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Comparative evaluation of translucency of Zirconia-reinforced lithium silicate and Lithium disilicate materials fabricated by CAD/CAM system

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ABSTRACT
Objectives*: To evaluate and compare translucency of Zirconia reinforced lithium silicate and lithium disilicate. Zirconia reinforced lithium silicate glass ceramic has been introduced to the dental market for dental CAD/CAM applications. Lithium disilicate glass ceramic has more favourable mechanical properties compared with conventional dental porcelains and has excellent optical properties.*
Materials and Methods*: The translucency of the specimens placed on white or black backings was measured with a reflection spectrophotometer (Color Eye 7000A, Xrite; GretagMacbeth) in the wavelength range of 400 to 700 nm with 10-nm data intervals. Standard Commission Internationale de l'Eclairage (CIE) illuminant D65 and 2-degree observer function were used. Standard black and white discs were used to calibrate the spectrophotometer before each measurement. Spectrophotometric data were recorded in CIELab color values.*
Results*: Lithium disilicate has (0.811) higher translucency than Zirconia reinforced lithium silicate (0.78).*
Conclusion*: The IC Lithium disilicate glass-ceramic -ceramic revealed higher optical properties compared with VS Zirconia reinforced lithium silicate.*
Keywords*: Lithium disilicate, Zirconia reinforced lithium silicate, CAD/CAM, translucency*

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I. Introduction

Metal-ceramic restorations have been a trusted option for restoring dentition for a very long time in prosthodontics. They do, however, have a number of drawbacks. Especially in cases with thin gingival biotype and high lip line, the opacity of the metal coping beneath produces an opaque-looking prosthesis and a metallic reflection through gingiva when smiling. To address these drawbacks, particularly those relating to aesthetics, all-ceramic restorations have recently gained popularity over metal-ceramic ones.[1]

Ceramics are widely used in dental applications because of their superior esthetics, chemical stability, and biocompatibility as compared to conventional metal-ceramic restorations.[2]

Translucency is defined as the extent to which light is diffused rather than reflected or absorbed.[3] It occurs when a light beam, passing through a material, is partly scattered, reflected, and transmitted through the object: the greater the quantity of light that passes through the object, the higher the translucency.[4] Hence it depends on the scattering and absorption coefficients.[5] It is an essential optical property for simulating the natural appearance of adjacent teeth.[6] It is one of the main parameters in matching the appearance of the natural tooth and was identified as pivitol factor in controlling aesthetics especially in the anterior region.[7]

Glass ceramic restorations are popular amongst clinicians due to their superior aesthetic properties. [8] Lithium disilicate ceramic restoration (IPS e.max CAD; Ivoclar Vivadent, Schaan, Lichtenstein) is one of the monolithic ceramic systems that has gained popularity for anterior and posterior single crowns as well as partial coverage restorations because of its superior physical properties.[9]Lithium disilicate ceramic is one of the monolithic CAD-CAM materials developed to provide exceptional esthetics without requiring a veneering porcelain. [10]Lithium disilicate crystal ceramics present outstanding esthetics, high strength, and the ability to be cemented or adhesively bonded. Owing to its fairly low refractive index, this material can be very translucent.[3]

Recently, a Zirconia reinforced lithium silicate glass ceramic (Vita Suprinity; Vita Zahnfabrick, Bad Säckingen, Germany) for dental CAD/CAM applications for the fabrication of inlays, onlays, partial crowns, veneers, anterior and posterior crowns has been introduced to the dental market which aims to combine the positive material characteristics of both lithium disilicate ceramic and zirconia. This new glass ceramic is enriched with zirconia (≈10% by weight). It has been proposed that the structure which is obtained after crystallization, exhibits enhanced mechanical properties and fulfils the highest esthetic requirement.[9]

Monolithic CAD-CAM materials are presented to satisfy demand for esthetically acceptable restorations with better optical and physical properties.[11]With the expanding use of dental CAD/CAM systems, ceramics with different compositions have been introduced to solve this problem and satisfy patient demand for natural looking restorations, it also reduces the number of clinical appointments and manufacturing time needed to produce esthetic ceramic restorations.[10]

Therefore, the purpose of this in vitro study was to investigate the physical, and optical characterization of two esthetic commercially available materials ie. Zirconia reinforced lithium disilicate and Lithium disilicate fabricated by CAD/CAM system.

II. Material and Methods

For the present study, Zirconia-reinforced lithium silicate and Lithium disilicate were tested for translucency. Two groups were made each consisting of 7 samples.

