Moreover, clinical parameters including type [18], color [19], and thickness [20] of cement can also influence the final result. Because it is necessary to determine the factors affecting the color of ceramic restorations in order to predict the treatment result, the present study was undertaken to systematically review articles on the effect of ceramic thickness and luting cement shade on final restoration color.

MATERIALS AND METHODS

Study design

In this systematic review, *in vitro* studies that assessed the effect of ceramic or veneering thickness on the color of ceramic restorations were investigated. The studies were selected based on inclusion and exclusion criteria as shown in Table 1.

Table 1: Inclusion and exclusion criteria of articles

Inclusion criteria
1. *In vitro* study 2. Evaluation of color of ceramic crown 3. Quantitative evaluation of color 4. Study included test and control groups 5. Study with test group used a ceramic layer of different thicknesses 6. Evaluation of color of control group without presence of ceramic veneer 7. English language article
Exclusion criteria
1. Study without control group 2. Systematic review study 3. Case report 4. Evaluation of results based on questionnaires 5. Human or animal studies

This systematic review was based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) 2010 guidelines. The PICO strategy (population, intervention, comparison, and outcome) was used to determine the question under study. The primary issue addressed in the present study was the effect of ceramic thickness and cement shade on the final color of ceramic crowns and veneers after restoration.

Search strategy

An electronic literature search was undertaken through MEDLINE (National Library of Medicine) via PubMed to identify relevant articles. The search was limited to the English language and to articles published from 2006 to 2016. The medical keywords used as search terms based on PICO are listed in Table 2.

Table 2: Keywords used as search terms based on PICO

Population
Crown OR dental crown OR tooth crown OR jacket crown OR full jacket crown OR all-ceramic OR dental prosthesis OR single crown OR single unit OR fixed prosthesis OR fixed restoration OR fixed prosthodontics OR fixed dental prosthesis OR FDP OR tooth reconstruction
Intervention
Thickness OR layer OR dentin porcelain OR cement OR liner OR adhesive
Comparison
- Not indicated -
Outcome
Color OR shade OR translucency OR CIE OR spectrophotometer OR colorimeter

Screening and selection

After an electronic article search, the studies were evaluated according to title and abstract. The full text of the selected articles was then assessed more precisely and evaluated based on inclusion and exclusion criteria. Articles meeting the inclusion and exclusion criteria were selected. All stages of article selection were performed by two investigators and disagreements were discussed with a third author.

Data extraction

After the final selection of articles, the sample size, ceramic type, ceramic thickness, cement color and the results were extracted. Data extraction was performed by two investigators individually and disagreements were discussed with a third author. The information obtained was then compared qualitatively.

RESULTS

The primary literature search found 109 articles as shown in Figure 1. After examination of the title and the abstract, 58 studies were selected and their full text was provided. Next, studies that did not assess the thicknesses of the ceramic or the different combinations of core and veneer thickness were excluded. A total of 17 studies were finally included in the present systematic review.

