




Influence of occlusal thickness on the fracture resistance of chairside milled lithium disilicate posterior full-coverage single-unit prostheses containing virgilitite: A comparative in vitro study

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Abstract

Purpose: To evaluate the fracture resistance of chairside computer-aided design and computer-aided manufacturing (CAD-CAM) lithium disilicate mandibular posterior crowns with virgilitite of different occlusal thicknesses and compare them to traditional lithium disilicate crowns.

Materials and Methods: Seventy-five chairside CAD-CAM crowns were fabricated for mandibular right first molars, 60 from novel lithium disilicate with virgilitite (CEREC Tessera, Dentsply Sirona), and 15 from traditional lithium disilicate (e.max CAD, Ivoclar Vivadent). These crowns were distributed across five groups based on occlusal thickness and material: Group 1 featured CEREC Tessera crowns with 0.8 mm thickness, Group 2 had 1.0 mm thickness, Group 3 had 1.2 mm thickness, Group 4 with 1.5 mm thickness, and Group 5 included e.max CAD crowns with 1.0 mm thickness. These crowns were luted onto 3D-printed resin dies using Multilink Automix resin cement (Ivoclar Vivadent). Subsequently, they underwent cyclic loading (2,000,000 cycles at 1 Hz with a 275 N force) and loading until fracture. Scanning electron

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microscopy (SEM) assessed the fractured specimens. Statistical analysis involved one-way ANOVA and the Kruskal-Wallis Test ($\alpha = 0.05$).

Results: Fracture resistance varied significantly (<0.001) across mandibular molar crowns fabricated from chairside CAD-CAM lithium disilicate containing virgilitite, particularly between crowns with 0.8 mm and those with 1.2 and 1.5 mm occlusal thickness. However, no significant differences were found when comparing crowns with 1, 1.2, and 1.5 mm thicknesses. CEREC Tessera crowns with 1.5 mm thickness exhibited the highest resistance (2119 N/mm²), followed by those with 1.2 mm (1982 N/mm²), 1.0 mm (1763 N/mm²), and 0.8 mm (1144 N/mm²) thickness, whereas e.max CAD crowns with 1.0 mm occlusal thickness displayed the lowest resistance (814 N/mm²).

Conclusions: The relationship between thickness and fracture resistance in the virgilitite lithium disilicate full-coverage crowns was directly proportional, indicating that increased thickness corresponded to higher fracture resistance. No significant differences were noted among crowns with thicknesses ranging from 1 to 1.5 mm. This novel ceramic exhibited superior fracture resistance compared to traditional lithium disilicate.

KEYWORDS

CAD-CAM systems, computer-aided design, dental crowns, dental materials, dental occlusion

Lithium disilicate ceramics, initially introduced in 1988 as IPS Empress 2, have undergone significant advancements in composition and manufacturing methods.^{1,2} These ceramics, classified as glass ceramics, found their early application in heat-pressed restorations with a crystalline lithium disilicate filler content of around 70%, providing a flexural strength of 350 MPa.^{3,4} In 2005, the introduction of IPS e.max Press marked an improvement in optical and mechanical features, achieving flexural strength values ranging from 370 to 460 MPa.⁵ This enhancement was attributed to the presence of elongated and closely interlocked disilicate crystals, inhibiting crack propagation.⁶ The integration of computer-aided design and manufacturing (CAD-CAM) technology into dentistry led to the development of ceramics compatible with these modern techniques. In 2006, IPS e.max CAD emerged as a CAD-CAM-specific lithium disilicate material, offering practitioners greater versatility.⁷

The lithium disilicate crystalline content undergoes different stages during the crystallization process, categorized into three phases.^{8–11} The transformation concludes with lithium metasilicate crystals (blue stage) evolving into lithium disilicate crystals. The current CAD-CAM lithium disilicate version (e.max CAD by Ivoclar Vivadent), featuring 0.2–1.0-micron platelet-shaped crystals, is provided in partially crystallized blocks. These blocks come in a range of shades and translucency levels and require full crystallization in a furnace for clinical application to achieve the desired shade and translucency.⁸ With approximately 40% lithium metasilicate crystals (Li₂SiO₃) embedded in a glassy phase alongside lithium disilicate nuclei, these ceramics demonstrate excellent properties.^{4,9} Clinicians in Austria and Saudi Arabia widely adopted chairside CAD-CAM systems (e.g., PrimeScan, Dentsply Sirona),^{12,13} and patients favor the convenience of digital impressions.^{14,15} Chairside CAD-CAM lithium disilicate, like e.max CAD, has consistently demonstrated its

