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STUDY ON ASSESSMENT OF SURFACE ROUGHNESS AND TRANSLUCENCY OF ARTIFICIALLY AGED ZIRCONIA AND LITHIUM DISILICATE VENEERS AN IN-VITRO STUDY

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ABSTRACT

Statement of Problem*:* Multiple studies have been conducted to evaluate the effect of aging on the mechanical properties of computerized-aided design and computerized-aided manufacturing (CAD/CAM)-based zirconia; however, there is a scarcity of literature discussing the effect of aging on change in translucency and surface roughness for both Translucent zirconia and lithium disilicate. ***Aim of the study****:* To evaluate the surface roughness and translucency of zirconia and lithium disilicate veneers aged by artificial aging. ***Materials and Methods****:* Twenty laminate veneers from two different materials were fabricated on typhodont of upper left lateral incisors. 10 zirconia laminates (Dentsply Cercon HT) {Group 1} and 10 lithium disilicate (IPS Emax CAD for Cerec and Inlab) {Group 2} laminates were milled by CAD/CAM milling machine (Dentsply Sirona). The veneers were sintered at 1450 degree celsius with heating rate of 8 degree Celsius and holding time was about 2 hours. All specimens were subjected to an aging procedure low thermal degradation (LTD) using an autoclave (134_C, 2 bar pressure) for 5 hours. Translucency parameter and surface roughness were evaluated. ***Results****:* With high translucency zirconia after L-TD, there was no statistically significant change in mean Surface roughness after aging. Lithium disilicate had the highest surface roughness values. There was a significant difference ($p = 0.001$) after artificial ageing. With high translucency zirconia and Lithium disilicate both there was no statistically significant decrease in mean translucency parameter after aging. ***Conclusion****:* Lithium disilicate had the highest surface roughness values that is statistically significant increase in surface roughness ($p = 0.001$) after artificial ageing. The surface roughness values of translucent zirconia are under an acceptable limit of 0.2 µm. The differences recorded between translucency of translucent zirconia and LDS ceramics are not significant after L-TD.

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INTRODUCTION

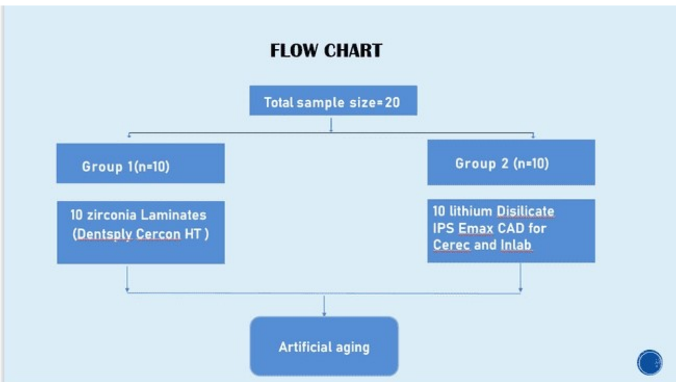
Dental ceramic restorations have been used for decades in dental prostheses such as crowns and fixed dental prostheses due to their exceptional cosmetic and biocompatible properties.[1] They achieve a precise mimicry of color, translucency, and texture of human dentition. Nowadays, cosmetic demands are the primary reason to visit a dental clinic, and full ceramic prostheses usually meet these demands.[2]

