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Comparison of the color stability of different monolithic dental ceramics and dental composites- A narrative review

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Abstract

Background and Aim: Special measures are necessary to prevent discoloration of dental composites and monolithic dental ceramics. The present study compared the color stability of different dental composites and ceramics based on previous studies.

Materials & Methods: For this study, all studies related to the subject under discussion, during 1995-2021 by systematic search in internationally available databases including Web of Science, Science Direct, Scopus, PubMed, and Google Scholar, Checked out. Finally, 35 fully relevant studies were selected to investigate the main objective.

Results: The study results showed that repeated firing of dental ceramics causes discoloration of these structures. As the number of repetitions increases, the amount of color change (ΔE) also increases. Foods or eating habits such as tea, coffee, soft drinks, some medications, some mouthwashes such as chlorhexidine or nicotine can change the color of composites and dental ceramics, thereby affecting their beauty. In addition, materials used in teeth bleaching, including a variety of peroxides (Carbamide/Hydrogen) in gel or liquid form, can change the color of dental composites.

Conclusion: Based on the results of this study, it can be concluded that dentists need to use high-quality and strong ceramics and dental composites and should consider the number of repeated firing that does not change color. In addition, people who use ceramic and dental composites should reduce the consumption of beverages such as coffee, tea, soft drinks, etc., as much as possible to minimize the color change in ceramics and dental composites. In addition, reducing the use of

bleaching compounds or low concentration bleaches can effectively reduce the discoloration of dental ceramics.

Keywords: Monolithic Dental Ceramics, Dental Composites, Color Stability, Bleaching Compounds

Introduction

The need of the dental community for up-to-date and efficient dental materials, which facilitate the work of dentists and increase patient comfort, creates a stable competition between different commercial companies in the field of research and development, marketing, and price of products. This has led to continuous technological advances in dental materials [1]. These factors have made the competition in the research and production of dental materials into a very dynamic and exciting field. Marketing researchers have predicted that the location of restorative materials, dental cement, bindings, and blind-forming materials will increase significantly [1-3].

Among the most popular materials, zirconia ($ZrO2$), lithium disilicate ceramics, glass ceramics, glass-infiltrated ceramics, and hybrids are of great importance [4-11]. A review of research, patents, and marketing conditions of ceramic materials show that dental ceramics is a potential stimulus field for advanced technology and future development of dentistry [12-15]. Therefore, the application of technology in ceramic materials has made it possible to produce metal-free restorations from all-ceramic materials [13]. Qualitative improvements in the properties of all-ceramic materials include aesthetics, non-chemical reaction, biocompatibility, low thermal conductivity, color stability, and mechanical properties such as high flexural strength and abrasion resistance make these materials superior to metal-ceramics [16].

Due to its unique physical, mechanical and chemical properties, the use of all-ceramic restorations is increasing day by day. Unlike in the past, all-ceramic restorations are used due to their translucency and beautiful quality appearance, and resemblance to natural teeth in the natural area. Today, with the improvement of mechanical properties and increasing the strength of ceramics, they can be used in molars and even as a substitute for metal furnaces [17].

The color of the restoration should mimic the seemingly natural nature of the teeth. So a big challenge for dentists is the color matching between the restoration and the adjacent natural teeth. Some teeth have a range of colors, and choosing the best matching ceramic blocks for them is difficult, even for experienced restorative dentists. In addition, the sintering and dyeing methods may change their color. On the one hand, these factors complicate the presentation of ideal beauty. On the other hand, the adaptability and tolerance of individuals can reduce the complexity of this color adaptation [18 and 19]. An accepted method for measuring color matching is to measure the mean color difference using the CIE lab formula [20-22].