clinical effectiveness, with survival rates over 95%.¹⁶ Due to its desirable esthetic¹⁷ and mechanical properties,^{8,11} in comparison to other crown materials such as composite resin, zirconia, and metal-ceramic, it has become a popular choice among clinicians. Long-term evaluations endorse CAD-CAM lithium disilicate's durability,^{18,19} affirming its choice for posterior crown restorations in the present *in vitro* study.

Recent developments have introduced novel lithium disilicate ceramics blended 0.5-micron needle-like and 0.2–0.3 micron platelet-like virgilitite crystals within a zirconia glass matrix, requiring a notably shorter partial crystallization process of only 4.5 to 12 min at 760°C, compared to the traditional 20–31 min process,^{20–23} further expanding the range of CAD-CAM materials available to practitioners. One such material, CEREC Tessera by Dentsply Sirona, offers a range of shades and translucency options.^{20,21} This partially crystallized material requires a glazing firing process at 760°C.^{22,23} The choice of cement for CEREC Tessera and IPS e.max CAD crowns might not be influenced by crown thickness²¹ as the company recommends any type of cement (adhesive, self-adhesive, or conventional) for both anterior and posterior crowns. Although Dentsply Sirona claims that this novel ceramic offers a high flexural strength of over 700 MPa, limited independent data is available.^{20,24–28}

Therefore, this study aimed to compare the fracture resistance of a chairside CAD-CAM lithium disilicate with virgilitite crowns for mandibular first molars with varying occlusal thicknesses (i.e., 0.80, 1.00, 1.20, and 1.50 mm). Also, this study compared the resistance of this novel material for prosthetic restorations to the traditional lithium disilicate with identical occlusal thickness (i.e., only in the 1.0 mm scenario). The first null hypothesis was that there is a significant difference among fracture resistance of the virgilitite lithium disilicate crowns based on different thicknesses. The second null hypothesis was that there is no difference in fracture resistance of virgilitite-containing and traditional

TABLE 1 Description of milled ceramic materials included in this study.

Ceramic brand	Manufacturer	Chairside crystallization requirements	Composition
CEREC Tessera ^{20–23}	Dentsply Sirona (Charlotte, NC, USA)	Stand-by temperature: 400°C; closing time: 3:30; heating rate: 60°C/min; firing temperature: 760°C; and holding time: 1:30 min.	57%–80% SiO ₂ ; 11%–19% Li ₂ O; 0%–13% K ₂ O; 0%–11% P ₂ O ₅ ; 0%–8% ZrO ₂ ; 0%–8% ZnO; 0%–12% other oxides.
e.max CAD ^{6–9}	Ivoclar Vivadent (Schaan, Liechtenstein)	Stand-by temperature: 403°C; closing time: 6 min; heating rate: 90°C/min; firing temperature: 820°C; and holding time of 0:10 min.	SiO ₂ : <78%, Li ₂ O: <12% and coloring oxides: <12%.

lithium disilicate posterior crowns with the same occlusal thickness.

MATERIALS AND METHODS

Specimen preparation

The sample size was calculated using G* Power analysis with an effect size of 0.25 or 0.5, significance level ($\alpha = 0.05$), and power (0.8). Further analysis suggested that each group required a sample size ranging from 9 to 35. Considering previous publications that used 10–15 samples per group,^{21,29} a sample size of 15 crowns per group was deemed appropriate for this study.

Four mandibular right first molar typodont teeth (1560 Dentoform, Columbia Dentoform, Lancaster, PA, USA) were prepared with standardized chamfer margins (1.00 mm) and varying occlusal reductions (0.8, 1.00, 1.20, and 1.50 mm). Digital impressions of the prepared teeth were obtained using a chairside CAD-CAM system (CEREC Primescan, Dentsply Sirona, Charlotte, NC, USA). A total of 75 restorations were manufactured, categorized by thickness and material into five groups ($n = 15$ per group): CEREC Tessera crowns with 0.80 mm occlusal thickness, CEREC Tessera crowns with 1.00 mm occlusal thickness, CEREC Tessera crowns with 1.20 mm occlusal thickness, CEREC Tessera crowns with 1.50 mm occlusal thickness, and e.max CAD crowns with 1.00 mm occlusal thickness. Detailed information regarding the chairside CAD-CAM dental ceramics used can be found in Table 1.

