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REVIEW ARTICLE

Colour Constancy of Dental Porcelain after Exposure to Universally Consumed Beverages: A Methodical Review of Literature

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ABSTRACT:
For dental porcelain, precise shade matching of tooth coloured restoration with the adjacent dentition is deemed necessary. However the colour instability in porcelain restoration is a common problem now a day's particularly when they exposed to routinely consumable beverages which sever its nature of being tooth coloured. Therefore in this concern the authors has tried to emphasize the historical outlooks, researches on colour stability and difficulties and current trends for colour stability in tooth coloured restorative materials predominantly dental porcelains. A meticulous literature search was executed using MEDLINE/PubMed and other scholarly research bibliographic databases using Medical Subject Headings (MeSH) from 1950 to 2017. Study results showed that there is no ceramic existing which could be classified as total stain free.

Key words: Color constancy, Porcelains, Spectrophotometer.

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INTRODUCTION

Of all the esthetic restorative materials known to mankind ceramics have proven themselves to be the most natural in appearance, texture, color, reflectance and translucency so much so that distinguishing them from the natural teeth at times may be impossible. They also offer the benefit of proven biocompatibility and reduced propensity for retaining the bacterial plaque, they does not absorb water or conduct heat and have proven very acceptable to oral tissues. Porcelain has been established as an ultimate anterior esthetic restorative material because of its natural appearance, good wear resistance and color stability. Porcelain has color rendering and optical properties that simulate natural teeth.[1]

Now days, spectrophotometer has been comprehensively used to measure the quantity of color change in dental materials. While defining "A spectrophotometer is scientific standardized colorimetric equipment for matching and measuring color that gives information about reflectance curve as a function of wavelength in entire range".[2] For checking its discoloration prospective of porcelain, it is important to think the type of diet which is consumed by the particular populace. The normally consumed dietary food includes the soft drinks, beverages and the fruit juices.[3] However, the literature shows largely studies concern with color stability of porcelain restoration but, there is exceptionally small confirmation about qualitative and quantitative evaluation of color stability of porcelain. Considering these fact in mind, authors has legitimately investigated the appropriate historical outlooks, studies on colour stability, dilemmas and present beliefs for colour stability in dental ceramics.

Methods of Literature Search

In this third millennium, a number of internet-based instruments are accessible that sustain the exploration of research data from the existing medical literature pool. Some of the well-known internet based popular search engines (Google, Yahoo), scholarly search bibliographic databases (PubMed, PubMed Central, Medline Plus, Cochrane, Medknow, Ebsco, Science Direct, Hinari, WebMD, IndMed, Embase) and textbooks were explored until Sep 2017 using MeSH (Medical Subject Headings; PubMed) based keywords such as "Color Stability", "Feldspathic Porcelains", "Spectrophotometer", "CIELAB system". The search was limited to reviews, systematic researches and meta-analyses in various dental journals published over the last 67 years in English and Spanish. A total of 112 articles were identified however after examining the titles and abstracts, this number was finally condensed to 40 articles.

A methodical Literature outlook

Gross and associates evaluated colorimetric measurements on four composite resins [Adaptic (Johnson and Johnson), Prestige (Lee Pharmaceutical), Addent XV (3M Mfg. Co.) and smile (Kerr Mfg. Co.] before and after controlled immersion treatments.[4,5]

