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Review Article

Comparison between color stability of zirconia and lithium disilicate

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ABSTRACT

The most widely used glass-ceramic is lithium disilicate (LD) because of its remarkable optical qualities, high strength, and simplicity of manufacture. Greater marginal strength, reduced porosity, and net-shaped manufacturing by pressing are further benefits of LD. The development of yttrium stabilized trigonal zirconia polycrystalline (Y-TZP) ceramics is the result of the pursuit for a material with both mechanical capabilities, like the resistance provided by metallic restoration, and the distinctive optical characteristics of glass-ceramic. The main drawback is the fragile veneering ceramics, which are prone to chipping, debonding, and breakage. There is evidence that extrinsic variables such beverages, mouthwashes, acid solutions, dental brushing, and increased temperatures might cause ceramic surfaces to deteriorate. The composition and surface shape of ceramic materials have an impact on the extrinsic pigment absorption or adsorption from the oral cavity. The main causes for the clinical replacement of anterior restorations, according to prior research, are poor color matching and color instabilities. Monolithic zirconia is more prone to staining from chlorhexidine, green tea, and coffee. In monolithic zirconia, the aging-related color changes are more pronounced. The color of the background substructure influences how zirconia restorations look overall. In terms of color stability and translucency, LD ceramic has also been proven to be more aesthetically pleasing. In comparison to monolithic zirconia, bilayer zirconia with feldspar veneering ceramic displayed reduced discoloration overall. It has been noted that monolithic zirconia is more susceptible to low-temperature degradation than the core Y-TZP. The use of current literature to infer outcomes has several limitations because in most vitro investigations, thermocycling has been carried out in water rather than oral cavity saliva and the influence of sunlight exposure, salivary proteins, food coloring, tobacco, different enzymes, and surface-related factors on the color stability is yet to be examined.

Keywords: Lithium disilicate, Zirconia, Color stability, Y-TZP ceramics, Fixed prosthesis coloring

INTRODUCTION

A society that values aesthetics is driving rising demand for cosmetic dental services.[1] A revolution in dental materials as well as various novel therapeutic techniques have been brought about by aesthetic dentistry. Indirect restoration made of different all-ceramic materials is a common procedure in modern dentistry. The most widely used glass-ceramic is lithium disilicate (LD) because of its remarkable optical qualities, high strength, and simplicity of manufacture.[2,3] Greater marginal strength, reduced porosity, and net-shaped manufacturing by pressing are further benefits of LD.[4,5] Full contour fabrication of LD prosthesis eliminates the problem of physical-mechanical compatibility among two incompatible materials. Therefore, relative to bilayer ceramic repair, the probability to break or for the veneer to crack is smaller. Even though LD is one of the many flexible indirect restorative materials, due to its 2.8–3.5 MPa fracture toughness, caution is required when treating bruxism subjects with significant occlusal stress and non-vital teeth.[6] Clinical applications include front fixed prosthesis, anterior veneers, posterior inlay or onlay, and tooth-implant supported single crowns.[7,8] The development of yttrium stabilized trigonal zirconia polycrystalline (Y-TZP) ceramics is the result of the pursuit for a material with both mechanical capabilities, like the resistance provided by metallic restoration, and the distinctive optical characteristics of glass-ceramic. The main drawback is the fragile veneering ceramics, which are prone to chipping, debonding, and breakage. These medical issues hastened the modification of translucency and microstructure.

The replacement teeth's size, texture, and shapes must be replicated in the prosthesis, along with matching light response. Moreover, the longevity of the cosmetic restorations depends on the restoration's color stability. Ceramics' physico-mechanical features have been improved, however they are still prone to discoloration.[9,10] There is evidence that extrinsic variables such beverages, mouthwashes, acid solutions, dental brushing, and increased temperatures might cause ceramic surfaces to deteriorate[11-13] The composition and surface shape of ceramic materials have an impact on the extrinsic pigment absorption or adsorption from the oral cavity.[14,15] It is recommended to use mouthwash ingredients with antibacterial qualities, such as benzydamine and chlorhexidine gluconate, in addition to mechanical oral hygiene techniques. Chlorhexidine is known to leave dark stains on the tongue's dorsum, various restorative materials, and teeth when used for an extended period of time. The staining of teeth and restorations is linked to non-enzymatic browning and colored metal sulfide production.[16] Supragingival calculi development is also seen to rise with prolonged use of chlorhexidine.[17] Few scholars have suggested that the precipitation of food chromogens and locally adsorbed chlorhexidine is what causes the coloring. The main causes for the clinical replacement of anterior restorations, according to prior research, are poor color matching and color instabilities.[18]

METHODS

This study is based on a comprehensive literature search conducted on 21 October 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about comparison between color stability of zirconia and lithium disilicate. There were no restrictions on date, language, participant age, or type of publication.