There are two terms for the color difference threshold for dental ceramics. The "sensitivity threshold" represents the smallest color change that can be visually detected by 50% of human observers, and the color change that is acceptable to 50% of observers is called the "acceptance threshold" [23-25]. O'Brien et al. (1997) [19] have classified color differences by clinically acceptable values in this case. Their study defined $\Delta E = 0$ as a stable color and a color change with $\Delta E < 1$ incomprehensible and observable. Their study showed that if the color difference is from 1 to 2, it should be clinically understandable by 50% of observers, and the value of $\Delta E = 3.7$ can be detected by 100% of observers. Thus, values of ΔE> 3.7 are not clinically acceptable. Douglas et al. (2007) [18] reported a color difference of 2.6 for clinical comprehensibility. Because of the above, the purpose of this review is the color stability of different monolithic dental ceramics and dental composites.

Materials & methods

This study aimed to investigate the rate of discoloration of ceramics and dental composites due to various factors. For this purpose, systematic searches of internationally available databases including Web of Science, Science Direct, Scopus, PubMed, and Google Scholar were performed between 1995 to 2021. Systematic review using Mesh terms "Color stability", "Monolithic", "Dental ceramics", "Dental composites", "Restorations", "Polishing Procedure", "surface finishing procedure" and "Beverages", "Firing", "Coffee", "Tea", "Bleaching" and "Color changing" were performed. For other databases, the same mesh terms were used similarly. The references were thoroughly evaluated to verify that no articles were missed for inclusion in the study (Reference Checking). In addition, the citations from the research were also checked (Citation Tracing) to make sure that the search was thorough and successful. Based on Figure1, the search for literature, especially articles, was done according to the PRISMA guideline. In addition, unofficial reports, articles in a letter to editor format, and unpublished articles and content posted on Internet sites were removed from the list of downloaded files. Finally, 35 published articles were reviewed for the present review.