Separate groups of specimens of the four materials were immersed in three separate solutions [distilled water, solution of distilled water and coffee and solution of distilled water and tea] for 12 days at 55 degree C. For all materials and surface finishes, immersion in coffee and tea produced significantly greater color change than distilled water. Coffee produced significantly greater color changes than tea. When immersed in a tea solution, specimens of the same material with differing surface finishes showed greater differences in color changes than when immersed in control and coffee solutions. Chan and co-workers investigated the ability of foods to stain the composite resins using 40 freshly extracted and unrestored third molars by preparing class V cavities with 900 cavosurface margins.[6] Immediately after preparation the cavities, the buccal preparations were restored with Adaptic composite and lingual preparations with Concise composite. The specimens were divided into 5 groups and immersed them in solutions of coffee, tea, a cola beverage, soy sauce, and distilled water (control). All the samples were placed in an incubator at a constant temperature (37^0 C). They concluded that coffee and soy sauce stained composite resin restoration to a significantly greater degree than did tea or cola beverage. Generally the greatest degree of staining with all samples occurs during the first week of the study time. The stain penetration was superficial and was estimated to 5µm or less. Asmussen measured the color changes resulting from storage in water on a number of experimental and proprietary composite resins.[7] DEBA-containing resins were more color stable than resins containing equimolar concentrations of DEPT. In general the light activated materials were more color stable than the chemically activated materials. The color change was not affected by pH, but decreased when the oxygen had been removed from the storage water. The test for color stability using UV-light irradiation gave results for proprietary resins that were not correlated with the results obtained by water storage. Seghi and colleagues used instrumental calorimetric techniques to evaluate the color differences that can exist between different brands of porcelains with identical shade designations.[8] They examined Opaque and body porcelain of four different corresponding shades of three brands of porcelain. All reflectance measurements were taken with a double-beam spectrophotometer. They concluded that the CIELAB color system provides an objective technique for evaluating the color of dental porcelains, corresponding shades of different brands of porcelain can produce perceivably different colors, the perceived color differences between the brands were mostly a result of differences in all three color directions, greater color differences were found to exist between the corresponding opaque porcelains than between the corresponding layered samples. Seghi and O'Brien evaluated the performance of three currently available photometric devices by testing the performance capabilities of the instruments on various shades of opaque and translucent dental porcelain surfaces.[9] The CIELAB color difference matrices were used for the performance analysis. Samples were prepared in the form of a disc of diameter 12 mm. The translucent samples were sectioned to a 1 mm thickness for stimulation of the thickness that would be utilized in an ideal clinical situation. A 1µm diamond polishing paste was used for the final finish. Each sample disc was measured by each measuring device three times. The colorimeter recorded the data directly in CIELAB coordinates relative to standard illumination D65. They concluded that instrument colorimeter showed best overall performance.

Um and Ruyter evaluated the color stability of light activated and heat polymerized resin based veneering materials after exposure to boiled coffee, filtered coffee, and tea.[10] They used two light activated materials viz. Visio-gem and Dentacolor and three heat polymerized materials viz. Vitapan, Isosit and Biodent. After color measurement the specimens were reimmersed in the test solutions for additional 1,000 hours. The 1,000 hour specimens were removed from the test solutions and cleansed with the same treatment as described for 48 hour samples and measured the color, after cleansing the samples were ground with silicone carbide paper for 60 seconds and again the color was measured. They concluded that one of the light activated resin based veneering material (Dentacolor) underwent intrinsic discoloration during long term immersion in staining solutions, the discoloration of other materials was mainly due to surface adsorption of the colorants. Later on Khokhar and co-workers evaluated the color stability of selected indirect cornposite resins.[11] Twenty-six specimens each of Dentacolor, VisioGem, Brilliant D. 1., and concept were fabricated and immersed in chlorhexidine, coffee, and tea. The modifying effect of saliva on staining was also studied. Coffee and tea both stained the tested materials, but tea stained more than coffee. The addition of chlorhexidine and saliva increased staining when used with tea. Most staining was superficial and could be removed with regular oral hygiene: however, residual staining, which might become cumulative, was recorded. They concluded that Brilliant D. 1. samples exhibited the most discoloration and Concept samples the least. Koidis and associates investigated four techniques for making collarless metal-ceramic restorations study to examine the final color consistency, the bacterial plaque accumulation, and the surface characteristics of the porcelain margin.[12] Metal surfaces exhibited the greatest in vitro bacterial plaque accumulation (42.43%), and the margins of the platinum foil technique accumulated the least plaque (7.23%). In addition, the wax hinder and the platinum foil techniques produced the smoothest surfaces, whereas again the shoulder porcelain technique exhibited pronounced surface roughness. From the obtained results, and with the limitations of this in vitro study, they concluded that surface roughness is not a predominant factor in the initial process of bacterial plaque accumulation.

