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Comparison of Translucency and Flexural Strength of Zirconia Reinforced Lithium Silicate, Zirconia and Lithium Disilicate

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Abstract

Objectives: Optimal mechanical and aesthetic properties are expected from all ceramic restorations in dentistry to maintain good prognosis. Zirconia restorations have had mechanical advantages and lithium disilicate ceramics have provided aesthetic advantages. This study intended to compare the four-point flexural strength and translucency of zirconia reinforced lithium silicate with solid zirconia and lithium disilicate.
Material and Methods: 90 bars (1x4x18 mm) for flexural strength test (n=30) and 30 square shaped (1x10x10 mm) samples for translucency measurement (n=10) were obtained from solid zirconia (BR-BruxZir), zirconia reinforced lithium silicate (VS-Vita Suprinity) and lithium disilicate (EM-Emax CAD) blocks. All BR samples were sintered, VS and EM were crystallized according to the manufacturer's recommendations. These samples were grinded and polished. Subsequently, they were ultrasonically cleaned and flexural strength values (MPa) were obtained in a universal test device. Color measurements were performed with a dental spectrophotometer using black and white backgrounds to determine the translucency values. Statistical analysis was performed using one-way ANOVA and Tukey HSD tests. Results: BR showed the highest mean flexural strength. There was no significant difference between EM and VS ($p>0.05$), while BR showed significantly different flexural strength ($p<0.05$). EM and VS showed similar translucency, whereas translucency of BR was significantly lower than other groups ($p<0.05$).
Conclusions: Lithium silicate reinforced with zirconia showed similar translucency with lithium disilicate. However, being reinforced with zirconia did not contribute to four point flexural strength.

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Keywords: Four-point flexural strength; lithium disilicate; translucency; zirconia; zirconia reinforced lithium silicate.

Introductıon

Innovations in the production of all-ceramic restorations have attracted attention for the last three decades due to the need for metal-free restorations [1]. Zirconia restorations provide mechanical advantages due to their high hardness and fracture toughness [2], and glass ceramic restorations provide an aesthetic advantage, but their fragility limits their use in areas where chewing force is intense [3]. Therefore, there is an increasing interest in anatomical zirconia restorations that do not require veneer porcelain and have good optical and mechanical properties [4,5]. Solid zirconia is a good alternative to metal-supported porcelain restorations. Its resistant to chipping provides the advantage of use in individuals with bruxism, and could be preferred in cases where there is not enough preparation distance for metal-supported porcelain restorations. Enhanced colloidal production increases the durability of zirconia and improves its translucency. Pre-colored blocks do not require any coloring process before sintering, and after sintering, translucency and color close to natural appearance can be obtained [6]. Lithium disilicate monolithic restorative materials' flexural strength is

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130±30 MPa in the blue phase, when they are in precrystalline form and contain metasilicate and lithium disilicate cores. After the designed restorations are obtained from the blocks, heat treatment is applied. During this heat treatment, metasilicates dissolve, lithium disilicate crystallizes and restoration is obtained according to the selected block color. At this point, the ceramic has a crystal content of 70%, 1.5 µm in size, and it has a 360 Mpa flexural strength [7]. It is reported that the recently introduced zirconia-reinforced lithium silicate CAD/CAM blocks combine the material properties of zirconia and glass ceramics. It is recommended to be used as an anatomical monolithic restoration due to its different colors and translucency [8].
The structure and composition of ceramics affect also the optical properties resulting from its interaction with light [9]. Optical properties have an important role in providing translucency close to the natural tooth and improving the aesthetic results. The CIELab system enables the detection of small color differences in materials and is based on the discrimination of red, green and blue color receptors. In this three-dimensional color space, there are three axes as 'L, a, b'. The 'L' color coordinate represents lightness-darkness; In the 'a' color coordinate, positive values increase green and negative values increase redness; In the 'c' color coordinate, positive values indicate yellowness and negative values indicate blueness. Differences in materials are calculated with the formula ($\Delta E= [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$) [10]. Contrast ratio and/or translucency parameter (TP) are used to determine the translucency property of ceramics. TP is defined as the color difference obtained using black (B) and white (W) backgrounds of a certain thickness [11,12] and is calculated using the 'L,a,b' values with the following equation:
$TP= [(L_B-L_W)^2 +(a_B-a_W)^2 +(b_B-b_W)^2]^{1/2}$ [13]
The aim of this study is to evaluate the mechanical and optical properties of zirconia reinforced lithium silicate material, which was developed to eliminate the risky sides of glass ceramics from a mechanical point of view and polycrystalline ceramics from an aesthetic point of view, and to compare them with solid zirconia and lithium disilicate. The null hypotheses (H_0) of this study are as follows: 1) Flexural strengths of zirconia reinforced lithium silicate and lithium disilicate are similar. 2) Translucency of zirconia reinforced lithium silicate and lithium disilicate is similar.