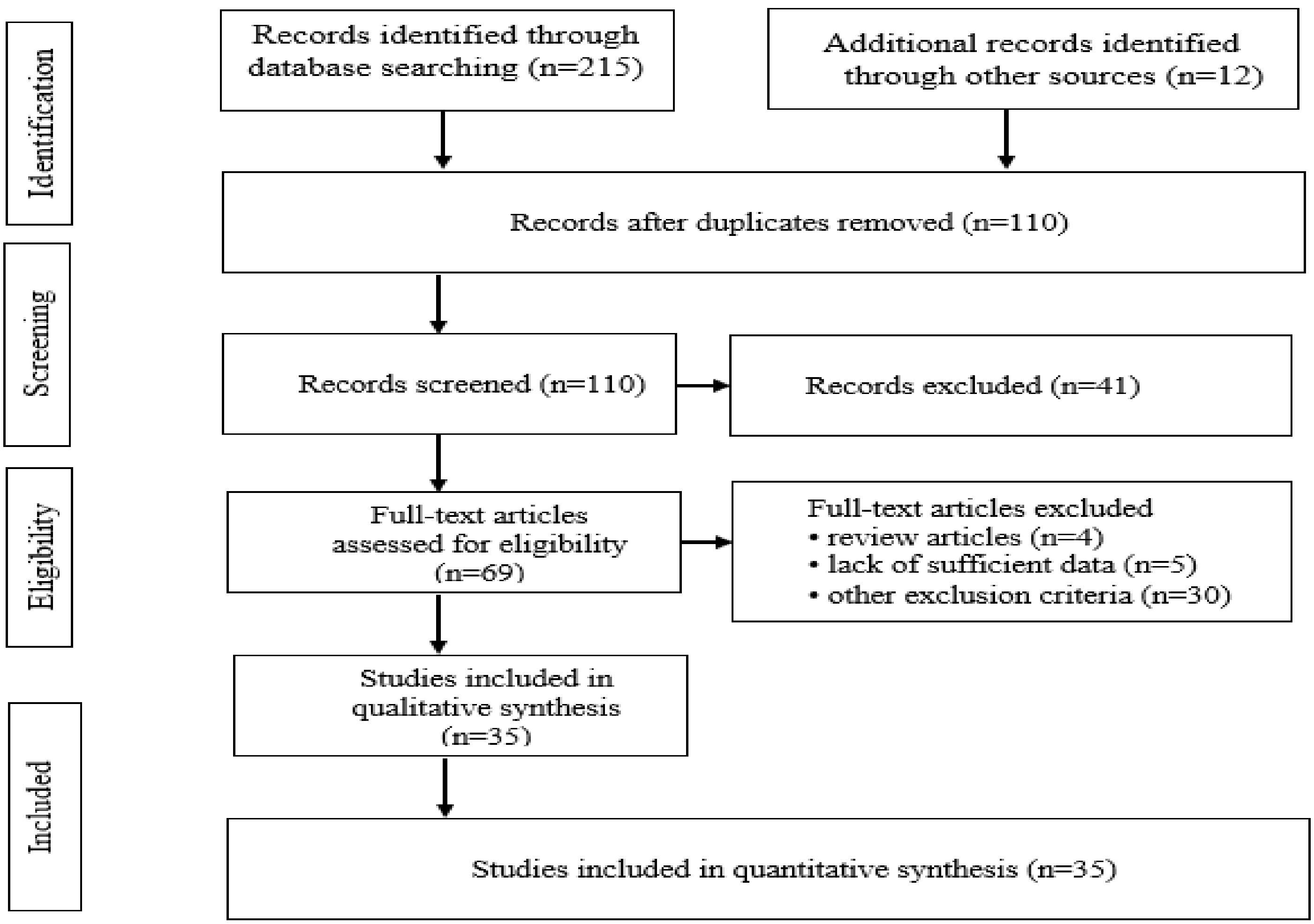

Figure 1: Flow diagram of study identification according to PRISMA.

Results & discussion

Effect of repeated firing on the color changes

So far, many researchers have evaluated the differences in the color of monolithic veneered all-ceramic dental ceramics [26, 27]. Color stability of CAD-CAM monolithic ceramic class under simulated oral conditions in the studies of Palla et al. (2018), Alp et al. (2018), Aurélio et al. (2017), Al Ben Ali et al. (2014), Kim et al. (2016) and Gonuldas et al. (2014) has been reviewed. They examined the effect of some interventions such as surface treatments, brushing, thermocycling, patient age, discoloration with beverages, change in translucency on discoloration [26, 28-32].

The study of Nejatidanesh et al. (2019) evaluated the effect of repeated firing on the color of lithium disilicate glass-ceramic with different translucencies [33]. In this study, 20 samples of lithium disilicate glass-ceramics (IPS e. Max CAD) with high and low translucency were prepared in two groups (n = 10). The samples were cut into rectangles with dimensions of 12×14×1 mm. Then, the samples were fired three times, and after the first and third firing, the color-determining coordinates were measured using a spectrophotometer. The color difference (ΔE) was calculated between the first and third firing. The present study results showed that the color change due to firing in low and high translucency lithium samples was 1.342±0.88 and 0.757±0.40, respectively. Based on the results of this study, it was found that repeated firing causes a significant difference in the color of lithium disilicate color with low translucency compared to the type with high translucency ($P < 0.05$) [33].

In addition, the results of the study by Kalantari et al. (2017) showed that repeated sintering causes further compression of the microstructure of LDS crystals. Also, based on the findings of the study, repeated baking showed a significant effect on color changes ($P < 0.05$) [34]. The color of CAD-CAM ceramic systems is affected by the crystalline components and the size of the crystal. Smaller crystals and crystalline content mainly lead to more color differences of LT glass-ceramics compared to HT samples [26, 35]. In addition to repeated heat treatment and firing, it affects the crystal components and the size of the crystal. Therefore, the negative effect of multiple furnaces on the beauty of dental ceramics should be considered during laboratory and clinical processes [33].

The appearance characteristics of dental ceramics are influenced by the chemical composition, microstructure, shape and average particle size, crystalline phase composition, and matrix in terms of refractive indices and manufacturing process [33]. Color and translucency are two different appearance features. Lithium disilicate (LDS) translucency can affect the final color and appearance, so it should be considered [31 and 36]. At the same time, the translucency of the restorative material is a key factor in providing a natural appearance and is also important in covering the properties of the material. Therefore, it makes sense that high-translucency LDS should not be used for dark-faced teeth [33].