O'Keefe evaluated the effect of dissolution in APF gel on the color of metal ceramic samples that were surface colored using metallic oxides.[13] The color of uncolored samples was measured with a reflectance spectrophotometer. Three colorants viz. blue no. 104, orange no. 111 and brown-gray no. 115 were applied uniformly to the surface. After coloration the color was measured with a reflectance spectrophotometer. Three dissolution cycles were performed, each consisting of submersion in an acidic gel for 30 minutes followed by weighing and spectrophotometric analysis. They concluded that dissolution in acidulated phosphatefluoride gel dose affect the color of extrinsic metallic oxide colorants, changes in color difference were most evident with the blue colorant. Soon after Razzoog 15 investigated the color stability of two different dental porcelains, Ceramco and Procera, after they were exposed to 900 hours of accelerated aging.[14] CIELAB reading were recorded with a chroma meter II before and after exposure to 900 hours of accelerated aging simulation. After the aging process the color differences between the pretest and posttest condition were calculated. They concluded that, although statistical comparisons demonstrated a difference in color change ($p \leq 0.05$) between Ceramco and Procera porcelain in three of the shades tested, critical remarks of color refer to both types having “slight” color change, in terms of color stability, neither porcelain had “noticeable” changes after 900 hours of accelerated aging.

Yannikakis has authentically evaluated the discoloration effect of coffee and tea on some materials that were commonly used in the fabrication of provisional restorations. They evaluated six commercially available provisional resins (Jet, Caulk TBR, Protemp Garant, Luxatemp Solar, Provipont DC and SR-Ivocron-PE) after 1day, 7 days, and 30 days of immersion in two staining solutions (tea and coffee).[15] After immersion of specimens into test solutions for different time period, they measured color changes by using a Dr Lange Micro color tristimulus colorimeter and concluded that after 7 days immersion, all materials showed observable color changes, light curing composite were the least color stable. The coffee solution exhibited more staining capacity than the tea solution. Hiyasat investigated the effect of carbonated beverages on the wear of human enamel and dental ceramics using three dental ceramics: a conventional porcelain (Vitadur Alpha), a hypothermal low fusing ceramic (Duceram-LFC), and a machinable ceramic (Vita Mark II). Half of the samples from each group were exposed to distilled water and other half to the Coca cola.[16] The specimens were tested in a wear machine under a load of 40 N at a rate of 80 cycles/minute and for a total of 25,000 cycles. They concluded that exposure to carbonated beverage accelerated the enamel wear and decreased the wear resistance of Duceram- LFC and Vita Mark II ceramics, overall, Vita Mark II was most resistant to wear and significantly less abrasive than conventional alpha porcelain.