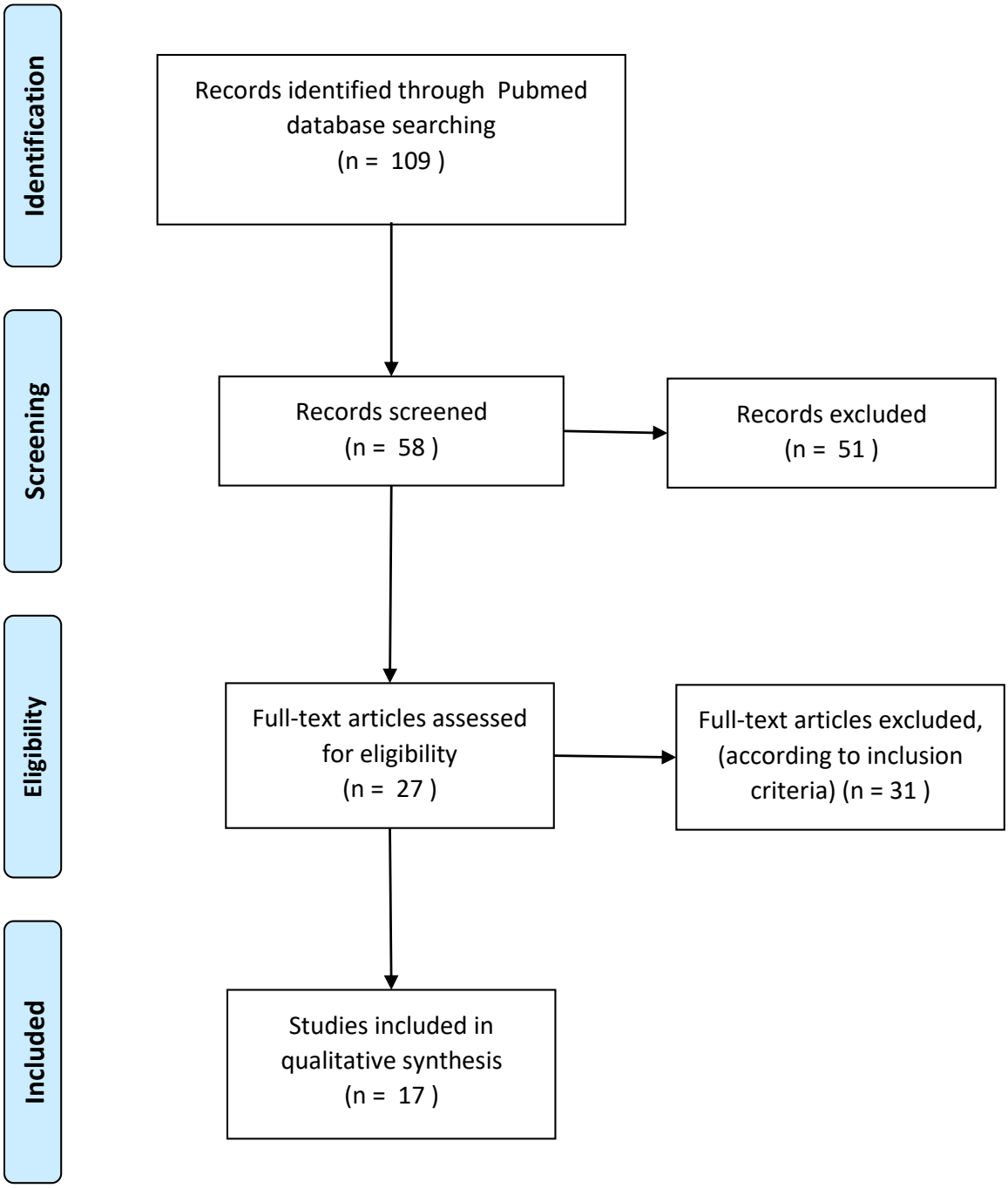

Fig 1: Flowchart of study selection.

The effect of veneering thickness and cement color on the color of ceramic restorations were investigated in ten studies [16, 18, 19, 21-27]. The results of these studies are summarized in Table 3. The most common ceramic type used was IPS Empress made using the pressing technique. Different ceramic thicknesses (0.3 to 2.5 mm) were also investigated. The cement color used in the studies was different.

Table 3: Summary of studies evaluating effect of ceramic thickness and cement color on restoration color and translucency