The mandibular right first molar teeth were scanned using a laboratory scanner (D100, 3Shape, Copenhagen, Denmark), resulting in the production of 75 resin dies (Model Resin, Formlabs, Somerville, MA, USA) through a three-dimensional (3D) printer (FormLab 3, Formlabs, Somerville, MA, USA). The CEREC Tessera crowns were subjected to glazing and sintering processes as per the guidelines set by the manufacturer. The firing protocols for both CEREC Tessera and e.max CAD crowns strictly followed the manufacturer's instructions. The Programat C2S furnace (Ivoclar Vivadent) was used consistently for both materials, allowing uniformity in terms of heating rate, holding time, cooling rate, peak temperature, vacuum settings, firing cycles, and atmospheric control throughout the processes. Thus, there were no

variations in the firing protocols. Homogeneity testing, which evaluates a sample's compositional and characteristic uniformity, was not conducted in this study as it fell outside the research scope.

All restorations received appropriate intaglio surface treatment with 5% hydrofluoric acid application for 30 s (for CEREC Tessera) and 20 s (for e.max CAD), cleaning with Ivoclean (Ivoclar Vivadent) paste, and silanization with Monobond Plus (Ivoclar Vivadent). Printed resin dies underwent 38% etching with Total Etch (Ivoclar Vivadent) for 165 s, followed by rinsing and air-drying. Cementation of restorations was accomplished using Multilink Automix resin cement (Ivoclar Vivadent) under a load of 200 g. It was light-cured from occlusal, buccal, lingual, mesial, and distal for 20 s in each area and allowed to self-cure for 6 min.

Fracture assessment

In this study, the measured outcome was fracture resistance, quantified as the maximum stress a material can withstand without failure,³⁰ usually expressed in megapascals (MPa) or Newtons per square millimeter (N/mm²). This critical property assesses the durability of dental restorations, which, if below the necessary threshold, are prone to fracture under typical chewing forces, necessitating additional clinical intervention.^{31,32}

The cemented restorations were securely positioned within a steel jig and subjected to cyclic loading using polyethylene balls (Delrin Dupont, Wilmington, DE, USA) for 5 million cycles at 1 Hz, applying a load of 275 N, all conducted in a controlled environment (distilled water) at 23°C (Figure 1). Subsequently, restorations were loaded until fracture, and load values were recorded in Newtons using an Instron 4204 testing machine (Norwood, MA, USA).

SEM imaging

All specimens were visually assessed, and one specimen per group was chosen for scanning electron microscopy (SEM) images. The selected specimen exhibited patterns similar to all other specimens within the same group. Field emission SEM images were obtained by coating the fractured specimens with gold using a sputter coater (Quick Coater