Group 1 was Zirconia- reinforced lithium silicate and Group 2 was Lithium disilicate. The samples were fabricated by CAD/CAM system.

MATERIALS

1) Zirconia reinforced lithium silicate. (Vita suprinity, Vita Zahnfabrick, Bad Säckingen, Germany) **(Fig 1)**

2) Lithium disilicate (IPS E.max CAD; Ivoclar Vivadent, Schaan, Lichtenstein) **(Fig 2)**

Fig 1: Zirconia reinforced lithium silicate ingot (Vita Suprinity; Vita Zahnfabrick, Bad Säckingen, Germany)

Fig 2: Lithium disilicate ingot (IPS e.max CAD; Ivoclar Vivadent, Schaan, Lichtenstein)

EQUIPMENT

1) Desktop scanner (Shining 3D company, India)
2) CAM machine (Arum 5X-300D, Korea)
3) Vernier caliper (Mitutoyo, Japan)
4) Spectrophotometry (VITA EASY SHADE ADVANCE V, Germany)
5) Cad Software (Exocad software)

Fig 3: Wet milling of zirconia reinforced lithium silicate ingot

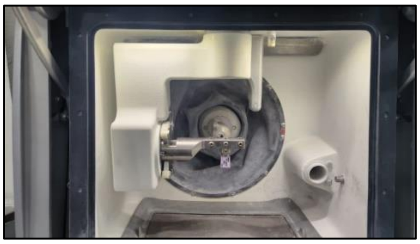


Fig 4: Wet milling of lithium disilicate ingot

Study design:

This experimental In vitro study was carried out at Department of Prosthodontics, Crown & Bridge.

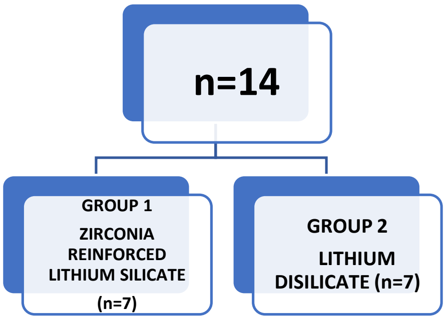
Sample size:

The sample size was estimated by using G power 3.1.9.2. Software with effect size 0.25, power of study 80%, alpha error 5%, beta error 20%, confidence interval 95% and significance level set at 5%.

The sample size was calculated using this formula:

$$N = \frac{2S^2(Z1+Z2)^2}{(M1-M2)}$$

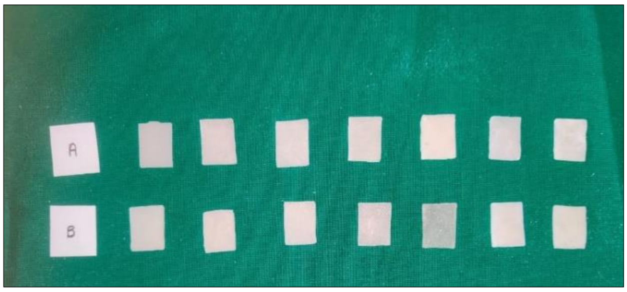
It came out to be **7** samples per group. Hence the sample size was taken to be taken as **7** samples per group. A total of 14 samples were made for the study and were divided into two groups. The Group 1 comprised of 7 samples made using Zirconia reinforced lithium silicate and Group 2 comprised of 7 samples made using Lithium disilicate



Fabrication of the specimen:

The specimens of the dimension 15x10x1.5 mm were first designed in a Exocad software**.** Two types of ceramics materials were used in this study: Zirconia reinforced lithium silicate glass-ceramic (Vita Suprinity; VS) **(Fig 1)** and Lithium disilicate glass-ceramic (IPS e.max CAD; IC) **(Fig 2)** The thickness of the wax patterns was verified according to the decided dimensions using vernier caliper. Pre-crystallized CAD-CAM blocks (15×10×1.5mm) were sectioned perpendicularly with a diamond blade blocks using a water cooled low-speed diamond saw and polished. The specimens (zirconia reinforced lithium silicate and lithium disilicate) with the required dimensions for each test were cut out from respective After that, the specimens were fully crystallized using a Programat P500 furnace following the respective manufacturer's recommendations. Specimen surfaces were polished under water cooling in a polishing machine.