DISCUSSION

Dental prosthetics' success depends on their capacity to restore both function and appearance. All-ceramic restorations are recommended in the front region due to deeper translucency adjacent to the native tooth.[19] For prosthetics to function successfully over time, the permanence of the established color is essential. Using a spectrophotometer, it is possible to assess how commonly consumed liquids such as coffee, tea, and chlorhexidine mouthwash affect the color stability of all-ceramic restoration. Studies that assess color stability and translucency make use of CIE Lab-based measures like color difference (ΔE) and translucency parameter. In a study evaluating the effects of accelerated aging on the translucency and color stability of monolithic zirconia and LD with various surface treatments, it was discovered that the aging process had an effect on the samples' color and translucency, particularly the zirconia specimens, which were found to be clinically unacceptable (E=5.03). Ceramics' surface disintegration is influenced by the material composition, manufacturing processes, surface finishing, and assessment methods.[20,21] According to Palla et al, the unglazed pressed ceramic's rough surface allows water to seep in and cause the silica network to disintegrate.[22] Reduced crystallinity and improved color pigment absorption result from this. While glazed-pressed ceramics are resistant to water penetration and silica network breakdown because they don't have surface irregularities or microcracks. After immersing in the coffee for 72 hours at 1.71, Gawriolek et al reported the mean color parameter of the Ivoclar Porcelain System (IPS) e. max, a LD crown.[23] Mean color change for both glazed and polished computer-aided design and computer-aided manufacturing (CAD-CAM) processes was described by Alencar-Silva et al.[24] Due to drinks, LD ceramic is below the 1.30 perceptibility threshold. Monolithic zirconia is more prone to staining from chlorhexidine, green tea, and coffee. In monolithic zirconia, the aging-related color changes are more pronounced. In terms of color stability and translucency, LD ceramic has also been proven to be more aesthetically pleasing.

Without a ceramic covering to protect it, the monolithic zirconia is open to water and bodily fluids. Low-temperature deterioration is the slow and spontaneous tetragonal to monoclinic phase transition that occurs on the zirconia surface when it comes into contact with water, water vapor, or bodily fluids at 37°C.[25-27] Phase conversion to monoclinic resulted in a volume increase of 4%. This 4% rise in the volume of the particles below the surface leads to stress buildup all across the monoclinic particles, which separates them from the surface and produces structural breakdown, surface roughness, and the emergence of microcracks.[28] This material degrades at low temperatures as a result of the exposure.[29] Because they are not covered by a ceramic veneer, monolithic zirconia restorations are immediately exposed to the intraoral environment. Manufacturers of monolithic zirconia lower the alumina percentage to increase translucency. According to Fathy et al, the alumina content is responsible for the material's resistance to low-temperature deterioration.[30] They claimed that because monolithic zirconia has a lower alumina content than core zirconia, it is more prone to low-temperature deterioration. Monoclinic phase change causes surface porosity, which improves incident light scattering and decreases translucency.[31] Monolithic zirconia might therefore be more susceptible to low-temperature deterioration.[32] When zirconia restorations are exposed to the oral environment over an extended period of time, this circumstance has a negative impact on their aesthetics.[27] Zirconia kept its colorimetric qualities after an aging protocol, according to Volpato et al.[27] However, in an autoclave without ultraviolet light exposure, these authors utilized an aging protocol. According to Dikicier et al, the average color difference between the zirconia specimens was 1.29.[33] In comparison to other research, this number was significantly lower. This variation might be the result of the scientists employing veneered samples made from colored pre-sintered blocks instead of a separate coloring process before sintering. According to other investigations, metal oxides may be responsible for the aging-related color change in ceramic materials. Metallic pigments are used to shade ceramics' colors, and these oxides are easily destroyed by UV light.[33] As a result, the considerable color shift in the zirconia material observed in some studies evaluating aging changes may be a result of metal oxides dissolving due to ultraviolet light exposure during the aging process. After aging, the surface develops porosity, which increases incident light dispersion and reduces translucency.[30] Additionally, because each phase has a different refractive index, the presence of monoclinic and tetragonal phases in the structure decreases translucency with time.[30] After hydrothermal aging, Zirconia's translucency parameter mean values significantly decreased, according to Fathy et al's research.[30] Similar to the previous study, the zirconia group's translucency parameter values reduced, although this change was not statistically significant. As a result, the considerable color shift in the zirconia material observed in some studies evaluating aging changes may be a result of metal oxides dissolving due to ultraviolet light exposure during the aging process. After aging, the surface develops porosity, which increases incident light dispersion and reduces translucency.[31] Additionally, because each phase has a different refractive index, the presence of monoclinic and tetragonal phases in the structure decreases translucency with time.[30,34] After hydrothermal aging, Zirconia's translucency parameter mean values significantly decreased, according to Fathy et al's research.[30] Similar to the previous study, the zirconia group's translucency parameter values reduced, although this change was not statistically significant. The different aging processes are to blame for this discrepancy. In their research, autoclave aging was carried out using more rigorous conditions—15 hours at 134°C and 200 kPa pressure, or 45 to 60 years in the patient's mouth. In the current investigation, the specimens were subjected to reduced temperature values and an artificial aging period that was similar to just one year of use. According to Liu et al, changes in contrast ratio values that are 0.07 or higher can be seen with the unaided eye.[35] Lee determined that this threshold value's matching translucency parameter value was 2.[36] The color stability of ceramic systems is also impacted by the interplay of surface treatments with aging.[32,37] Comparing monolithic zirconia to ordinary zirconia, it was discovered that the translucency increased. Even with standard LD at the same material thickness, the monolithic zirconia's translucency was still inferior.[38,39] Numerous research indicated no statistically significant differences between the surface treatments in the values of the translucency parameter. This suggested that the subgroups' surfaces had similar roughness characteristics, indicating that the polishing method used in these trials was similar to glazing. This shows that several polishing techniques can be used to create a surface that resembles glazed surfaces.[40-42] Other surface elements like shine have an impact on the appearance of ceramic materials (dull or glossy).[32,40] The short amount of time used to replicate the lifespan of the prosthesis in practice was another drawback of this study. Only water vapor was used for the aging process, and conventional temperatures were used. To reflect clinical conditions more accurately, more research needs to be done over longer times in the presence of saliva, colored beverages, smokes, and other enzymes.