Veneers are ideal for correcting small imperfections, rebuilding your grin, and boosting your confidence. Thanks to their effectiveness and popularity, there are several kinds of veneers available today, with translucent zirconia and lithium disilicate being the most commonly used. Zirconia materials have rapidly revolutionized to fulfill the need for a material that combines the mechanical properties of porcelain fused to metal (PFM) materials with the esthetic and high degree of biocompatibility of the glass-ceramics. [3]The transformation toughening mechanism is responsible for the higher fracture toughness, hardness, and flexural strength of yttria-stabilized tetragonal zirconia polycrystalline. The most translucent 5-YTZP materials are ideal for anterior crowns, laminate veneers, and fixed dental prostheses. Increasing the yttria content from 3 mol. % to 5 mol. % produces high translucency by reducing the light scattering defect, resulting in higher cubic phases.[4,5] Pressable ceramics containing leucite and lithium disilicate crystals are widely known for making anterior veneers, crowns, inlays, and onlays. They provide excellent esthetics and marginal fit due to translucent ceramic cores. Lithium disilicate glass ceramics are commonly used in practice, with interlocking microstructure and high content of crystalline phase (formed by lath-like Li2Si2O5 crystals. The heating cycle controls the crystallization of lithium disilicate, 60-70 % in which lithium metasilicate (Li2SiO3) reacts with the glassy phase (SiO2) to originate lithium disilicate (Li2Si2O5). [5]The excellent mechanical properties are a result of a decrease in the size of the platelet-shaped crystals and an increase in interlocking among crystals.[6-8] The final mechanical properties of ceramic materials depend on several factors, including the heating rate, sintering temperature and duration, source of stabilizing oxides, and heating source of ceramic materials.[9] Translucency, which is the relative amount of light passage through an object, is a crucial factor that affects the natural looks and liveliness of restorations. [10] It is affected by several factors like grain size, distribution, processing method, cement type and thickness, saliva, dietary products, sintering temperature, number of firing cycles, zirconia-based all-ceramic system brand, and thickness. Low-temperature degradation causes surface degradation due to water penetration, leading to surface roughness of polycrystalline zirconia, thus impacting its physical properties. [11] Multiple studies have evaluated the effect of aging on the mechanical properties of computerized-aided design and computerized-aided manufacturing (CAD/CAM)-based zirconia. However, there is a scarcity of literature discussing the effect of aging on the change in translucency and surface hardness for both zirconia and lithium disilicate veneers.

Aim of Study: The aim of this in vitro study was to evaluate and compare the surface roughness and translucency of zirconia and lithium disilicate veneers aged by artificial aging. The null hypothesis was that zirconia and lithium disilicate veneers aged by artificial aging would not affectthe surface roughness and translucency.

MATERIALS AND METHODS

Twenty laminate veneers from two different materials were fabricated on typodont of upper right central incisors. 10 samples for 5Y-TZP HT zirconia (Dentsply Cercon HT) and 10 samples for milled lithium disilicate HT (IPS EMaxCAD for CEREC and Inlab) (Flow chart 1).



Flow chart 1.

Sample Preparation: Before starting the preparation, a silicone index was used to guide the preparation and for standardization of the preparation. The index was made by taking pre-preparation impressions for typodonts using a silicone rubber base (Zhermack - C Silicone Putty type 0) (heavy body). The impression was sectioned vertically to get a side view of the preparation to guide the incisal and labial reduction (incisocervically). The preparation was done in labial reduction and incisal overlap design with dimensions of (1 mm) incisal reduction, 0.5 mm labial reduction, and Palatal reduction was made 1mm below the incisal edge with chamfer finishing line. The preparation ended 1mmabove the cementoenamel junction (CEJ). The depth of reduction was checked by using a digital caliper[12]. The prepared typodonts were scanned using a CAD/CAM scanner to obtain a digital image. Astereolithography (STL) file of the proposed specimen was virtually designed using CAD software. The STL file was sent to the CAM software for milling. Once the milling was completed, the collected zirconia samples were de-dusted. The sides having the mark of sprue attachments were polished using abrasives. The ideal sintering temperature recommendedby the manufacturer was 1450 degrees Celsius. The heating rate was 8 _C, and the holding time was about 2 h. A total sintering cycle of 6 h and 10 min was kept constant for all the samples (Fig 1).