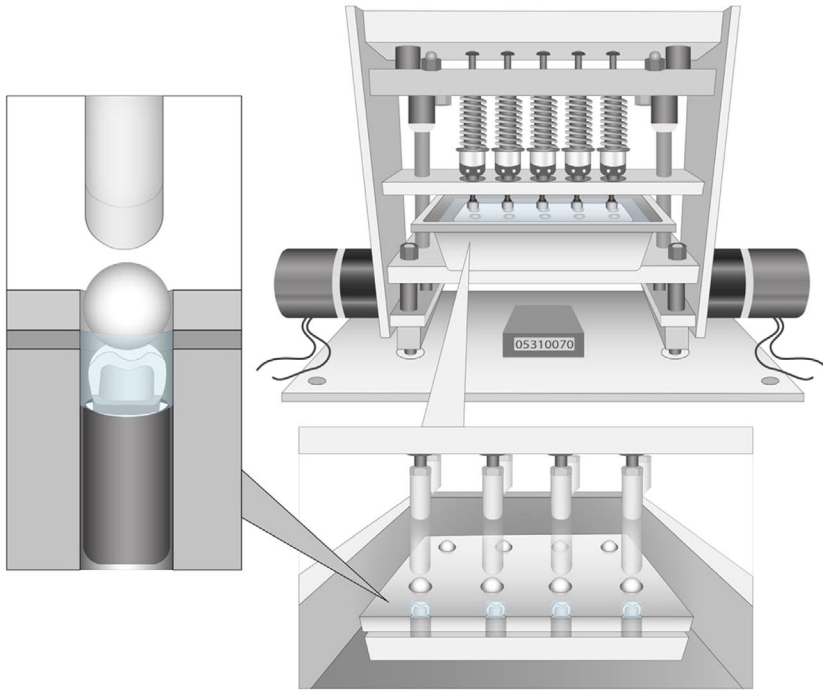


FIGURE 1 Schematic representation of the fatigue loading machine used for subjecting the specimens to cyclic loading before fracture testing.

Type SC-701, Sanyu Electric, Singapore) to ensure electrical conductivity. The images were captured at an accelerating voltage of 15 kV.

Data analysis

The fracture resistance data were statistically analyzed using the independent-sample Kruskal-Wallis test (SPSS Statistics 25, IBM, Armonk, NY, USA) to assess the influence of crown thickness at a significance level ($\alpha = 0.05$). Pairwise comparisons with Bonferroni correction were conducted to evaluate differences between novel and traditional ceramics of the same and different thicknesses.

RESULTS

Fracture test for restorations

The fracture resistance of novel chairside CAD-CAM lithium disilicate with virgillite, with varying thicknesses, and traditional lithium disilicate is summarized in Table 2. The fracture resistance of lithium disilicate with virgillite (CEREC Tessera) posterior crowns varied with occlusal thickness. For instance, crowns with 1.5 mm occlusal thickness showed the highest mean resistance at 2119 N/mm², followed by 1.20 mm at 1982 N/mm², 1.00 mm at 1763 N/mm², and thinner 0.80 mm crowns at 1144 N/mm². Traditional lithium disilicate (e.max CAD) crowns at 1.00 mm had the lowest mean resistance, at 814 N/mm². The fracture resistance values across different thicknesses and between the two ceramic materials had significant differences (Table 3).

SEM observations

SEM analysis of the fractured specimens utilized a fractographic approach (Supplementary Figures 1 and 2). Thinner lithium disilicate restorations with virgillite, especially at 0.80 and 1.00 mm thicknesses, showed fewer, more distinct fracture lines. In contrast, those at 1.20 and 1.50 mm displayed complex crack patterns with notable irregularities, with the 1.50 mm variant uniquely revealing fracture lines in the resin die.

DISCUSSION

A primary aim of this comparative *in vitro* study was to assess the fracture resistance of chairside CAD-CAM lithium disilicate with virgillite posterior crowns of varying occlusal thicknesses. The findings supported the first hypothesis, indicating significant differences in fracture resistance among virgillite-containing crowns with different occlusal thicknesses (Tables 2 and 3). Considering that the novel ceramic with 1.00 mm thickness demonstrated a resistance twice that of traditional lithium disilicate, the second null hypothesis, which suggested no difference in fracture resistance between the novel lithium disilicate containing virgillite and traditional lithium disilicate with the same occlusal thickness, was rejected.

Recent studies have investigated the fracture resistance of chairside CAD-CAM dental ceramics. Findings indicate significant differences in fracture resistance based on occlusal thickness. A study on traditional chairside CAD-CAM lithium disilicate e.max CAD crowns showed that thickness impacts fracture resistance, with 1.50 mm crowns

TABLE 2 Fracture resistance of milled lithium disilicate containing virgillite and traditional lithium disilicate molar crowns.

Group	Material	Thickness	Number of samples	Load for fracture mean in N/mm ² (SD)
1	CEREC Tessera (Dentsply Sirona)	0.80 mm	15	1144 (280) ^{A,B,C}
2	CEREC Tessera (Dentsply Sirona)	1.00 mm	15	1763 (561) ^D
3	CEREC Tessera (Dentsply Sirona)	1.20 mm	15	1982 (457) ^{A,E}
4	CEREC Tessera (Dentsply Sirona)	1.50 mm	15	2119 (508) ^{B,F}
5	e.max CAD (Ivoclar Vivadent)	1.00 mm	15	814 (146) ^{D,E,F}

Note: Significant differences are indicated by the presence of the same uppercase superscript letter within the load for fracture column.

