Effect of Chemical Aging on the Color Stability of Two Ceramic Materials; Zirconia Reinforced Lithium Silicate and Lithium Disilicats Ceramics

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Article information

Abstract

Objectives: The presence of fine-grained crystals of lithium silicate, which contains a high amount of glass provides the material it's optical and mechanical characteristics. This unique microstructure allows this material to be processed in a dental lab quickly and efficiently in its crystalline state and the exact tooth shade. This study aims to evaluate the color stability of zirconia reinforced lithium silicate ceramic and lithium disilicates ceramic restorations.

Materials and Methods: In this in vitro study, 40 discs of 2mm thickness and 10mm in diameter would be fabricated, all samples were divided into two groups (n=20) according to ceramic material used: group Z zirconia reinforced lithium silicates ceramic(ZLS) and group L lithium disilicate ceramic(LS) discs. Each group was subdivided into two subgroups according to the aging process (n=10) (before and after aging).

CIELAB color parameters of all samples were calculated from spectral reflectance measurements on a spectrophotometer to evaluate the effect of chemical aging on the color stability.

Statistical Analysis: One-way ANOVA analysis was used to compare measurements among groups.

Results: ZLS showed lower color stability than LS, and there was a statistical difference between them. Aging affected the color stability of the two ceramics but within an acceptable range with lithium disilicates.

Conclusion: ZLS gave lower color stability than LS and aging affected the color stability of both types of ceramic.

The postulated hypothecs of this study were ZLS will be higher color stability than LS and chemical aging will have a huge effect.

1. Introduction

Collagen is a main protein in all animal tissues, which comprises about 30% of total protein. It is found in bones, tendons, ligaments, eye lenses, skin, and corneas. More than 29 different of collagen from various animals have been identified. In addition, each type of collagen has a specific molecular structure and amino acid sequence [1]. The production of collagen in the body decreased through a bad diet and age. While collagen injections are not a preference for most people, so the subsequent best alternative to obtain collagen is through diet. Consequently, pure collagen has been mixed in many food products [2].

In the last 10 years, zirconia and high-strength glass-ceramics (e.g. lithium disilicate) appeared and became more used clinically in prosthodontics and restorative dentistry.

The main reason for the evolution of zirconia reinforced lithium silicate (ZLS) is its strength which is about 1000 MPa and on the other hand, the high-strength glass-ceramic is about 360 to 400 MPa, to provide safely ceramic options for many properties to use.

The dissolution of zirconia reinforces the glass matrix and in combination with the glass-ceramic crystals, it produces a very high strength material.

Zirconia reinforced lithium silicate high glass content gives the material an excellent optical and mechanical characteristics. Light optical characteristics affect all benefits, with high edge strength and excellent polishability. The unique microstructure with this light optical and mechanical properties allow the material to be processed in a dental lab quickly and efficiently.

The presence of 10% of zirconium oxide assures a proper high strength. The crystallites particles are 4 to 8 times smaller than crystals of conventional lithium disilicates. The net result is an ultra-fine microstructure which provides high flexural strength with a high glass content, which has a great impact on optical and mechanical properties of the material.

Zirconia-reinforced lithium silicate can be processed rapidly and efficiently in the dental lab. It can be milled in a fully crystalline state. Restorations are customized with stains and

glaze directly on the tooth-colored framework, which makes it easier to create a pleasant aesthetic design and to control the definitive appearance of the restoration.

The 70 % crystal phase of the lithium disilicates glass-ceramic material refracts the light very naturally, while also providing better flexural strength (360 to 400 MPa). This gives more indications for use and the ability to place restorations using usual cementation techniques, while also having strength and aesthetics (1).

The aging environment of the restoration also affects the polished surface which in turn affects the color stability (2).

2. Materials and Methods

2.1 Sample grouping:

Discs of 2 mm thickness and 10 mm in diameter were fabricated by using IsoMet 4000 micro saw (Buehler Germany precision cutting, Germany) (n=40).

All samples were divided into two groups according to the type of ceramic:

Group (n=20) Z: zirconia reinforced lithium silicates ceramics (Celtra due, Dentsply-Sirona, Bensheim, Germany).

Group (n=20) L: lithium disilicate ceramics (IPS E.MAX, Ivoclar Vivadent AG, Schaan, Liechtenstein, USA).

Each group was subdivided into two subgroups (n=10) according to the aging procedure:

Subgroup --ZA: aging.

Subgroup --ZB: no aging.

Subgroup --LA: aging.

Subgroup --LB: no aging.