Artificial Aging: Artificial aging is performed according to the ISO 13356 recommendation (ISO13356, 2008). All samples were placed on dry gauze to prevent any contamination or rusting of metals on the samples and placed on the steel tray of the steam autoclave at 134°C and 0.2 MPa pressure for 5 hours. Aging was done on consecutive cycles and not on one continuous cycle and each cycle lasted for approximately half an hour which was started when the temperature reached 134°C and the total number of cycles was about 11 cycles. After the aging was completed the samples were taken out of the autoclave and cleaned and dried to remove any debris over the surface of the samples which may affect the readings. Then measurement of TP was done again in the same way mentioned before and was compared with the results taken before aging statistically.

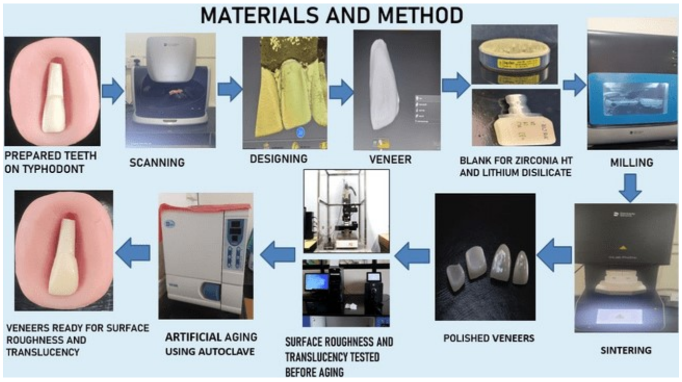


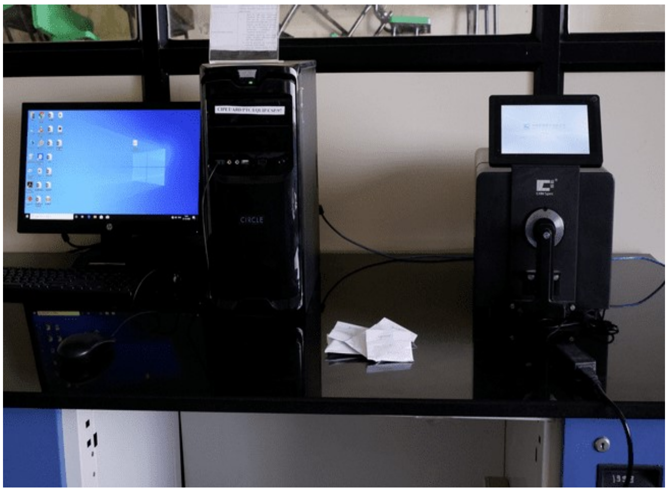
Figure 1.

Surface Roughness Measurement: The veneers were evaluated for surface roughness on a *non-surface contact profilometer (zeta 20 3D, zeta instruments, Germany)* with magnification set at 20x. (Figure 2). Each side was scanned three times at three randomly selected locations and the arithmetic average (Ra-value) was registered.The average surface roughness of each specimen was represented by ***Ra*** (arithmetical mean deviation of the profile). These measurements were taken at the baseline before Artificial Agingand After Artificial Aging.

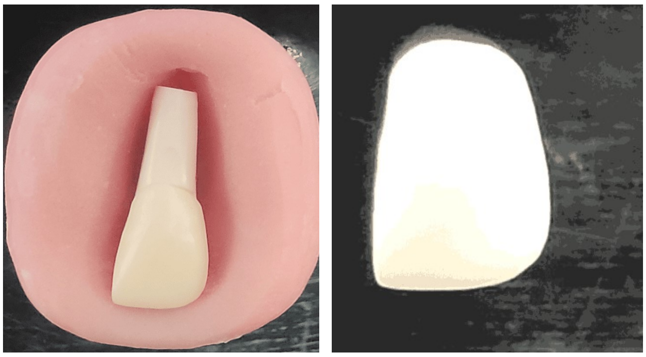
Armamentarium used for Evaluation of surface roughness-Profilometer (Figure 2)

Translucency Parameter (TP value): The Translucency was performed via a Spectrophotometer with a cold cure acrylic resin jig (Figure 4). Specimens were placed in the middle of the aperture for the two backings. The translucency parameter (TP) was obtained by calculating the color difference of the sample over the white and black background (Figure 5) as follows -TP=[(Lw* - Lb*)2 + (aw* - ab*)2 + (bw* - bb*)2]1/2.