Wahadni and Martin presented a review of a number of studies that have examined the visual and microscopic appearance and roughness of glazed, unglazed and polished porcelain surfaces using techniques such as, scanning electron microscopy and surface profilometry.[17] All have agreed that glazed porcelain provides a smooth and dense surface. Many have shown that polishing can produce an equally smooth surface, which may even be esthetically better. Some studies supported the use of polishing as an alternative to glazing. However, reports have shown that unglazed porcelain is more abrasive than glazed. Douglas evaluated and characterized the color stability of various new generation indirect resins (ceramic-polymers) when subjected to accelerated aging.[1] Initial specimen color parameters were determined in the CIELAB color order system with a colorimeter. Color difference data were subjected to a one-way analysis of variance to examine the interaction between material and time interval of aging. He found out that all the indirect resins tested demonstrated color stability at or below a quantitative level that would be considered clinically acceptable. Later on Vargas compared the color stability of a conventional glass ionomer (Ketac-Fil), a light polymerized resin-modified glass ionomer (Photac-Fil), a polyacid-modified resin composite or compomer (Dyract) and a microfilled resin composite (Silux Plus).[18] A colorimetric evaluation, according to the CIEL*a*b* system, was performed at 24 hours (baseline) and at the end of each week. Color difference values (ΔE^*) were calculated. The conventional glass ionomer, resin-modified ionomer and compomer materials underwent significant color changes over time ($p<0.01$). Those materials darkened and showed color shifts in both the red-green and yellow-blue axes. In one more recent study, Paul and associates tested the hypothesis that spectrophotometric assessment of tooth color is comparable with human visual determination.[19] On 30 patients, three operators with unreported visual color deficiency independently selected the best match 10 the middle third of unrestored maxillary central incisors, using a Vita Classical Shade Guide. The same teeth were; measured by means of a reflectance spectrophotometer. In the human group, all 3 visual shade selections matched in only 26.6%. In the spectrophotometric group, all 3 shade selections matched in 83.3%. In 93.3%, ΔE values of visually assessed tooth shades were higher than spectrophotometrically assessed ΔE values ($p < 0.000$]). The results suggest that spectrophotometric shade analysis is more accurate and more reproducible compared with human shade assessment. Della tested the hypothesis that the etching mechanism changes according to the type of etchant and the ceramic microstructure and composition.[20] They quantitatively and qualitatively analyzed 15 dental ceramics using scanning electron microscopy, back scattered imaging, x-ray diffraction, optical profilometry and wavelength dispersive spectroscopy. They observed and suggested that the etching mechanism is different for the three etchants, with HF producing the most prominent etching pattern on all dental ceramics examined. Kalin investigated the wear behaviour of alumina ceramics in different water-lubricated conditions with a range of pH values from 0.85 to 13.[21] They also observed that significantly different wear surfaces are generated for different pH values, and these surfaces have a diverse effect on the wear and friction behaviour. Wear mechanisms were established by employing surface topography analyses and scanning electron microscopy (SEM). The chemical and electrochemical effects under the selected tri-biological conditions were discussed to help explain the observed behaviour. Their findings suggest that by varying the pH of a solution low-wear and/or high-wear of alumina ceramics can be obtained to suit the requirements of the process.