Materıals and Methods

90 bars (1x4x18 mm) for flexural strength test (n=30) and 30 square shaped (1x10x10 mm) samples for translucency measurement (n=10) were obtained from solid zirconia (BR-BruxZir), zirconia reinforced lithium silicate (VS-Vita Suprinity) and lithium disilicate (EM-Emax CAD) blocks with a precision cutting device (Micracut 151 , Metkon Instruments Inc., Bursa, Turkey) at 250 rpm under water cooling. BR samples were sintered, VS and EM were crystallized according to the manufacturer's recommendations. These samples were grinded and polished with 240, 400, 800, 1200 and 2400 grit SiC. Then they were ultrasonically cleaned in distilled water for 10 minutes and the four-point flexural strength test was performed on a universal test machine (Lloyd LRX, Ametek Inc.). The values were recorded as MPa. The CIELab coordinates of the ceramic samples were determined using a dental spectrophotometer (Vita Easyshade V, Vita Zahnfabrik, Germany). Translucency parameters were measured and calculated for the same sample using black and white backgrounds according to the formula.

Results

The highest mean flexural strength was obtained in the BR, whereas the lowest mean flexural strength was observed in the EM. As a result of the comparisons, it was determined that there was no significant difference between EM and VS ($p>0.05$), however a statistically significant difference was found in the BR group compared to the other groups ($p<0.05$). Table 1 shows the mean flexural strength values (MPa) and comparisons.

In the translucency measurement results, the highest mean value was obtained in the EM and the lowest mean value was observed in the BR. Significantly lower translucency values were obtained in the BR compared to the EM and VS ($p<0.05$). There was no significant difference between EM and VS ($p>0.05$). Table 2 shows the mean translucency values and comparisons.

Bruxzir (BR)	IPS e.max CAD (EM)	Vita Suprinity (VS)
470,32 (98,31) A	139,15 (22,69) B	149,21 (32,99) B
** The same capital letters in the superscript show that there is no significant difference in the groups between the columns (p>0.05).*		

Table 1. Mean flexural strengths of the materials (standard deviation).

Bruxzir (BR)	IPS e.max CAD (EM)	Vita Suprinity (VS)
12,17 (0,60) A	21,26 (1,14) B	21,03 (0,73) B
** The same capital letters in the superscript show that there is no significant difference in the groups between the columns (p>0.05).*		

Table 2. Mean translucency values of the materials (standard deviation).

Discussion

Flexural strength and translucency measurements were made in this study, considering that lithium silicate blocks reinforced with zirconia could combine the aesthetic properties of lithium disilicate and the durability of solid zirconia. Lithium silicate reinforced with zirconia showed similar results to lithium disilicate in terms of flexural strength and translucency. Therefore, null hypotheses were accepted.

The production techniques used for dental ceramics and the structural properties of the materials are effective in determining their durability. Various shapes and sizes of pores, micro and macro cracks, milling parameters are among the factors affecting their durability[14,15]. Biaxial, three-point and four-point flexural strength tests can be used to investigate the mechanical properties of ceramic materials [16]. In this study, it has been shown that zirconia has a significantly higher flexural strength than lithium disilicate. Although it was thought that zirconia-reinforced lithium silicate ceramics would show flexural strength similar to zirconia or higher than lithium disilicate glass ceramics, the results did not confirm this. Therefore, it couldn't be said that lithium silicate containing glassy matrix reinforced with zirconia provides a significant advantage in terms of durability compared to lithium disilicate. In another study[17] the three-point flexural strength of the VS was found to be 179 ± 56 MPa, in our study the four-point flexural strength was determined as 149.21 ± 32.99. In another study[18] comparing LD and VS, the three-point flexural strength was found to be 289 MPa ± 20 and 230 ± 20 MPa respectively, and it was reported that LD had significantly higher flexural strength. It is thought that test mechanisms may lead to different results. The three-point test configuration exposes only a very small portion of the sample to maximum stress. Therefore, the three-point flexural strengths are likely to be much greater than the four-point flexural strengths. Although three-point flexural strength is easier to test, four-point flexural strength is preferred and recommended in determining the properties of materials [19]. In a study[20] on molar crowns, it was reported that zirconia was found to be higher than zirconia-reinforced lithium silicate and lithium disilicate, whereas zirconia-reinforced lithium silicate had significantly the lowest strength. In our study, VS has a higher mean flexural strength than EM, but no significant difference was found.