Findings of the study Nejatidanesh et al. (2019) showed that a 1mm thick LT sample in the range 2> EΔ> 1, which is consistent with the results of studies by Li et al. (2012) and Kalantari et al. (2017) [34, 37]. Furthermore, this color difference is based on the classification of O'Brien et al. (1997) [19] were within a clinically acceptable range that could be detected by 50% of observers.

Based on the results of previous studies [33 and 34], further firing cycles can increase color changes. Therefore, it is suggested that HT blocks be preferred when restoration requires greater thickness. Dentists should also be more careful about contours and colors to avoid the need for additional firing [33].

Further studies are needed on the effect evaluation of the number of firing on the translucent color changes of all-ceramic restorations. In order to provide successful beauty for all-ceramic restorations, some laboratory and clinical factors such as color scale, light source during color evaluation, composition, translucency, opalescence, coronary thickness, tooth color under restoration, presence of post and blind inside root, cement, ceramic compaction method, temperature and number of ceramic firing times, ceramic thickness and glazing period should be considered. In addition to optical properties, it is necessary to consider other factors such as stability in the oral environment and strength. So, strength should not be sacrificed for more beauty. In choosing the right materials for restoration, all of the above factors must be considered. Because color stability is essential for ceramic materials, polishing and glazing should be considered. Prolonged glazing, compared to the normal glazing process, causes a noticeable discoloration and opacity in the LDS [33].

Effects of bleaching agents on the color changes

The color change of tooth is one of the main complaints of patients regarding the beauty of anterior teeth. There are several ways to solve this problem. Bleaching teeth is a relatively non-invasive way to control the external or internal colors of teeth. This technique is divided into live methods, office on live teeth, and root canal treatment in terms of how to do the work [38]. Materials used in teeth whitening include a variety of peroxides (Carbamide/Hydrogen) in gel or liquid form. The mechanism of action of these substances is generally based on the release of free radicals. In this way, unstable free radicals enter into a chemical reaction with pigment molecules, making them smaller and fainter. Numerous studies have evaluated the effect of bleaching on tooth structure. But their effect on restorative materials is not exactly known [39].

After whitening restored teeth, changes in the structure of the composites may occur, such as porosity, surface roughness, and reduced composite hardness. These changes increase the likelihood of bacteria adhering to the surface and increase the color of the composite. Some studies show no significant discoloration in the composite restoration after teeth whitening with 10 to 16% carbamide [40]. However, contrary to the results of this study, other studies have reported significant changes in the color and physical properties of composites following the use of 6-15% carbamide [41, 42].

Restorative materials with different chemical compositions respond differently to bleach. Microfield composites have fillers with an average diameter of 0.04 microns. These composites have a high polishing capability and good transparency but poor mechanical properties. In comparison, microhybrid composites have fillers with an average diameter of one micron and are suitable for use in areas under stress [38]. Nanocomposites contain particles of 0.01 to 100 nanometers. According to studies, these composites have a lower shrinkage rate than micro-hybrid composites and therefore accept less color [43].

Siluran composites were introduced to reduce polymerization shrinkage. These composites act by opening the rings due to cationic agents and having a siloxane group with a hydrophobic nature; they have insufficient water absorption. The oxidant group created the shrinkage property of these composites, which prevents shrinkage when the rings open [44].

In the study by Davari et al. (2019), The effect of leaching materials on color and translucency changes of composite materials with nanoparticles with silicone base was investigated. This study showed that the color changes in the microhybrid composite were more than nanohybrids and siloranes (P <0.001). Also, color changes in the 20% carbamide peroxide bleaching group were significantly higher than in the control group (P<0.001) (ΔE> 3.3). According to the results of this study, translucency and color changes were consistent. In addition, rebound samples were less affected by bleaching [38]. In studies by Canay et al. (2003) [45] and Hubbezoglu et al. (2008) [46]. The effect of 10 to 16% carbamide peroxide did not change the color of the composite (ΔE <2). Whereas, in the study of Rao et al. (2009), significant discoloration was observed following the use of 16 to 20% carbamide peroxide [47]. A study by Rosentritt et al. (2003) also showed that carbamide peroxide gel caused a significant color change in the microhybrid composite, and bleaching with carbamide peroxide was recognized as a suitable way to brighten the color of veneers [48].