Naguib and Moussa studied the role of different pH levels within the oral environment color transmission coordinates and flexural strength of glass ceramics.[22] Twenty specimens of each of Vitadur Alpha detin porcelain, Duceram LFC dentin and IPS empress 2 were prepared and tested in 4% acetic acid at 800C for 45 minutes, in lactic acid and in carbonated beverage (Coca cola) intermittent with a buffer solution 30 days before being subjected to spectrophotometric analysis, scanning electron microscope treatment and flexural strength testing using the ball on ring test method. They concluded that, with the exception of IPS empress 2 stored in acetic acid, none of the tested ceramic proved to be optically or mechanically stable. Sham determined the color stability of 5 provisional prosthodontics materials before and after immersion in distilled water or coffee for 20 days or exposure to ultraviolet (UV) light for 24 hours.[23] Color was measured as CIEL*a*b* with a colorimeter before and after the immersion or UV exposure. Color change (ΔE) was calculated. They concluded that Luxatemp and Integrity (bis-acryl-methacrylate based resins) demonstrated acceptable color stability and were the most color-stable provisional prosthodontic: materials tested compared to the methyl/ethyl methacrylate based resins. Butler compared the surface roughness of 3 different porcelains when exposed to 2 fluoride solutions, a 10% solution of carbamide peroxide, and distilled water. The discs (10 specimens/group) were immersed in 1.23% APF, 0.4% stannous fluoride, 10% carbamide peroxide, and distilled water for 50 seconds (control).[24] The discs in the 10% carbamide peroxide solution were immersed for 48 hours. The surface of each disc was evaluated with surface profilometry (0.1 mm/s speed, 600-mm range). They concluded that immersion in the 3 solutions had no effect on the polished surfaces of all-ceramic specimens tested. Kourtis investigated the influence of various metal alloys and porcelains on the final color of metal ceramic complex.[25] They used four metal ceramic restorations, a Ni-Cr (thermobond), Co-Cr (Wirobond), Pb rich nobel alloy (Cerapal 20), and a high noble Au alloy (V Delta) and two porcelains viz. Vita Omega and Ceramco Silver. They analyzed the specimens with a spectrophotometer and concluded that type of alloy substrate and overlying porcelain significantly affected the color. Au and Co-Cr alloy were found to be brighter than the Ni-Cr and Pb alloys. Ceramco porcelain was found to be most red (higher L value) of all tested alloys. Gold and Pb alloys caused a yellow shift to the metal ceramic color compared to the Ni-Cr and the Co-Cr alloys with both porcelains. Gupta and co-workers evaluated the effect of three commonly consumed beverages viz. coffee, tea and coca cola on color stability of two universal hybrid composites viz. Filtek Z 250 and Teric-cream and an aluminous porcelain i.e. Vitadur alpha. Distilled water was taken as control.[2] A reflectance spectrophotometer was used to measure the color changes. They concluded that composite showed more discoloration than porcelain in all the solutions. Considering the mean staining intensity of all the solutions, coffee caused more discoloration than tea, coca cola and water as evident by the results which showed that all the materials including porcelain discoloured more in coffee. Kamala and Annapurni evaluated the effect of acidic solution on the surface roughness of ceramic material. Each sample was abraded with medium grit diamond on half of the disc while other half retains the glaze.[3] The samples were immersed in 1.23% APF gel, 16% carbamide peroxide, Coca-cola and distilled water (control). The surface roughness was evaluated with surface profiler before and after exposure to acidic solutions followed by SEM analysis. With SEM analysis they found out that acidic solutions etched the ceramic surfaces. Finally they concluded that although polished ceramic surface showed no significant effect after exposure to acidic solutions, roughening of porcelain may occur following application of fluoride gel, bleaching agent and on exposure to Cocacola. Jensdottir investigated the erosive potential of soft drinks minutes of soft drinks within the first minute of exposure to teeth, and about the potentially protective role of salivary proteins.[26] They hypothesized that the erosive potential is determined primarily by pH and decreases in the presence of salivary proteins. However, Sasahara compared the surface roughness of 4 dental porcelains with different microstructures (d.Sign-D, Finesse-F, Noritake-N and Symbio-S) using varied surface treatments.[27] Visual inspection was made using the scanning electron microscope. Micro structural characterization was also performed (hardness, leucite content and particle size). Reglazed specimens presented significantly rougher surfaces compared to glazed specimens. They concluded that the best choice of surface treatment for leucite-based porcelains depended on the material considered. Porcelains lower leucite content (F and S) tended to present lower roughness compared to those with higher leucite content after being polished with rubbers or discs followed by diamond pastes. Ahed investigated the average surface roughness of 2 dental ceramics: IPS Empress 2 (layering glass-ceramic, Ivoclar Vivadent) and In-Ceram/Vitadur Alpha (Vita), glazed, unglazed, or refinished using different techniques.[28] The average roughness measurements were taken from each specimen with a surface roughness tester. It was found that unglazed IPS Empress 2 is rougher than unglazed In-Ceram/Vitadur Alpha. They concluded that, regardless of the type of ceramic or pre-treatment, any adjusted ceramic restoration should be reglazed or subjected to a finishing sequence that is followed through to a final stage of polishing with diamond paste.