There are spectrophotometers, colorimeters and imaging systems for clinical evaluation of optical properties. Many devices can be used for color determination [21]. Spectrophotometers are devices that can be used in the evaluation of optical properties and the most accurate measurements can be easily obtained. They record the light transmission and reflection of the object [10]. The scattering of the light coming into the restoration under the surface is an important factor in obtaining the natural appearance. If the majority of the light is scattered or reflected, it causes the material to appear opaque, while the majority of it is transmitted or a small part of it is scattered, making it appear translucent [22]. If the material is completely transparent, all the light is transmitted and the white color is perceived; if it is completely opaque, all light is absorbed and black color is perceived. Generally, however, some of the wavelengths (colors) are absorbed and others transmitted. In this case, the perceived color is determined by the transmitted wavelengths [23]. Metal oxides and opacifiers in ceramics can prevent the transmission of light and adversely affect the translucency feature, which has an important effect on the natural appearance of the restoration [24]. The translucency values of dental ceramics are affected by grain size, chemical structure, pores and crystalline content. Since zirconia does not contain a glassy matrix, it shows lower translucency than other ceramics due to its dense polycrystalline structure [25]. Higher crystalline content increases flexural strength and decreases translucency [26]. In this study, BR showed a significant difference in terms of translucency compared to other groups. Having a polycrystalline content caused it to exhibit lower translucency than other ceramics containing glassy matrix. In a similar study[27], VS showed higher translucency than EM. Bahgat et al[28] showed that VS (22.43±0.69) had a significantly higher translucency than EM (20.41±0.41), and Günal et al[29] showed that EM (16.13±0.33) had a significantly higher translucency than VS (14.26±0.52). In this study, the highest translucency value was observed in the EM group, but no significant difference was found between the translucency values of VS and EM. However, it is thought that the zirconia content in the glassy matrix reduces the translucency value compared to EM.

However, this study was not free of limitations. The specimens were manufactured and tested according to ideal conditions, therefore clinical conditions may not be reflected actually. Degree of technique sensitivity were not evaluated in terms of clinical use. The visual shade detections must also be experienced chairside with the tested ceramics in this study by different thicknesses and color devices.

Conclusıon

VS could not provide an advantage in combining the strength of zirconia and the aesthetic properties of lithium disilicate. Although it has similar properties with EM in terms of translucency, it does not differ in flexural strength. Further studies on the subject will be useful for making comparisons that will contribute to clinical use.