See Table 3 for detailed information on Bonferroni's pairwise comparisons.

Abbreviation: SD, standard deviation.

TABLE 3 Pairwise comparisons of the fracture resistance of milled ceramic molar crowns.

	Group 1 (CT 0.80 mm)	Group 2 (CT 1.00 mm)	Group 3 (CT 1.20 mm)	Group 4 (CT 1.50 mm)	Group 5 (EC 1.00 mm)
Group 1 (CT 0.80 mm)					
Group 2 (CT 1.00 mm)	0.069				
Group 3 (CT 1.20 mm)	0.004	1.000			
Group 4 (CT 1.50 mm)	0.003	1.000	1.000		
Group 5 (EC 1.00 mm)	0.930	0.001	<0.001	<0.001	

Note: Sequential Bonferroni significance.

Abbreviations: CT, CEREC Tessera; EC, e.max CAD.

withstanding 1540 N, 1.00 mm crowns 1162 N, and 0.80 mm crowns 980 N.³³ Similarly, zirconia crowns displayed varying resistances: 2.0 mm crowns at 5934 N, 1.5 mm at 5540 N, decreasing progressively to 0.5 mm crowns at 1454 N.³⁴ The present study extends these findings to novel ceramic materials,^{20,24–28} affirming the trend of thickness-related fracture resistance. It also fills a research gap by comparing novel virgillite-reinforced and traditional lithium disilicate mandibular molar crowns, both 1.0 mm thick. In another study comparing virgillite-lithium disilicate and standard lithium disilicate disc-shaped specimens, virgillite-lithium disilicate showed lower fatigue strength, reliability, and surface roughness, while both had similar hardness values.⁵

Total human chewing forces typically range from 100 N during regular chewing to 320 N during habitual occlusion.³⁵ This study's findings reveal that the evaluated dental crowns displayed fracture resistance values between 814 and 2119 N, exceeding the maximum natural biting force. Therefore, it can be inferred that all tested restorations possess fracture resistance within clinically acceptable limits. The SEM results from this study align with another study examining traditional lithium disilicate (IPS e.max CAD) at thicknesses of 0.80, 1.00, and 1.50 mm.³³ The findings indicate that the crowns with 0.80 and 1.00 mm thicknesses exhibited fewer and less visible crack lines compared to the 1.50 mm crowns. The increase in fracture complexity observed in the thicker crowns may be due to the higher bending forces

they are subjected to. In another in vitro study,⁵ evaluating both lithium disilicates, fractures initiated from surface imperfections within the area of tensile stress concentration.

Certain limitations of this study should be considered. First, it concentrated exclusively on mandibular molar crowns; thus, subsequent investigations are advised to incorporate other tooth locations. Another limitation arises from the use of printed dies. While natural dentition would introduce more complexities and variables, such as the need to source a significant number of caries-free molars, manual tooth preparation, and careful handling to prevent desiccation, the use of printed dies is a common practice in in-vitro studies.^{21,29,36,37} The use of a single-load fracture test may not fully replicate the varied mechanical stresses in the dynamic oral environment. Consequently, the failure modes observed in these tests may not fully represent in vivo crown performance. Also, more extensive crack studies are recommended to understand better the fracture patterns. As a result, these findings warrant careful interpretation and further clinical studies are necessary before providing clinical recommendations.

CONCLUSIONS

The fracture resistance of the novel chairside CAD-CAM lithium disilicate molar crowns with virgillite is not sig-


nificantly influenced by variations in occlusal thicknesses between 1 and 1.5 mm. This suggests that within this range, this occlusal thickness may not be a critical factor for clinicians to consider under high-load conditions. The new ceramic material with an occlusal thickness of 0.80 mm displayed higher fracture resistance than traditional lithium disilicate ceramics, even at a greater thickness of 1.00 mm. While providing valuable information for material selection in posterior restorations, clinical recommendations require further research and validation.