Effects of different drinks consumption on the Color changes

One of the most important factors influencing the success of composite resin restorations over time is their color stability [49, 50]. Discoloration of composite resins can cause patient dissatisfaction and lead to treatment failure in the long run [51]. Therefore, the ability of resin composite restorative materials to resist discoloration, which is mainly used for regeneration in beautiful areas, is important [52]. Despite the many advances that have been made in the field of dental composites, discoloration is still a major problem [50]. Composite restorations change color in the oral environment, but the important issue is the extent of this color change, which should normally be to the extent that it is not visible to the naked eye [52]. The discoloration of dental composites may be due to internal factors related to the structure of the composites or external factors such as the type of nutrition or idiopathic [53]. Foods or eating habits such as tea, coffee, soft drinks, some medications, some mouthwashes such as chlorhexidine or nicotine can affect the beauty of the composite by changing its color [50, 52, 54, 55].

Based on studies by Mahdisiar et al. (2014) and Ertas et al. (2005), coffee consumption is one of the eating habits that has changed the color of the composite [52, 49]. The results of a study by Aguiar et al. (2011) showed that non-alcoholic beverages increase the concentration of color pigments in composites more than alcoholic beverages [56]. A study by Mahdisiar et al. (2014) showed that coffee could change the color of three types of dental composites after 72 hours so that the amount of color change compared to the initial state (before being placed in the coffee solution) was significant [49]. Recent studies have shown that two factors, pH and the presence of sugar in coffee, can play an important role in causing discoloration in dental composites. The low pH of the solution causes more surface degradation and thus more adsorption of pigment adhesion [50, 57, 58].

In the study of Jalalian et al. (2019), The effect of different surface preparation methods on the color stability of monolithic zirconia ceramics was investigated. In this study, 12 samples of monolithic zirconia blocks with dimensions (1.5 × 14 × 14 mm) were prepared and divided into two groups, including glazed and polished after glaze. All samples were placed in an aqueous tea solution for two weeks. Then, the monolithic zirconia ceramic paint was measured before and after tea by spectrophotometer. This study showed that the color change (ΔE) in the glazed group was equal to 1.4 and in the polished group was equal to 2.03. In comparison, the color change in the polishing group was about 2 times that of the glazing group (P = 0.004). Based on the results of this study, it can be said that surface preparation by the glass method causes more color stability in monolithic zirconia ceramics [59]. Results of the study Heydari et al. (2012) showed that the variables of baking number and type of ceramics have a significant effect on the color change of dental ceramics. According to the results of this study, with increasing cooking repetitions, the rate of color change (ΔE) increased. Although coffee beverages caused slight color changes on dental ceramic samples, these changes were not statistically significant [60].

Conclusion

The study results showed that repeated baking of dental ceramics causes discoloration. As the number of repetitions increases, the amount of color change (ΔE) also increases. Foods or eating habits such as tea, coffee, soft drinks, some medications, some mouthwashes such as chlorhexidine or nicotine can affect the beauty of dental composites and ceramics by changing their color. In addition, materials used in teeth whitening, including a variety of peroxides (Carbamide/Hydrogen) in gel or liquid form, can change the color of dental composites. Based on the results of this study, it can be concluded that dentists should not use high quality and strong ceramics and dental composites and should consider the number of cakes that do not change color. In addition, people who use ceramic and dental composites should reduce the consumption of beverages such as coffee, tea, soft drinks, etc., as much as possible to minimize the color change in ceramics and dental composites. In addition, reducing the use of bleaching or low concentration bleaches can effectively reduce the discoloration of dental ceramics.

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