Jakovac tested the loss of mass in samples of four different dental ceramic materials apatite glass ceramic (IPS-Empress 2 for layering), alumina ceramic (Vitadur alpha), Lithium disilicate glass ceramic (IPSEmpress 2 for colouring) and alumina (IPS-Classic) in an acid medium.[29] They concluded that, different ceramic materials have different values of loss of mass, without regards to the similarity of chemical composition of product name, losses of mass values were minimal, the established values most probably do not have any clinical or toxicological consequences, the values cannot be generalized and cannot be transferred to dental ceramic materials that were not tested. Sarac compared the effect of different porcelain polishing methods on the color and surface texture of a feldspathic ceramic.[30] Color measurements were made using a colorimeter (Minolta CR-321 Chroma Meter) according to the CIEL*a*b* color system. Color differences (DE) between the control group and experimental groups were calculated. Then the surface roughness (Ra) (mm) of the same specimens was evaluated using a profilometer. They concluded that the use of an adjustment kit alone or preceding polishing paste or polishing stick application created surfaces as smooth as glazed specimens. The use of polishing paste alone did not improve the smoothness of the porcelain surface. Sarac and Turk conducted a study to investigate the effects of three surface conditioning methods on shear bond strength (SBS) and on surface roughness (Ra) of a feldspathic ceramic, and to compare the efficiency of three polishing techniques.[31] The specimens were divided into three groups according to the surface conditioning methods: air-particle abrasion (APA) with 25-µm aluminum trioxide (Al2O3) (group A); hydrofluoric acid (HFA) (group H); APA and HFA (group AH). They concluded that APA or APA + HFA created rougher porcelain surfaces than HFA alone. Davis compared the pHs and titratable acidities of commercially available calcium-fortified and unfortified 100 percent juices, and enamel and root surface lesion depths after they were exposed to different juices.[32] They exposed enamel and root surfaces to different 100 percent juices for 25 hours and measured lesion depths. They concluded that Calcium concentrations in commercially available, calcium-fortified 100 percent juices are sufficient to decrease and prevent erosion associated with extended exposure to a beverage. Celik and associates evaluated the effect of repeated firing on color of all ceramic restoration.[33] They used two different shades (A1, A2) of veneering porcelain. 20 disc shaped ceramic specimens were made, 4mm in diameter with 1mm core thickness (n=10). The repeated firings were performed (3, 5, 7 or 9 firings) for the specimens and color difference was determined using a spectrophotometer. They found out that the color of all ceramic specimens is influenced by repeated firings. However, color changes that occurred are clinically acceptable.

Ghahramanloo evaluated the effect of tea, cola, orange juice and distilled water on the color stability of a porcelain (Vita VMK 95) and a reinforced composite resin (GC Gradia). Twenty discs of each material were prepared with a diameter of 20+2mm and thickness of 2+0.2 mm. Specimens from group were immersed in staining solutions at 500 C for 30 days.[34] They concluded that ΔE of all the materials was changed after immersion in all the staining solutions during the experimental process and tea caused most significant color change. Koskal and Dikbas evaluated the color stability of two brands of porcelain teeth (Vivoperl PE and Vialumin Vacuum) and three brands of acrylic denture teeth (SRVivodent DCL, Vitapan and Optostar).[35] Samples were immersed into three staining drinks at test groups and distilled water as a control. Color measurements of teeth were performed by using a spectrophotometer. Instant coffee was found to be the most chromogenic agent among the solutions tested ($p<0.0001$). Among the materials tested, porcelain was found to be more resistant to discoloration. They concluded that acrylic teeth showed a higher degree of color change and that the amount of color change for each group increased proportionally with time.

Atay investigated the effects of porcelain treatment techniques on the color change of feldspathic porcelain before and after exposure to distilled water, coffee, red wine, and cola and examine the surface texture of the porcelain with field-emission SEM.[36] The specimens were prepared and stored in red wine, coffee, and cola. After removal, the specimens were dipped in distilled water. Color measurements were made with a spectrophotometer, and color differences were determined using the CIE-LAB system. They concluded that immersion time and types of surface treatment were significant factors for color stability of feldspathic porcelain. Yilmaz determined the effects of various types of metal alloys on the color of opaque porcelain after repeated firings. Seven different types of metal ceramic alloys were used for the study.[37] The specimens were subjected to 1 opaque firing, 4 consecutive dentin firing cycles, and 1 glaze firing cycle. They subsequent porcelain firings significantly affected the color of a 0.1-mm-thick layer of opaque porcelain for all alloys tested. After the third and fourth firings, 1 base metal alloy (B-ANP) showed significantly greater color change than the remaining dental alloys when the color difference was compared to baseline. In addition, the color change in a noble alloy (N-CD) was significantly less than that of the other alloys after glaze firing. However, color shifts after repeated dentin firings were imperceptible ($\Delta E<2.6$) and clinically acceptable ($\Delta E<5.5$) for each type of alloy.