These measurements were taken atbaseline (before Artificial Aging) and After Artificial Aging.



Armamentarium used for Evaluation of Translucency - spectrophotometer (Figure 4)



Sample over the white and black background Figure 5

Statistical Analysis

- The results were analyzed using statistical software (SPSS, version 22; SPSS Inc., Chicago, IL, USA).
- The means and standard deviations were compared using Paired t test and a multiple comparisons test.
- A p-value < 0.05 was considered significant

RESULTS

The following information should be noted: The surface roughness of zirconia and lithium disilicate before aging had a mean and standard deviation of 0.289 ± 0.045 µm and 0.270 ± 0.022 µm, respectively. After artificial aging, the mean and standard deviation surface roughness values were 0.304 ± 0.02 and 0.372 ± 0.048, respectively (as shown in Table 1). This indicates that the changes due to aging were 0.015 ± 0.008 and 0.102 ± 0.036, respectively. When it comes to high translucency zirconia after L-TD, there was no statistically significant change in mean surface roughness after aging. Lithium disilicate had the highest surface roughness values, and there was a significant difference (p = 0.001) after artificial aging. Regarding the translucency parameter values, high translucency zirconia and lithium disilicate had values of 11.56 ± 1.35 and 14.51 ± 1.43 before artificial aging.

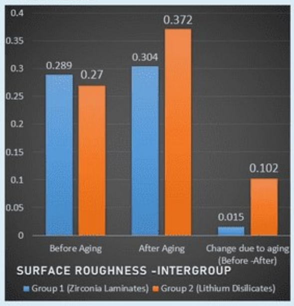
After artificial aging, the translucency parameter decreased to 11.07 ± 1.3 and 13.96 ± 1.32, respectively (as shown in Table 2). Thus, the change due to aging was 0.49 ± 0.56 and 0.55 ± 0.48. However, for both high translucency zirconia and lithium disilicate, there was no statistically significant decrease in mean translucency parameter after aging.

SURFACE ROUGHNESS

	Group 1 (Zirconia Laminates) Mean (SD)	Group 2 (Lithium Disilicates) Mean (SD)	Unpaired t test	P value, Significance
Before Aging	0.289 (0.045)	0.270 (0.022)	t = 1.468	p =0.103 (NS)
After Aging	0.304 (0.02)	0.372 (0.048)	t = -4.381	p=0.008*
Change due to Aging (Before -After)	0.015 (0.008)	0.102 (0.036)	t = -3.276	p =0.018*

p>0.05 – no statistical significant difference *p<0.05 -significant

Table 1: Intergroup comparison between Group 1 (Zirconia laminates) and Group 2 (lithium disilicate) in relation to surface roughness parameter measured before and after aging process



GRAPH 1

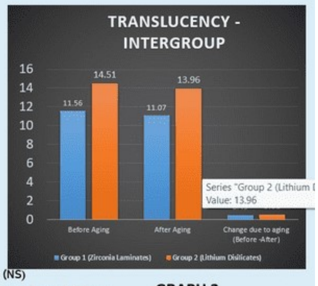
Table 1 **Graph 1**

TRANSLUCENCY PARAMETER

	Group 1 (Zirconia Laminates) Mean (SD)	Group 2 (Lithium Disilicates) Mean (SD)	Unpaired t test	P value, Significance
Before Aging	11.56 (1.35)	14.51 (1.43)	t = -8.261	p = 0.002*
After Aging	11.07 (1.3)	13.96 (1.32)	t = -7.812	p= 0.004*
Change due to Aging (Before -After)	0.49 (0.56)	0.55 (0.48)	t = -0.751	p = 0.412 (NS)

p>0.05 – no statistical significant difference *p<0.05 -significant (NS)