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REFERENCES

- Culp L, Empress 2. First year clinical results. *J Dent Technol*. 1999;16:12–15.
- Oh SC, Dong JK, Lüthy H, Schärer P. Strength and microstructure of IPS Empress 2 glass-ceramic after different treatments. *Int J Prosthodont*. 2000;13:468–72.
- Kelly JR, Benetti P. Ceramic materials in dentistry: historical evolution and current practice. *Aust Dent J* 2011;56:84–96.
- Willard A, Gabriel Chu TM. The science and application of IPS e.Max dental ceramic. *Kaohsiung J Med Sci*. 2018;34:238–42.
- Freitas JS, Souza LFB, Pereira GKR, May LG. Surface properties and flexural fatigue strength of an advanced lithium disilicate. *J Mech Behav Biomed Mater*. 2023;147:106154.
- Zarone F, Di Mauro MI, Ausiello P, Ruggiero G, Sorrentino R. Current status on lithium disilicate and zirconia: a narrative review. *BMC Oral Health*. 2019;19:134.
- Guess PC, Stappert CF, Strub JR. Erste klinische Ergebnisse einer prospektiven Studie an IPS e.max Press- und Cerec ProCAD-Teilkronen. *Schweiz Monatsschr Zahnmed*. 2006;116:493–500.
- Sasany R, Yilmaz B. Marginal discrepancy and fracture load of thermomechanically fatigued crowns fabricated with different CAD-CAM techniques. *J Prosthodont*. 2023;32:602–7.
- Vivadent Ivoclar. Scientific Documentation IPS e.max CAD. Liechtenstein. 2011.
- Fasbinder DJ, Dennison JB, Heys D, Neiva G. A clinical evaluation of chairside lithium disilicate CAD/CAM crowns: a two-year report. *J Am Dent Assoc*. 2010;141:10Se4S.
- Lien W, Roberts HW, Platt JA, Vandewalle KS, Hill TJ, Chu T-MG. Microstructural evolution and physical behavior of a lithium disilicate glass-ceramic. *Dent Mater*. 2015;31:928–40.
- Krastev T, Payer M, Krastev Z, Cardelles JFP, Vegh A, Banyai D, et al. The utilisation of CAD/CAM technology amongst Austrian dentists: a pilot study. *Int Dent J*. 2023;73:430–34.
- Nassani MZ, Ibraheem S, Shamsy E, Darwish M, Faden A, Kujan O. A survey of dentists' perception of chair-side CAD/CAM technology. *Healthcare (Basel)*. 2021;9:68.
- de Paris Matos T, Wambier LM, Favoreto MW, Rezende CEE, Reis A, Loguercio A, et al. Patient-related outcomes of conventional impression making versus intraoral scanning for prosthetic rehabilitation: a systematic review and meta-analysis. *J Prosthet Dent*. 2023;130:19–27.
- Afrashtehfar KI, Alnakeb NA, Assery MKM. Accuracy of intraoral scanners versus traditional impressions: a rapid umbrella review. *J Evid Based Dent Pract*. 2022;22(3):101719.
- Aziz A, El-Mowafy O. Six-year clinical performance of lithium disilicate glass-ceramic CAD-CAM versus metal-ceramic crowns. *J Adv Prosthodont*. 2023;15(1):44–54.
- Li R, Lin YC, Sadid-Zadeh R. Shade match comparison of CAD-CAM single crowns to a lithium disilicate crown. *J Prosthodont*. 2024;33(3):246–51. <https://doi.org/10.1111/jopr.13676>
- Makhija SK, Lawson NC, Gilbert GH, Litaker MS, McClelland JA, Louis DR, et al. Dentist material selection for single-unit crowns: findings from the National Dental Practice-Based Research Network. *J Dent*. 2016;55:40–47.
- Rauch A, Reich S, Dalchau L, Schierz O. Clinical survival of chair-side generated monolithic lithium disilicate crowns: 10-year results. *Clin Oral Investig*. 2018;22:1763–69.
- Hölken F, Dietrich H. Restoring teeth with an advanced lithium disilicate ceramic: a case report and 1-year follow-up. *Case Rep Dent*. 2022;2022:6872542.
- Jurado CA, Bora PV, Azpiazu-Flores FX, Cho S-H, Afrashtehfar K-I. Effect of resin cement selection on fracture resistance of chairside CAD-CAM lithium disilicate crowns containing virgillite: a comparative in vitro study. *J Prosthet Dent*. 2023;0022-3913(23)00558-9. <https://doi.org/10.1016/j.prosdent.2023.08.019>
- Phark JH, Duarte S Jr. Microstructural considerations for novel lithium disilicate glass ceramics: a review. *J Esthet Restor Dent*. 2022;34:92–103.
- Demirel M, Diken Türksayar AA, Donmez MB. Translucency, color stability, and biaxial flexural strength of advanced lithium disilicate ceramic after coffee thermocycling. *J Esthet Restor Dent*. 2023;35:390–96.
- Jurado CA, Arndt K, Azpiazu-Flores FX, Faddoul F, França R, Fischer NG, et al. Evaluation of glazing and polishing systems for novel chair-side CAD/CAM lithium disilicate and virgillite crowns. *Oper Dent*. 2023;48(6):689–99.
- Jurado CA, Bora PV, Azpiazu-Flores FX, Cho SH, Afrashtehfar KI. Effect of resin cement selection on fracture resistance of chair-side CAD-CAM lithium disilicate crowns containing virgillite: a comparative in vitro study. *J Prosthet Dent*. 2023;S0022-3913(23)00558-9.
- Rauch A, Schmid A, Schmidt MB, Schmutzler A, Hahnel S, Rosentritt M. Aging and fracture resistance of screw-retained implant-supported molar crowns fabricated from lithium disilicate containing virgillite. *Int J Prosthodont*. 2023. <https://doi.org/10.11607/ijp.8369>. Online ahead of print.
- Hurle K, Lubauer J, Belli R, Lohbauer U. On the assignment of quartz-like LiAlSi(2)O(6)—SiO(2) solid solutions in dental lithium silicate glass-ceramics: virgillite, high quartz, low quartz or stuffed quartz derivatives? *Dent Mater*. 2022;38(9):1558–63.
- Rosentritt M, Schmid A, Huber C, Strasser T. In vitro mastication simulation and wear test of virgillite and advanced lithium disilicate ceramics. *Int J Prosthodont*. 2022;35(6):770–76.
- Jurado CA, Mourad F, Trevino DAC, Gouveia DN, Hyer J, Elgreatly A, et al. Comparison of full and partial coverage crowns with CAD/CAM leucite reinforced ceramic blocks on fracture resistance and fractographic analysis. *Dent Mater J*. 2022;41:295–301.
- The glossary of prosthodontic terms 2023: tenth edition. *J Prosthet Dent*. 2023;130(4 Suppl 1):e7–e126.
- AlHelal AA. Biomechanical behavior of all-ceramic endocrowns fabricated using CAD/CAM: a systematic review. *J Prosthodont Res*. 2024;68(1):50–62.
- Akiba S, Takamizawa T, Tsujimoto A, Nobuyuki M, Ishii R, Barkmeier WW, et al. Influence of different curing modes on flexural properties, fracture toughness, and wear behavior of dual-cure provisional resin-based composites. *Dent Mater J*. 2019;38(5):728–37.