Authors	Year	Specimens	Ceramic type	Ceramic thicknesses	Cement color	Results
Alqahtani *et al.;* [19]	2012	10 specimens for each ceramic	IPS Empress Esthetic, IPS e.max Press , IPS e.max Zir Press	0.5 , 0.7 mm	Opaque, A1, translucent, B0.5	ΔE value decreased significantly with increase in thickness of all ceramics. Opaque cement increased ΔE value significantly, followed by A1. Translucent and B0.5 cements showed no significant effect.
De Azevedo Cubas *et al.;* [21]	2011	15 specimens for each ceramic	Vitadur-Alpha; Noritake Super Porcelain EX-3; Vision-Esthetic; IPS Classic; All Ceram; Vintage Halo	1 , 1.5 , 2 mm	A3, A4	ΔE value decreased significantly with increase in thickness of all ceramics. Opaque cement had significantly higher ΔE value for all thicknesses.
Begum *et al.;*[22]	2014	15 specimens for each ceramic	IPS e.max and Cergo	0.5 , 1, 1.5 mm	Opaque, translucent	ΔE value increased significantly with increase of thickness of emax ceramic. Opaque cement resulted in significantly higher ΔE value.
Calgaro et al.(23)	2014	40 specimens in total	IPS Classic	0.5 , 0.7, 1 mm	A1, opaque, transparent, bleach	ΔE value decreased significantly with increase of thickness of all ceramics. Opaque cement had the lowest ΔE value, followed by bleach, transparent and A1.
Chaiyabutr *et al.;* [24]	2011	5 specimens for each thickness	IPS e.max	1 , 1.5, 2, 2.5 mm	Opaque, translucent	ΔE value decreased significantly with increase of thickness of all ceramics. No significant difference in ΔE values was found in opaque and translucent cement.
Kürklü *et al.;* [25]	2013	36 specimens in total	Feldspathic porcelain	0.5 , 1 mm	Chroma, clear, opaque	There was no significant difference in ΔE values with an increase in thickness. However, Opaque cement had significantly higher ΔE value for thickness of 0.5 mm.
Omar *et al.;* [26]	2010	60 specimens in total	Vitablokcs Mark	0.3, 0.5 , 0.7 mm	Light	ΔE value decreased as thickness increased from 0.3 to 0.5 mm. No significant differences were found with an increase in thickness from 0.5 to 0.7 mm.
Pires *et al.*;[16]	2016	40 specimens in total	IPS e.max	1.5 , 2 mm	With or without translucent cement	Thinner specimen with cement and the thicker one without cement had the highest and the lowest ΔE values, respectively.
Turgut and Bagis [18]	2013	392 specimens in total	IPS Empress Esthetic	0.5 , 1 mm	13 shades of cement	ΔE value decreased as ceramic thickness increased. There were differences between the various cement shades.
Turgut *et al.;* [27]	2014	224 specimens in total	IPS Empress	0.5 , 1 mm	Opaque, translucent, A1, B0.5	Increase in thickness increased L* and decreased a* and b*. Opaque cement had higher ΔE value and the translucent one had a lower ΔE value.

Seven studies evaluated the effect of veneering thickness on the color of ceramic restorations [28-34]. The results of these studies are shown in Table 4. The most common ceramic type used was IPS Empress. The thicknesses of the ceramic was 0.2 to 2 mm.

Table 4: Summary of studies evaluating effect of ceramic thickness on restoration color

Authors	Year	Specimens	Ceramic type	Ceramic thicknesses	Results
Ghulman and Awad [28]	2013	90 specimens in total	Duceram LFC, In-Ceram SPINELL, IPS Empress	0.8, 1.2, 1.5 mm	ΔE value decreased significantly with increase in thickness of all ceramics. Duceram LFC had the lowest ΔE value at thickness of 0.8 mm. No significant differences were found among ceramics.
Oh and Kim [29]	2015	60 specimens in total	IPS e.max Press	1 , 1.5 mm	An increase in thickness decreased L* and increased a* and b*.
Ozturk *et al.;* [30]	2008	40 specimens in total	IPS e.max Press, DC-Zirkon	0.5 , 1 , 1.5 mm dentine ceramic thickness	An increase in thickness decreased L* and increased a* and b* in both ceramic types.
Shokry e *et al.;* [31]	2006	16 specimens in total	IPS Empress and In-Ceram Spinell	0.2 to 1.5 mm veneering thickness	ΔE, a* and b* increased and L* decreased as total thickness increased. Regarding veneering thickness, for IPS Empress ceramic and In-Ceram Spinell, L* and a* changes were not significant, respectively.
Sinmazisk *et al.;* [32]	2014	90 specimens in total	Zirconia	0.3 , 0.4 , 0.5 mm dentine porcelain	An increase in dentine porcelain decreased L*, a* and b*.
Son *et al.;* [33]	2010	5 specimens in each group	IPS e.max and Lava	0.25 to 2 mm	An increase in dentine porcelain increased a* and b*.
Uludag *et al.;* [34]	2007	21 specimens in total	In-Ceram and IPS Empress	0.5 , 1 , 1.5 mm	An increase in thickness in In-Ceram decreased L* and increased a* and b*. An increase in thickness of IPS Empress decreased L* and a*.

DISCUSSION

Patients demand a beautiful smile as well as healthy dentition [35]. The tooth color is influenced by enamel morphology and thickness, the presence of pigments and the amount of exposed dentine. Pigments have different etiologies and can be internal or external. External pigments can derive from food deposition and cigarettes. Internal pigments can result from alterations in hard tissue by fluorosis or tetracycline consumption. Moreover, the pulp chamber decreases with an increase in age, and formation of secondary and tertiary dentine can cause changes in tooth color. Also, enamel thickness decreases because of wear, and tooth color tends to shift toward yellow [35].