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References

1. Denry I, Holloway JA. Ceramics for dental applications: A review. Materials (Basel). 2010;3(1):351-368. doi:10.3390/ma3010351
2. Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. A review of dental CAD/CAM: Current status and future perspectives from 20 years of experience. Dent Mater J. 2009;28(1):44-56. doi:10.4012/dmj.28.44
3. Albakry M, Guazzato M, Swain MV. Biaxial flexural strength and microstructure changes of two recycled pressable glass ceramics. J Prosthodont. 2004;13(3):141-149. doi:10.1111/j.1532-849X.2004.04025.x
4. Lee WF, Feng SW, Lu YJ, Wu HJ, Peng PW. Effects of two surface finishes on the color of cemented and colored anatomic-contour zirconia crowns. J Prosthet Dent. 2016;116(2):264-268. doi:10.1016/j.prosdent.2015.12.012
5.Baldissara P, Wandscher VF, Marchionatti AME, Parisi C, Monaco C, Ciocca L. Translucency of IPS e.max and cubic zirconia monolithic crowns. J Prosthet Dent. 2018;120(2):269-275. doi:10.1016/j.prosdent.2017.09.007
6. Do U, Anleitung GD. Bruxzir® milling blanks english. 1200:1-2.
7. Culp L, McLaren EA. Lithium disilicate: the restorative material of multiple options. Compend Contin Educ Dent. 2010;31(9):1-8.
8.Suprinity V. No Title. Published 2022. https://www.vita-zahnfabrik.com/en/VITA-SUPRINITY-PC-44049.html
9. Norton CBCG. Ceramic Materials: Science and Engineering. Springer Science & Business Media; 2007.
10.Kim-Pusateri S, Brewer JD, Davis EL, Wee AG. Reliability and accuracy of four dental shade-matching devices. J Prosthet Dent. 2009;101(3):193-199. doi:10.1016/S0022-3913(09)60028-7
11.Johnston WM, Reisbick MH. Color and translucency changes during and after curing of esthetic restorative materials. Dent Mater. 1997;13(2):89-97. doi:10.1016/S0109-5641(97)80017-6
12. Johnston WM. Review of translucency determinations and applications to dental materials. J Esthet Restor Dent. 2014;26(4):217-223. doi:10.1111/jerd.12112
13. Johnston WM, Ma T, Kienle BH. Translucency parameter of colorants for maxillofacial prostheses. Int J Prosthodont. 1995;8(1):79-86. http://www.ncbi.nlm.nih.gov/pubmed/7710631
14. Quinn GD, Hoffman K, Quinn JB. Strength and fracture origins of a feldspathic porcelain. Dent Mater. 2012;28(5):502-511. doi:10.1016/j.dental.2011.12.005
15. Mackert J, Williams AL. Microcracks in dental porcelain and their behavior during multiple firing. J Dent Res. 1996;75(7):1484-1490. doi:10.1177/00220345960750070801
16. Anusavice KJ, Kakar K, Ferree N. Which mechanical and physical testing methods are relevant for predicting the clinical performance of ceramic-based dental prostheses? Clin Oral Implants Res. 2007;18(SUPPL. 3):218-231. doi:10.1111/j.1600-0501.2007.01460.x
17. Ottoni R, Griggs JA, Corazza PH, Della Bona Á, Borba M. Precision of different fatigue methods for predicting glass-ceramic failure. J Mech Behav Biomed Mater. 2018;88(August):497-503. doi:10.1016/j.jmbbm.2018.09.004
18. Furtado de Mendonca A, Shahmoradi M, de Gouvêa CVD, De Souza GM, Ellakwa A. Microstructural and Mechanical Characterization of CAD/CAM Materials for Monolithic Dental Restorations. J Prosthodont. 2019;28(2):e587-e594. doi:10.1111/jopr.12964
19. Desk O. Standard Test Method for Flexural Strength of Advanced Ceramics at Ambient. Order A J Theory Ordered Sets Its Appl. 2003;03:1-19. doi:10.1520/C1161-13.2
20.Kashkari A, Yilmaz B, Brantley WA, Schricker SR, Johnston WM. Fracture analysis of monolithic CAD-CAM crowns. J Esthet Restor Dent. 2019;31(4):346-352. doi:10.1111/jerd.12462

21.Chu SJ, Trushkowsky RD, Paravina RD. Dental color matching instruments and systems. Review of clinical and research aspects. J Dent. 2010;38(SUPPL. 2):2-16. doi:10.1016/j.jdent.2010.07.001
22.Sulaiman TA, Abdulmajeed AA, Donovan TE, et al. Optical properties and light irradiance of monolithic zirconia at variable thicknesses. Dent Mater. 2015;31(10):1180-1187. doi:10.1016/j.dental.2015.06.016
23. Chu SJ, Devigus A, Paravina R, Mielesezko A. Fundamentals of Color: Shade Matching and Communication in Esthetic Dentistry. Quintessence, 2004:7-19.
24. Brodbelt RHW, O'brien WJ, Fan PL. Translucency of Dental Porcelains. J Dent Res. 1980;59(1):70-75. doi:10.1177/00220345800590011101
25. Vichi A, Carrabba M, Paravina R, Ferrari M. Translucency of ceramic materials for CEREC CAD/CAM system. J Esthet Restor Dent. 2014;26(4):224-231. doi:10.1111/jerd.12105
26. Sakaguchi RL, Powers JM. Craig's Restorative Dental Materials. Philadelphia:Elsevier, 2012:253–75.
27. Sen N, Us YO. Mechanical and optical properties of monolithic CAD-CAM restorative materials. J Prosthet Dent. 2018;119(4):593-599. doi:10.1016/j.prosdent.2017.06.012
28. Linhares LA, Pottmaier LF, Gré CP, De Ré Silveira RC, Shibata S, Vieira LCC. Effect of zirconia addition to lithium disilicate ceramic on translucency and bond strength using different adhesive strategies. Dent Mater. 2015;31(October):e28. doi:10.1016/j.dental.2015.08.064
29. Gunal B, Ulusoy MM. Optical properties of contemporary monolithic CAD-CAM restorative materials at different thicknesses. J Esthet Restor Dent. 2018;30(5):434-441. doi:10.1111/jerd.12382