The machinable lithium disilicate ceramic blocks consist of a metasilicate phase and display a bluish color. After milling the restoration from the blank, the metasilicate phase is transferred to the final lithium disilicate structure, obtained by a crystallization firing at 84^0C for 25min.



1

2

Fig 5: samples of Group 1 (Zirconia-reinforced lithium silicate)
Group 2 (Lithium disilicate)

Test for translucency

The test for translucency was performed using contrast ratio. The measurements were recorded with spectrophotometer equipped with an integrating sphere with a 10mm opening. The optical head was placed at a 90-degree angle to the specimens according to the manufacturer's instructions.

Measurements were repeated two times consecutively for each specimen and the average L*, a*, and b* values were recorded. ΔL*, Δa*, and Δb* represent the difference in lightness or darkness, red-green axis, and yellow-blue axis, respectively.

Contrast Ratio was calculated with the following equation:

CR = Yb/Yw.

$$Y=\frac{[L+16]^3}{[\ 116\ ]^3}$$

CR has been selected in the present study in order to easily compare results with the most recent literature. CR is the ratio of the reflectance of a specimen over a black backing (Yb) to that over a white backing (Yw) of a known reflectance, and is an estimate of opacity.CR ranges from 0 to 1, with 0 corresponding to transparency (totally translucent) and 1 corresponding to total opacity (absence of translucency).

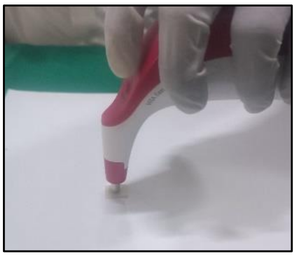
Process of sampling

A) INCLUSION CRITERIA

- Finished and polished samples.
- Samples without cracks.
- Samples without bubble.
- Samples with dimension 15x10x1.5mm more or less 0.5 mm.

B) EXCLUSION CRITERIA

- Unfinished and unpolished samples.
- Samples with dimension more or less 0.8 – 1mm
- Samples damaged during fabrication.



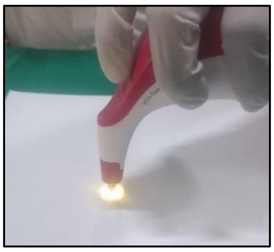


Fig 6: testing of samples on white background

Fig 7: testing of samples on black background

***Statistical Analysis*:**

Statistical analysis was performed using Statistical Product and service solution (SPSS) version 21 for Windows (SPCC Inc, IBM Chicago, IL). Confidence interval was set at 95% and probability of alpha error set at 5% Power of study set at 80%. Descriptive quantitative data was expressed in mean and standard deviation respectively. Data normality will be checked by Shapiro-Wilk Test. Inter group comparison of means between two study groups that is lithium disilicate and zirconia reinforced lithium silicate restorative materials was done using a paired t test.

Descriptive statistics in respect to translucency between Group 1 (Zirconia reinforced lithium silicate), Group 2 (Lithium disilicate) are given in Table no.1.The mean value and standard deviation for Group 1 (Zirconia reinforced lithium silicate) were 0.86 and 0.04. The mean value and standard deviation for Group 2 (Lithium disilicate) were 0.78 and 0.05.

The results obtained in this study using Zirconia reinforced lithium silicate and Lithium disilicate were comparable and within acceptable limits, a statistically significant difference was found between the study groups ($p< 0.001$).

The null hypothesis tested was that, there is no difference in the translucency of anterior ceramic restorations fabricated by CAD/CAM system. As statistically significant difference was found in translucency values of anterior ceramic restorations fabricated by CAD/CAM systems, the null hypothesis was rejected.

III. Results

The results of the mean translucency values of zirconia reinforced lithium silicate and lithium disilicate are shown in the table no.1. the paired t- test revealed that significant difference was observed between contrast ratio of the two groups. The mean CR value for lithium silicate was 0.78 and that of ZLS was 0.86. As the CR value for LDS is closer to 0 that means it is more translucent than ZLS.