33. Jurado CA, Pinedo F, Trevino DAC, Williams Q, Marquez-Conde A, Irie M, et al. CAD/CAM lithium disilicate ceramic crowns: effect of occlusal thickness on fracture resistance and fractographic analysis. *Dent Mater J*. 2022;41:705–9.
34. Prutt LS, Spitznagel FA, Bonfante EA, Malassa MA, Gierthmuehlen PC. Monolithic zirconia crowns: effect of thickness reduction on fatigue behavior and failure load. *J Adv Prosthodont*. 2021;13:269–80.
35. Lundgren D, Laurell L. Occlusal force pattern during chewing and biting in dentitions restored with fixed bridges of cross-arch extension. I. Bilateral end abutments. *J Oral Rehabil*. 1986;13:57–71.
36. Jurado CA, Sayed Ahmed A, Lawson NC, Azpiaz-Flores FX, Green C, Cho S-H. Fracture resistance of zirconia surveyed crowns with four different occlusal rest seat designs. *J Prosthodont*. 2023. <https://doi.org/10.1111/jopr.13737>. Online ahead of print.
37. Lawson NC, Jurado CA, Huang CT, Morris GP, Burgess JO, Liu PR, et al. Effect of surface treatment and cement on fracture load of traditional zirconia (3Y), translucent zirconia (5Y), and lithium disilicate crowns. *J Prosthodont*. 2019;28:659–65.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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