CONCLUSION

Dental porcelain has color and optical properties that simulate natural teeth. Nevertheless porcelain restorations are considered to be color stable, yet discoloration is one of the major factors for failure of esthetic restorations. There have been several intrinsic or extrinsic factors indentified which are responsible for alterations of surface characteristics and lustre of porcelain. Intrinsic factors involve changes within the material itself and extrinsic factors involve adsorption or absorption of stains in the oral cavity. Literature search has very well showed the range of variation and alteration in color and surface lustre of ceramics when artificially exposed with commonly consumed food stuffs.[37-40] This variation was both qualitative and quantitative. Majority of the ceramics what we have seen in the literature search, were feldspathic and more or less have same composition and firing cycles but all have shown different amount of color change and surface roughness. This discrepancy may be accredited to the difference in percentage of basic individual composition. In addition, the oral cavity is in a unvarying dynamic change.

REFERENCES

1. Douglas R. Color stability of new generation indirect resins for prosthodontic application. J Prosthet Dent 2000;83:166-70.
2. Gupta R, Prakash H, Shah N, Jain V. Spectrophotometric evaluation of color changes of various tooth colored veneering materials after exposure to commonly consumed beverages. J Indian Prosthodont Soc 2005;5:72-8.
3. Kamala KR, Annapurni H. Evaluation of surface roughness of glazed and polished ceramic surface on exposure to fluoride gel, bleaching agent and aerated drink: An in vitro study. J Indian Prosthodont Soc 2006;6:128-32.
4. Caul HJ, Schoonover IC. Color stability of direct filling resins. J Am Dent Assoc 1953;47:448-54.
5. Gross MD, Moser JB. Colorimetric study of coffee and tea staining of four composite resins. J Oral Rehab 1977;4:318-22.
6. Chan CK, Fuller LJ, Hormati AA. The ability of foods to stain two composite resins. J Prosthet Dent 1980;43:542-5.
7. Asmussen E. Factors affecting the color stability of restorative resins. Acta Odontol Scand 1983;41:11-8.
8. Seghi RR, Johnston MW, O'Brien JW. Spectrophotometric analysis of color between porcelain systems. J Prosthet Dent 1986;56:35-9.
9. Seghi RR, Johnson WM, O'Brien. Performance assessment of colorimetric devices on dental porcelains. J Dent Res 1989;68:1755-9.
10. Um MC, Ruyter E. Staining of resin based vennering materials with coffee and tea. Quint Int 1991;22:377-86.
11. Khokhar AZ, Razzoog EM, Yaman P. Color stability of restorative resins. Quint Int 1991;22:733-7.
12. Koidis PT, Schroeder K, Johnston, Campagni W. Color consistency, plaque accumulation, and external marginal surface characteristics of the collarless metal-ceramic restoration. J Prosthet Dent 1991;65:391-400.
13. O'Keefe LK, Powers MJ, Noie F. Effect of discoloration on color of extrinsic porcelain colorants. Int J Prosthodont 1993;6:558-63.
14. Razzog ME, Lang BR, Russell MM, May KB. A comparison of the color stability of conventional and titanium dental porcelain. J Prosthet Dent 1994;72:453-56.
15. Yannikakis AS, Zissis JA, Polyzois LG, Caroni C. Color stability of provisional resin restorative materials. J Prosthet Dent 1998;80:533-9.
16. Hiyasat ASA, Saunders PW, Sharkey WS, Smith RMG. Effect of carbonated beverages on the wear of human enamel and dental ceramics. J Prosthodont 1998;7:2-12.
17. Wahadni AA, Martin MA. Glazing and Finishing Dental Porcelain: A Literature Review. J Can Dent Assoc 1998;64:580-3.
18. Vargas MA, Kirchner HL, Arnold AM, Beck VL. Color Stability of Ionomer and Resin Composite Restoratives. J Oper Dent 2001;26:166-71.