Table 1: Descriptive statistics of contrast ratio of zirconia-reinforced lithium silicate and lithium disilicate for anterior restoration fabricated by CAD/CAM system

	Mean	SD	SE	Minimum	Maximum
Group1 (ZLS)	**0.86**	**0.04**	**0.01**	**0.82**	**0.92**
Group 2 (LDS)	**0.78**	**0.05**	**0.02**	**0.75**	**0.91**

IV. DISCUSSION

All-ceramic restorations are popularly applied in dentistry, thanks to their excellent biocompatibility and natural appearance as compared to conventional porcelain-fused-to-metal (PFM) crowns and bridges, this together with the benefit of CAD/CAM for faster fabrication.[12] The fabrication of a natural looking restoration requires not only color matching (value, hue, and chroma) but also matched translucency which is determined as the relative amount of light that is absorbed, transmitted, or reflected.[10]Patient expectations for natural-looking restorations have increased in recent years. Thus, ceramic restorations have become popular for the fabrication of dental restorations with improved esthetics. Normally, human eye is most sensitive to 555 nm wavelength. In translucency, when light passes through a material, it interacts with it in several ways depending upon the nature of the material and the light wavelength resulting in the combination of reflection, absorption and transmission of photons.[13] Translucency is a determining factor in material selection and is an essential optical property, especially for restorations in the esthetic zone.[10]

Restorations with optimal translucency are required for the fabrication of life-like restorations. Therefore, clinicians should be familiar with the translucency of newly introduced monolithic CAD/CAM materials when they choose the most appropriate material for a specific clinical situation. In order to achieve excellent aesthetics, material thickness should not be excessive because increased thickness is related to lower translucency.[7]

This study was performed to evaluate and compare the translucency of two anterior esthetic materials namely Lithium disilicate and Zirconia reinforced lithium silicate for anterior restoration fabricated by CAD/CAM system.

The aesthetic demands of clinicians and patients have led manufacturers to improve upon the translucency of zirconia and lithium disilicate ceramics.

In a study done by **Paolo Baldissara[4]**CAD/CAM ceramic translucency was evaluated using flat specimens of a standardized thickness by applying the contrast ratio method. Similarly in the present study specimens were CAD designed and fabricated with a standard thickness (15x10x1.5 mm). It was concluded in his study, that higher sintering temperatures leads to a more uniform crystalline arrangement, thus promoting better specular reflection and light transmission leading to a better perception of color.

The translucency of the fabricated specimens was evaluated. Group 2 (Lithium disilicate) (0.78) showed higher translucency value than Group 1 (Zirconia reinforced lithium silicate) (0.86) the results were statistically significant ($P = 0.089$).

Previous studies done by **Gulce Alp[14]** showed that LDS had higher translucency than ZLS before and after aging. Therefore, LDS may be preferred to ZLS for situations where the adjacent natural teeth are translucent. In their study, a thickness of 1.5 mm was used for both of the materials because the manufacturers recommended a minimum thickness of 1.5 mm for a crown restoration using these materials.

On the other hand, **Nazmiye Sen (2018) [10]** found that Zirconia-reinforced glass-ceramic reported to have a higher mean translucency parameter value than lithium disilicate ceramic. Unlike the contrast ratio test, translucency parameter test was conducted. The results of the test showed that the mean translucency parameter value of the zirconia reinforced lithium silicate was significantly higher than the translucency parameter values of the lithium disilicate.

Although translucency has clinical importance in the esthetics and natural appearance of restoration materials, few studies have investigated TP values for ZLS glass-ceramic. **Sen et al., Awad et al., and Caprak et al. (2015)[15]** showed that Vita Suprinity (ZLS) showed the highest TP values in all of these studies. The better TP values for ZLS ceramic might be due to the high glass content that results from smaller silicate crystals in the lithium silicate glassy matrix.

Since the results obtained in this study using Zirconia reinforced lithium silicate and Lithium disilicate were comparable and within acceptable limits, all of these anterior restorative materials fabricated by CAD/CAM system can be considered for further clinical evaluation.

Limitations of this study:

1) This in vitro investigation could not completely simulate clinical conditions. Therefore, further research of the optical properties of monolithic CAD-CAM restorative material is needed, especially by simulating the variables of the intraoral environment to make definitive clinical recommendations.

2) The other limitation was that the specimens were flat and no cementation procedure was applied. Color changes can be perceptible when cementation is applied. However, the effect of resin cements and underlying tooth color on the optical properties of glass-ceramic are other materials that could be investigated in further research.

V. CONCLUSION

Within the limitations of the study in which zirconia reinforced lithium silicate and lithium disilicate were evaluated for translucency. The following conclusions were drawn:

1) This present study evaluated and compared the translucency and of Zirconia-reinforced lithium silicate and Lithium disilicate for anterior restoration fabricated by CAD/CAM system.
2) Statistically significant difference was found between the translucency of Lithium disilicate and zirconia reinforced lithium silicate. (p = 0.089).

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