In comparison to monolithic zirconia, bilayer zirconia with feldspar veneering ceramic displayed reduced discoloration overall. It has been noted that monolithic zirconia is more susceptible to low-temperature degradation than the core Y-TZP. Additionally, earlier studies have demonstrated that the core tetragonal zirconia utilized in bilayer zirconia prostheses has greater crystal intensity counts than monolithic zirconia.[43] The lower average crystal size seen in the center of Y-TZP is also responsible for the material's greater resilience to low-temperature deterioration.

According to Keuper et al, monolithic zirconia's bigger grain sizes have stronger mechanical qualities but are less resistant to transformation.[44] Due to the ceramic's feldspar veneering, the hydrothermal aging's microcracks are not exposed to the discoloring solutions. Higher monoclinic phase, crystallinity, particle size, and porosity are all blamed for the improved refractive indices during hydrothermal aging.[34,42] The resultant color of bilayer zirconia could be indirectly impacted by the decreased translucency of core Y-TZP. According to Suputtamongkol et al, the color of the background substructure influences how zirconia restorations look overall. [45] The glaze was recommended by Camposilvan et al as a defense against hydrothermal aging for the underlying zirconia.[46] Researchers recommend polishing or glazing to create a smoother surface and to enhance the color stability because earlier studies have demonstrated that the finished restoration's surface roughness impacts color stability.[47]

In one investigation employing water, the average color change seen with IPS e. max and bilayer zirconia was less than 3.5. Previous studies indicate that color changes less than 3.5 are clinically acceptable and indiscernible. The monolithic zirconia had mean color changes that were only a little bit above the level considered clinically acceptable.

The use of current literature to infer outcomes has several limitations because most in vitro investigations that included thermocycling were carried out in water rather than oral cavity saliva. The repeated exposure of ceramics during immersing may have an impact on the discoloration of the tested ceramics because the staining solutions are frequently not renewed during the immersion duration. Studies frequently overlook the synergistic effects of brushing and micro-surface roughness. Additional research is required to assess different zirconia brands because many studies are restricted to a single brand. The limited amount of time used to replicate the clinical lifespan of the prosthesis during such research is another drawback. The influence of sunlight exposure, salivary proteins, food coloring, tobacco, different enzymes, and surface-related factors on the color stability of zirconia and LD is examined in further experiments to properly match clinical settings.

CONCLUSION

According to a survey of recent literature, LD ceramic performs better in terms of color stability and translucency than monolithic zirconia ceramic. Compared to LD ceramic, coffee staining was more pronounced in monolithic and bilayer zirconia. Lithium disilicate was more impacted by green tea than coffee. All of the discoloring agents that were evaluated on monolithic zirconia showed the least color stability, and polishing paste-treated zirconia specimens showed more color change over time than those with other surface treatments. However, there was no discernible variation in color change between the groups with various surface treatments in the LD material.

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