19. Paul S, Peter A, Pietrobon N, Hammerle FHC. Visual and Spectrophotometric shade analysis of human teeth. J Dent Res 2002;81:578-82.
20. Della Bona A, Anusavice JK. Microstructure, Composition and Etching, Topography of dental ceramics. Int J Prosthodont 2002;15:159-67.
21. Kalin M, Novak S, Vizintin L. Wear and friction behavior of alumina ceramics in aqueous solutions with different pH. Wear 2003;254:1141-6.
22. Naguib H, Moussa I. The effect of different pH levels on the optical properties and flexural strength of glass ceramics. Cairo Dent J 2003;19:319-38.
23. Sham KSA, Chu SCF, Chai J, Chow WT. Color stability of provisional prosthodontic materials. J Prosthet Dent 2004;91:447-52.
24. Butler JC, Masri R, Driscoll FC, Thompson AG, Runyan AD, Fraunhofer VAJ. Effect of fluoride and 10% carbamide peroxide on the surface roughness of low fusing and ultra low fusing porcelain. J Prosthet Dent 2004;92:179-83.
25. Kourtis GS, Tripodakis PA, Doukoudakis AA. Spectrophotometric evaluation of the optical influence of different metal alloys and porcelains in the metal-ceramic complex. J Prosthet Dent 2004;92:477-85.
26. Jensdottir, HoIbrook P, Nauntofte B, Buchwold, Bordow A. Immediate erosive potential of cola drinks and orange juices. J Dent Res 2006;85:226-30.
27. Sasahara RMC, Ribeiro F, Cesar PF, Yoshimura HN. Influence of the finishing technique on surface roughness of dental porcelains with different microstructures. J Oper Dent 2006;31:577-83.
28. Ahed WA. An in vitro investigation into the surface roughness of 2 glazed, unglazed, and refinished ceramic materials. Quint Int 2006;37:311-7.
29. Jakovac M, Babić ZJ, Ćurković L, Carek A. Chemical durability of dental ceramic material in acid medium. Acta Stomatol Croat 2006;40:65-71.
30. Sarac D, Sarac S, Yuzbasioglu E, Bal S. The effect of porcelain polishing system on the color and surface texture of feldspathic porcelain. J Prosthet Dent 2006;96:122-8.
31. Sarac SY, Turk ES, Sarac D, Turk T. Surface conditioning methods and polishing techniques effect on surface roughness of a feldspar ceramic. Angle Orthod 2007;77:723-8.
32. Davis ER, Marshall AT, Qian F, Warren JJ, Wefel SJ. In vitro protection against dental erosion afforded by commercially available, calcium-fortified 100 percent juices. Am Dent Assoc 2007;138:1593-8.
33. Celik G, Uludag B, Usumez A, Sahin V, Ozturk O and Goktug G. The effect of repeated firing on the color of an all ceramic system with two different veneering porcelain shades. J Prosthet Dent 2008;99:203-8.
34. Ghahramanloo A, Madani SA, Sohrabi K, Sabzevari S. An evaluation of color stability of reinforced composite resin compared with dental porcelain in commonly consumed beverages. J Can Dent Assoc 2008;136:673-80.
35. Koksal T, Dikbas I. Color stability of different denture teeth materials against various staining agents. Dent Mater 2008;27:139-44.
36. Atay A, Karayazgan B, Ozkan Y, Akyil MS. Effect of colored beverages on the color stability of feldspathic porcelain subjected to various surface treatments. Quint Int 2009;40:41-8.
37. Yilmaz B, Ozcelik BT, Wee GA. Effect of repeated firings on the color of opaque porcelain applied on different dental alloys. J Prosthet Dent 2009;101:395-404.
38. Buchalla W, Attin T, Hilgers DR, Hellwig E. The effect of water storage and light exposure on the color and translucency of hybrid and a microfilled composite. J Prosthet Dent 2002;87:264-70.
39. Lai LY, Lui FH, Lee YS. In vitro color stability, stain resistance, and water sorption of four removable gingival flange materials. J Prosthet Dent 2003;90:293-300.
40. Patel BS, Gordan VV, Barrett AA , Shen C, The effect of surface finishing and storage solutions on the color stability of resin-based composites. J Am Dent Assoc 2004;135:587-94.

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