Different methods are used to treat tooth color change, including bleaching and veneering [36]. Although bleaching is considered to be a safe method, it may result in tooth hypersensitivity and the results are not predictable [35]. Composite veneer can mask color change in the teeth [37]; however, these restorations have decreased longevity because they are more susceptible to color change, wear and marginal failure [38]. Porcelain veneer has become popular because it offers suitable color properties and translucency and also it is a conservative treatment. The survival rate of 96% of such restorations has been reported to be more than 20 years [39]. In general, ceramic veneer can cover the color and the form of tooth and provide an attractive smile [40].

In all-ceramic restorations with a high-strength core, veneering thickness can affect the ability to mask the underlying structures [31]. Also, in clinical situations, factors such as cement shade can affect the final color of the restoration [41]. The present study was undertaken to systematically review articles investigating the effect of ceramic thickness and luting cement shade on final restoration color. This was the first review of *in vitro* studies in this area. With regard to several variables between the studies including method, type and commercial brand of ceramic, method of color evaluation and background color, it was not possible to compare the results of studies directly; thus, data were analyzed descriptively. In studies that reported the results of color difference (ΔE), seven showed that ΔE decreased as veneering thickness increased [16, 18, 19, 21, 23, 24, 28]. Two studies reported that ΔE increased as the ceramic thickness increased [22, 31]. Kurklu *et al.;* [25] found no significant difference between two thicknesses (0.5 and 1 mm) of feldespathic porcelain. Omar *et al.;* [26] reported that ΔE decreased as the thickness increased from 0.3 to 0.5 mm; however, no significant differences were found from 0.5 to 0.7 mm.

Four studies on the effect of thickness on color parameters reported that L* decreased as the thickness increased [29, 30, 32, 34]. Turgut *et al.;* [27] studied IPS Empress ceramic and reported that L* increased as

the thickness increased. In two studies, an increase in ceramic thickness was accompanied by a decrease in the a* and b* parameters [27, 32] and three studies reported that an increase in ceramic thickness increased a* and b* [29, 30, 33]. Uludag *et al.;* [34] found that an increase in thickness increased a* and b* for In-Ceram, while a* decreased without a significant change in b* for IPS Empress.

One reason for the difference in reported results is the type of ceramic investigated. It was demonstrated that different ceramics show different color properties at different thicknesses [28, 34]. The method of the study, including the type of specimen and means of evaluating color change were different in different studies, which could affect the results. Four studies reported that ΔE was higher for opaque cement than translucent cement [19, 21, 22, 27]. Calgaro *et al.;* [23] found a decrease in ΔE after using opaque cement with classic IPS ceramic. Another study reported no difference between the opaque and translucent cement [24]. Kurklu *et al.;* [25] reported an increase in ΔE with feldespathic porcelain 0.5 mm in thickness using opaque cement; however, no significant difference was found between the opaque and translucent cements in greater thicknesses. It appears that translucent cement does not affect restoration color significantly [19] The difference in results reported in studies assessing the effect of cement shade on final restoration color could result from other factors. It has been shown that cement thickness [20], cement type [18, 26], and manipulation can affect the results [42]. One limitation of the present study was that it only reviewed *in vitro* studies. Restoration color can be affected by clinical applications that have not been considered in these studies. The color properties of the restoration can also be influenced by the presence of saliva. Nevertheless, *In vitro* studies allow investigators to control all variables and evaluate which is most desirable; moreover, it is ideal for evaluating the effect of thickness on restoration color.

CONCLUSION

Within the limitations of the present study, the literature review showed that several factors can affect the final color of a restoration. It was found that optical features and the color of the final restoration were influenced by ceramic thickness and cement color. Further investigation should consider variables such as ceramic type, fabrication method, color of underlying surface, background color and the type, manipulation and thickness of cement to determine the effect of ceramic thickness and cement color. The verification of results obtained from *in vitro* studies and the color stability of the ceramic should be investigated in clinical trials.