2.2 Disc fabrication:

Zirconia reinforced lithium silicate blocks and lithium disilicate blocks were turned into conical shape model with the required diameter (10 mm) and then cut the model into discs with (2 mm) by using IsoMet 4000 micro saw (Buehler Germany precision cutting, Germany)(fig .1,2&3)
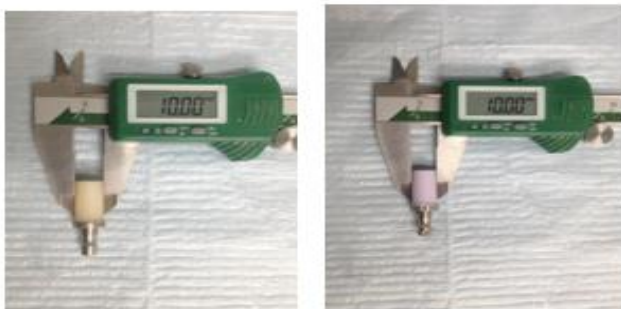

Fig.1 conical-shaped model
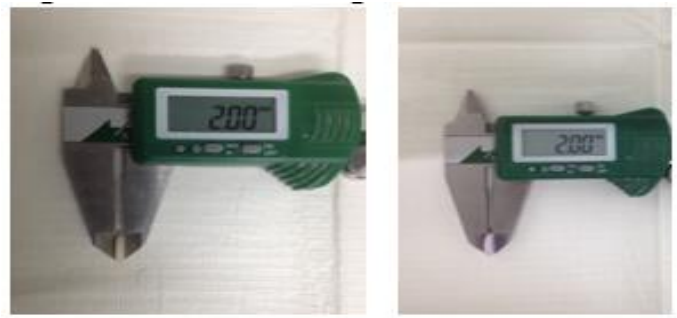

Fig.2 Disc fabrication using IsoMet 4000 micro saw

Fig.3 Disc thickness

2.3 Crystallization and glazing

After the fabrication of discs, the discs cleaned with a steam cleaner carefully blow-dry the restoration in an airstream then reassure for its measurements. Before glazing the surface cleaned with a steam cleaner.

Using IPS E.MAX CAD glaze (Ivoclar Vivadent AG, Schaan, Liechtenstein, USA) and was applied to the entire disc surface using a brush and then inserted into ceramic furnace programat P310 (Ivoclar Vivadent AG, Schaan, Liechtenstein, USA) (fig.4).

Celtra due firing program was (table 1):

IPS E-MAX firing program (table 2):

Fig.4 Crystallization and glazing

Table 1: Celtra due firing program

Standby Temperature B	Closing time S	Heating ratet η	Firing temperature T	Holding time H	Vacuum on/off	Long-term Cooling L	Cooling temperature tL
°C	min	°C/min	°C	min	Vac1(°C) Vac2 (°C)	°C	°C
500	3:30	60	820	1:00	off	750	50

Table 2: IPS E-MAX firing program

Stand-by temperature B [°C/°F]	Closing time S [min]	Heating rate t1 [°C/°F/min]	Firing temperature T1 [°C/°F]	Holding time H1 [min]	Heating rate t2 [°C/°F/min]	Firing temperature T2 [°C/°F]	Holding time H2 [min]	Vacuum 1 11 [°C/°F] 12 [°C/°F]	Vacuum 2 21 [°C/°F] 22 [°C/°F]	Long-term cooling L [°C/°F]	Cooling rate t̲ [°C/°Fmin]
403/757	0:30	120/216	850/1562	0:00	70/126	870/1598	3:30	690/850 1274/1562	850/870 1562/1598	705/1301	0

2.4 Aging procedure

The samples were first washed three times with ethyl alcohol then dried then immersed into a 4% acetic acid solution at a temperature of 800C and kept for 16 hours according to the ISO 6872 (3) Standards for hydrolytic resistance of dental ceramic materials. After cooling to room temperature, finally, the

samples would be removed, rinsed with distilled water and alcohol then dried.

2.5 Color stability test:

Color parameters L*, a*, and b* were assessed with a recording by using spectrophotometer Easy Shade V (Vita, Germany) (fig.5) before and after chemical aging.

Fig.5 Vita Easy Shade

Color difference (ΔE) was calculated using the CILAB color system. This system consists of lightness (L*), red-green (a*), and yellow-blue (b*) coordinates (fig.6). The CILAB (ΔE) value was calculated to provide a measurement of color change by using the equation [ΔE= [(ΔL*) 2 + (Δa*) 2 + (Δb*) 2]½.
The ΔE values determine whether the changes in the overall shade are perceivable to the human observer (4). Color differences with ΔE>1.0 are visually detectable (5) and values above 3.3 are considered clinically unacceptable (4).

Fig.6 L*, a*, b* readings

2.6 Statistical analysis

Statistical analysis was done by using one way ANOVA and Multiple Comparisons
Dependent Variable: VAR00002 LSD.