Table 2: Intergroup comparison between Group 1 (Zirconia laminates) and Group 2 (lithium disilicate) in relation to translucency parameter measured before and after aging process



GRAPH 2

Table 2 **Graph 2**

DISCUSSION

In this study, a low thermal degradation (LTD) aging procedure was employed on zirconia and lithium disilicate specimens using a steam autoclave. This method is widely accepted as an accelerated aging protocol, equivalent to 15-year clinical conditions. The approach is based on a previous study by Lughi and Sergo, which found that treating specimens in the autoclave for 1 hour at 134°C was equivalent to 3-4 years of in-vivo aging. Additionally, Sergo reported that 5 hours of aging at 134°C corresponds to 15-20 years at 37°C.[13] In this study, the process of aging was investigated, which involves the conversion of surface grains from tetragonal to monoclinic, in relation to water molecules. This conversion is accompanied by the development of uplifts on the surface, leading to microbreaking and grain pull-out. These changes can initiate an advanced decay of mechanical properties.[14] However, in this study, no relevant surface changes were observed, which can be explained by the fact that the samples were mirror polished. Therefore, after low-temperature degradation (LTD), they retained their polished surface. The results were consistent with a previous study by Choi YS, which reported that the aging process significantly increased the roughness (Ra) measurements values in all tested groups. However, the Ra values of that study were much lower than the Ra value of 0.2 µm observed in this study, which is still clinically acceptable.[15] These findings were also consistent with a study by Alghazzawi, which showed that the mean translucent parameter value before aging was significantly higher than after aging. This could be attributed to the transformation from tetragonal to monoclinic phase, which caused an increase in surface roughness and light scattering.[16] It was observed that after aging, lithium disilicate had a higher surface roughness value in comparison to zirconia. This is likely due to the irregular crystals of lithium disilicate or due to the manual polishing and glazing procedures. The presence of crystalline species within the glass indicates that the glass and crystalline phase dissolve at different rates, causing the surface to become rougher.

Our results were similar to a study conducted by Yuan et al. They found that longer simulated aging periods in experiments resulted in rougher surfaces with lithium disilicate. In contrast, zirconia showed no significant changes in surface roughness below 6000 cycles. However, this difference could be related to differences in manufacturers and material composition.[17]

The difference in TP values after aging may be caused by the difference in the crystalline content of the materials, which results in increased opacity. It was reported that the difference in TP values originated from the different grain size and crystalline structure of the materials. The effect of thermal cycling on the optical properties, such as color and opacity, could be explained by the increase in crystal size, the orientation of the crystals, and perhaps with the change of the glass matrix. Similar results were obtained in a study conducted by Vasiliu in 2019.[18]

Limitation of study

- This study has some limitations, as it was conducted in vitro & did not simulate clinical conditions.
- Further studies are needed using different artificial aging protocols; also In-vivo studies are needed to validate the in-vitro results and to understand the real performance of translucent zirconia and Lithium disilicate in the oral cavity.

CONCLUSION OF STUDY

- Lithium disilicate veneer samples showed statistically significant increase in surface roughness values ($p = 0.001$) after artificial ageing. Lithium disilicate showed higher surface roughness as compared with translucent zirconia samples.
- The surface roughness values of translucent zirconia were under an acceptable limit of 0.2 µm.
- The differences recorded between translucency of translucent zirconia and Lithium disilicate ceramics after artificial aging are not significant after L-TD.

Clinical Implications

- Lithium disilicate is the most commonly used material for laminate veneers but as the study shows that the surface roughness of translucent zirconia is less after aging, so we can consider translucent zirconia as good alternative to lithium disilicate.
- Even though the changes observed were statistically significant for Lithium disilicate, they were considered well within the limit, to achieve the best clinical outcome.

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Conflict of Interest: There is no conflict of interest.

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