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REFERENCES

1. Cal E, Güneri P, Kose T. Comparison of digital and spectrophotometric measurements of colour shade guides. Journal of oral rehabilitation. 2006 Mar 1; 33(3):221-8.
2. Stavridakis MM, Krejci I, Magne P. Immediate dentin sealing of onlay preparations: thickness of pre-cured dentin bonding agent and effect of surface cleaning. Operative Dentistry-University Of Washington-. 2005 Nov 1; 30(6):747.
3. Griggs JA. Recent advances in materials for all-ceramic restorations. Dental Clinics of North America. 2007 Jul 31; 51(3):713-27.
4. Fradeani M, Redemagni M. An 11-year clinical evaluation of leucite-reinforced glass-ceramic crowns: a retrospective study. Quintessence international. 2002 Jul 1; 33(7).
5. Mizrahi B. The anterior all-ceramic crown: a rationale for the choice of ceramic and cement. British dental journal. 2008 Sep 13; 205(5):251-5.
6. Yeo IS, Yang JH, Lee JB. In vitro marginal fit of three all-ceramic crown systems. The Journal of prosthetic dentistry. 2003 Nov 30; 90(5):459-64.
7. Derbabian K, Marzola R, Donovan TE, Arcidiacono A. The science of communicating the art of esthetic dentistry. Part III: precise shade communication. Journal of Esthetic and Restorative Dentistry. 2001 May 1; 13(3):154-62.
8. Rosenstiel L, Land MF. Fujimoto. Contemporary fixed prosthodontics. 2006; 4.
9. Van der Burgt TP, Ten Bosch JJ, Borsboom PC, Kortsmit WJ. A comparison of new and conventional methods for quantification of tooth color. The Journal of prosthetic dentistry. 1990 Feb 1; 63(2):155-62.
10. Berns RS. Billmeyer and Saltzman's principles of color technology. New York: Wiley; 2000 Mar.
11. Douglas RD, Przybylska M. Predicting porcelain thickness required for dental shade matches. The Journal of prosthetic dentistry. 1999 Aug 31; 82(2):143-9.
12. Stavridakis MM, Dent M, Papazoglou E, Seghi RR, Johnston WM, Brantley WA. Effect of different high-palladium metal-ceramic alloys on the color of opaque and dentin porcelain. The Journal of prosthetic dentistry. 2004 Aug 31; 92(2):170-8.
13. Seghi RR, Johnston WM, O'brien WJ. Spectrophotometric analysis of color differences between porcelain systems. The Journal of prosthetic dentistry. 1986 Jul 1; 56(1):35-40.
14. Mulla FA, Weiner S. Effects of temperature on color stability of porcelain stains. The Journal of prosthetic dentistry. 1991 Apr 1; 65(4):507-12.
15. Grah CL, O'Brien WJ, Boenke KM. Differences in color between fired porcelain and shade guides.