3. Results

The means & standard deviations of ΔE values were significantly affected by the interaction between the ceramic and the chemical aging. The effect of chemical aging on color change varied among groups. For the zirconia reinforced lithium silicates (Celtra due) before aging and zirconia reinforced lithium silicates (E-MAX) after aging (ΔE>1) and for lithium disilicate before aging and lithium disilicate after aging (ΔE<1). Table (3) shows that zirconia reinforced lithium silicates was color unstable than lithium disilicates and was clinically noticeable and it presents higher color difference (ΔE=1.2) after chemical aging while lithium disilicates was clinically accepted (ΔE=0.8) (fig.7)
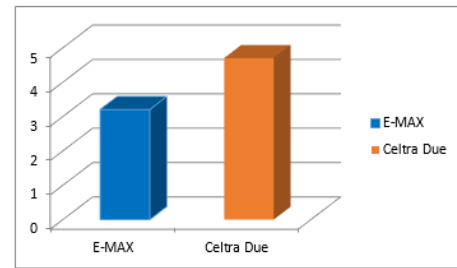

Fig.7 Comparison of ΔE of tested ceramics between before & after aging

4. Discussion

This study evaluated and compared the color stability of zirconia reinforced lithium silicate with the lithium silicate discs.

In the present study, the materials tests were conducted to evaluate the color properties of both ceramic materials under standardized conditions.
Discs were manufactured by micro-saw and they had the same design and parameters.
Several factors might result in aesthetic failure of all-ceramic restorations, and many are associated with the fabrication restorative procedures (6). Depending on the magnitude of this color difference, the restoration may be considered unaccepted and require to be changed (7) another factor that could result in restoration replacement is the decrease in esthetic appearance over time, simulated in this study by the chemical aging process.
In this in vitro study, a spectrophotometer was used due to its ability to produce measurements away from the subjective effect of color (8-11).
The device's reproducibility according to this study was elicited from 10 specimens of each group by calculating the ΔE value after two-color measurements of the same surface before and after chemical aging.
Many types of aging methods can be applied to clarify the color stability of dental ceramics. Most methods associated with extrinsic factors, including exposure to environmental conditions. In previous studies, ambient and ultraviolet irradiation (12), food and drink colorants such as Coffee, Tea, red wine, cola, orange juice (13-15), and other pigments such as salbutamol sulfate (16) and methylene blue (17-19) have been tested. However, the clinical discoloration from these beverages such as Coffee, Tea, Wine, and orange juice has a harmful effect than ultraviolet light or distilled water alone (15&20). Thus, in the present investigation, we preferred immersion in acids according to the ISO 6872 (3).
In this study, the color of zirconia reinforced lithium silicate was unstable and clinically noticeable (ΔE=1.2) than lithium disilicates (ΔE=0.8) due to the difference in (ΔE) as if (ΔE>1) this means that the color didn't change and clinically accepted and if (ΔE<1) this means the color changed and clinically unaccepted (21).
The two mechanisms have been explained for this color change process (22). 1st, the selective leaching of alkali ions, and 2nd, the dissolution of the ceramic silicate network (Si-O-Si). These mechanisms are controlled by the diffusion of hydrogen ions or hydronium ions (H3O+) from an aqueous solution into the ceramic and loss of alkali ions from the ceramic surface into an aqueous solution to maintain electrical neutrality (22).

 The acidic acid that is used result in rough tested ceramics surfaces. The ceramic restorative materials were subjected to various temperature and acidic changes caused by food and beverages in the oral cavity. For this reason, the ceramic materials should resist or have minimal changes in the oral cavity's environment. According to this Previous studies, it has been reported that the clinical shelf life of metal-ceramic restorations up to 20 years. (23-24).

Acetic acid is the acid used for aging in this study following ISO standard 6872 (3), and affected the color stability of both ceramics and change the color of ceramics.

These previous studies that have been documented had proved that increasing the surface roughness of ceramic surface may lead to a decrease in the strength and aesthetics of the material (25-26).

According to the increasing of the surface roughness of the studied ceramics, it may be related to major problems which are bacterial colonization and a decrease in the strength of the ceramic materials, in addition to that, it may lead to clinical failure of the ceramic restorations (27). Despite the Acetic acid is known to be a weak organic acid, however, it has a fairly corrosive effect to ceramics because of its chelating effect (28).

 The investigation was a vitro study so further investigations should explain color stability for prolonged aging times and in other media such as carbonated beverages or fruit juices, whereas for optimized clinical simulation, the combined effect of other contributing factors such as sunlight, saliva proteins/enzymes, and smoking also should be evaluated in more Vivo studies to elaborate the effect of aging on dental ceramics.

5. Conclusion

The color stability of zirconia reinforced lithium silicate and lithium disilicate and was changed but was clinically detectable in zirconia reinforced lithium silicates.

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