International Journal of Prosthodontics. 1992 Nov 1; 5(6).
16. Pires LA, Novais PM, Araújo VD, Pegoraro LF. Effects of the type and thickness of ceramic, substrate, and cement on the optical color of a lithium disilicate ceramic. The Journal of Prosthetic Dentistry. 2017 Jan 31; 117(1):144-9.
17. Stavridakis MM, Dent M, Papazoglou E, Seghi RR, Johnston WM, Brantley WA. Effect of different high-palladium metal-ceramic alloys on the color of opaque and dentin porcelain. The Journal of prosthetic dentistry. 2004 Aug 31; 92(2):170-8.
18. Turgut S, Bagis B. Effect of resin cement and ceramic thickness on final color of laminate veneers: an in vitro study. The Journal of prosthetic dentistry. 2013 Mar 31; 109(3):179-86.
19. Alqahtani MQ, Aljurais RM, Alshaafi MM. The effects of different shades of resin luting cement on the color of ceramic veneers. Dental materials journal. 2012; 31(3):354-61.
20. Niu E, Agustin M, Douglas RD. Color match of machinable lithium disilicate ceramics: Effects of cement color and thickness. The Journal of prosthetic dentistry. 2014 Jan 31; 111(1):42-50.
21. 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. European journal of dentistry. 2011 Jul; 5(3):245.
22. Begum Z, Chheda P, Shruthi CS, Sonika R. Effect of Ceramic Thickness and Luting Agent Shade on the Color Masking Ability of Laminate Veneers. The Journal of Indian Prosthodontic Society. 2014 Dec 1; 14(1):46-50.
23. Calgaro PA, Furuse AY, Correr GM, Ornaghi BP, Gonzaga CC. Post-cementation colorimetric evaluation of the interaction between the thickness of ceramic veneers and the shade of resin cement. Am J Dent. 2014 Aug; 27:191-4.
24. Chaiyabutr Y, Kois JC, LeBeau D, Nunokawa G. Effect of abutment tooth color, cement color, and ceramic thickness on the resulting optical color of a CAD/CAM glass-ceramic lithium disilicate-reinforced crown. The Journal of prosthetic dentistry. 2011 Feb 28; 105(2):83-90.
25. Kürklü D, Azer SS, Yilmaz B, Johnston WM. Porcelain thickness and cement shade effects on the colour and translucency of porcelain veneering materials. Journal of dentistry. 2013 Nov 30; 41(11):1043-50.
26. Omar H, Atta O, El-Mowafy O, Khan SA. Effect of CAD–CAM porcelain veneers thickness on their cemented color. Journal of dentistry. 2010 Dec 31; 38:e95-9.
27. Turgut S, Bagis B, Ayaz EA. Achieving the desired colour in discoloured teeth, using leucite-based cad-cam laminate Systems. Journal of dentistry. 2014 Jan 31; 42(1):68-74.
28. Ghulman MA, Awad MA. Color variation between matched and fabricated shades of different ceramics. Journal of Prosthodontics. 2013 Aug 1; 22(6):472-7.
29. Oh SH, Kim SG. Effect of abutment shade, ceramic thickness, and coping type on the final shade of zirconia all-ceramic restorations: in vitro study of color masking ability. The journal of advanced prosthodontics. 2015 Oct 1;7(5):368-74.
30. Ozturk O, Uludag B, Usumez A, Sahin V, Celik G. The effect of ceramic thickness and number of firings on the color of two all-ceramic systems. The journal of prosthetic dentistry. 2008 Aug 31; 100(2):99-106.
31. Shokry TE, Shen C, Elhosary MM, Elkhodary AM. Effect of core and veneer thicknesses on the color parameters of two all-ceramic systems. The Journal of prosthetic dentistry. 2006 Feb 28; 95(2):124-9.
32. Sinmazisik G, Demirbas B, Tarcin B. Influence of dentin and core porcelain thickness on the color of fully sintered zirconia ceramic restorations. The Journal of prosthetic dentistry. 2014 Feb 28; 111(2):142-9.
33. Son HJ, Kim WC, Jun SH, Kim YS, Ju SW, Ahn JS. Influence of dentin porcelain thickness on layered all-ceramic restoration color. Journal of dentistry. 2010 Dec 31; 38:e71-7.
34. Uludag B, Usumez A, Sahin V, Eser K, Ercoban E. The effect of ceramic thickness and number of firings on the color of ceramic systems: an in vitro study. The Journal of prosthetic dentistry. 2007 Jan 31; 97(1):25-31.
35. Jarad FD, Griffiths CE, Jaffri M, Adeyemi AA, Youngson CC. The effect of bleaching, varying the shade or thickness of composite veneers on final colour: an in vitro study. Journal of dentistry. 2008 Jul 31; 36(7):554-9.
36. Griffiths CE, Bailey JR, Jarad FD, Youngson CC. An investigation into most effective method of treating stained teeth: an in vitro study. journal of dentistry. 2008 Jan 31; 36(1):54-62.
37. Peumans M, Van Meerbeek B, Lambrechts P, Vanherle G. Porcelain veneers: a review of the literature. Journal of dentistry. 2000 Mar 31; 28(3):163-77.
38. Peumans M, Van Meerbeek B, Lambrechts P, Vanherle G. The 5-year clinical performance of direct composite additions to correct tooth form and position. Clinical oral investigations. 1997 Mar 1; 1(1):12-8.
39. Layton DM, Walton TR. The up to 21-year clinical outcome and survival of feldspathic porcelain veneers: accounting for clustering. International Journal of Prosthodontics. 2012 Nov 1; 25(6).
40. ALGhazali N, Laukner J, Burnside G, Jarad FD, Smith PW, Preston AJ. An investigation into the effect of try-in pastes, uncured and cured resin cements on the overall color of ceramic veneer

restorations: an in vitro study. Journal of dentistry. 2010 Dec 31; 38:e78-86.

41. Vichi A, Ferrari M, Davidson CL. Influence of ceramic and cement thickness on the masking of various types of opaque posts. The Journal of prosthetic dentistry. 2000 Apr 30; 83(4):412-7.Mizrahi B. The anterior all-ceramic crown: a rationale for the choice of ceramic and cement. British dental journal. 2008 Sep 13; 205(5):251-5.