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RESEARCH AND EDUCATION

Effect of resin cement selection on fracture resistance of chairside CAD-CAM lithium disilicate crowns containing virgilite: A comparative in vitro study

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ABSTRACT

Statement of problem. Studies on the fracture performance of a recently introduced computer-aided design and computer-aided manufacturing (CAD-CAM) lithium disilicate ceramic containing virgilite with different cements are lacking.

Purpose. The purpose of this in vitro study was to evaluate the fracture resistance of crowns made of a recently introduced chairside CAD-CAM lithium disilicate containing virgilite cemented with different types of adhesive luting cement.

Material and methods. Sixty complete coverage crowns for a maxillary right central incisor were milled out of a lithium disilicate with virgilite (CEREC Tessera) (n=48) and a traditional lithium disilicate (e.max CAD) (n=12) using a chairside CAD-CAM system (Primescan). The central incisor tooth preparation included a 1.5-mm incisal reduction, a 1.0-mm axial reduction, and a 1.0-mm chamfer finish line. The restorations were bonded with different types of resin cement to 3D printed dies of the tooth preparation and were divided into 5 groups (n=12 per group): e.max CAD with Multilink Automix (E.Mu); Tessera with Multilink Automix (T.Mu); Tessera with Calibra (T.Ca); Tessera with Unicem (T.Un); and Tessera with Speedcem (T.Sp). The cemented restorations were stored in water for 30 days and then loaded until they were fractured in compression. The load at fracture was analyzed with a 1-way analysis of variance (ANOVA) and the honestly significant difference (HSD) Tukey test (α=.05).

Results. The mean fracture resistance of traditional lithium disilicate and virgilite lithium disilicate anterior crowns significantly differed depending on the type of resin cement used (P<.05). Group E.Mu displayed the highest values (946.35 ±155 N), followed by group T.Un (819.59 ±232 N), group T.Sp (675.52 ±153 N), and group T.Mu (656.95 ±193 N). The lowest values were displayed by group T.Ca (567.94 ±184 N).

Conclusions. The fracture resistance of lithium disilicate containing virgilite and traditional lithium disilicate crowns cemented with the same cement displayed statistically similar values. However, significant differences were observed when the virgilite lithium disilicate crowns were cemented with different types of adhesive luting cement. The crowns in the T.Ca group displayed the lowest fracture resistance. (J Prosthet Dent 2025;133:203-207)

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Clinical Implications

Traditional lithium disilicate ceramics demonstrate higher fracture resistance than lithium disilicate with virgilite ceramics for anterior crowns. The resin cement type influenced fracture resistance.

Recent versions of lithium disilicate ceramics, such as the one containing virgilite (Cerec Tessera; Dentsply Sirona), have been developed for chairside computer-aided design and computer-aided manufacturing (CAD-CAM) systems to improve esthetic and mechanical properties.[1–3] Cerec Tessera is composed of lithium disilicate ($Li_2Si_2O_5$) and virgilite ($Li_{0.5}Al_{0.5}Si_{2.5}O_6$) crystals, with a 0.5-μm-long needle-like shape embedded in a zirconia glass matrix. This ceramic is supplied partially crystallized, with a shortened sintering process time. Although the manufacturer claims better mechanical properties than those of traditional lithium disilicate, limited independent data is available.[3]

An understanding of the cements and adhesive systems used to bond glass-ceramic restorations is important to clinical success.[4–6] Resin cements for glass-ceramics have different properties, numbers of application steps, viscosities, and light polymerization needs and are either self-etching or self-adhesive. Given the wide range of ceramics and cementation techniques available,[7–18] resin cement selection can be challenging for inexperienced clinicians. Therefore, this study aimed to compare the fracture resistance of maxillary right central incisor crowns made with a virgilate-containing lithium disilicate ceramic (Cerec Tessera; Dentsply Sirona) cemented with 4 different resin cements with a traditional lithium disilicate (e.max CAD; Ivoclar AG) as a control. The null hypotheses were that no difference would be found in the fracture resistance of the crowns fabricated with the 2 lithium disilicates or cemented with the 4 resin cements.

MATERIAL AND METHODS

A typodont tooth of a maxillary right central incisor (1560 Dentoform; Columbia Dentoform) was prepared for a ceramic crown with 1.5-mm incisal clearance, 1.0-mm axial reduction, and a 1.0-mm chamfer finish margin. The typodont tooth was scanned with a chairside scanner (Primescan; Dentsply Sirona), and a complete coverage single crown was digitally designed to the dimensions of the original typodont tooth. Sixty complete coverage restorations were milled (CEREC Primemill; Dentsply Sirona): 48 lithium disilicate with virgilite (Cerec Tessera A1, Medium Translucency, C14; Dentsply Sirona) and 12 lithium disilicate (IPS e.max CAD, A1, Medium Translucency, C14; Ivoclar AG). The restorations were glazed and fired (Programat S2; Ivoclar AG) according to the manufacturer's recommendations and polished using a lithium disilicate polishing system (e.max Finishing/Polishing System; Brasseler). The typodont tooth was scanned with a laboratory scanner (Freedom HD; DOF Inc.), and 60 dies were printed from a resin cast using a 3D dental printer (Gray Resin V4, FormLab 3B; Formlabs), washed (From Wash; Formlabs) for 15 minutes with isopropyl alcohol, and polymerized (Form Cure; Formlabs). The crowns were divided into 12 specimens per group, and their intaglio surfaces were treated according to the manufacturers' recommendations (Tables 1, 2).

Before fracture testing, the restorations were immersed in water at 37 °C for 30 days to simulate the oral environment's aging effects. The specimens were then placed in a vertical position, secured in a brass fixture, and loaded against a Ø8-mm stainless-steel ball. A 1.0-mm rubber sheet was placed between the ball and the restorations to distribute the incisal forces. The ball was placed on the incisal edge of the crown. The crowns were loaded at 1.0 mm/min with a universal testing machine (Model 44111; Instron) until fracture, recorded with a 25% reduction in load. The crowns were inspected to ensure that fracture had occurred, and the fracture load was recorded as the maximum compressive force.[19,20]

The data were analyzed using a 1-way analysis of variance (ANOVA) and the honestly significant difference (HSD) Tukey post hoc test (α=.05). All statistical analyses were performed using a statistical software program (IBM SPSS Statistics, v25; IBM Corp).

Table 1. Description of chairside CAD-CAM ceramics tested[19]

Group	Ceramic Type	Manufacturer	Date Released to Market	Composition of Ceramics
E.Mu (control)	e.max CAD	Ivoclar AG	2006	Approximately 65 vol% of lithium disilicate (Li_2O•$2SiO^2$) as principal crystal phase, and 30 vol% glass base.
T.Mu, T.Ca, T.Un, and T.Sp	Cerec Tessera	Dentsply Sirona	2022	Lithium aluminum silicate virgilite crystals. Specific details of composition not disclosed by manufacturer.

CAD-CAM, computer-aided design and computer-aided manufacture; E.Mu, e.max CAD with Multilink Automix; T.Ca, Tessera with Calibra; T.Sp, Tessera with Speedcem; T.Mu, Tessera with Multilink Automix; T.Un, Tessera with Unicem.

Table 2. Description of resin cements tested[15–17]

Group	Type of Cement	Manufacturer	Composition of the Luting Cement	Application Method
E.Mu and T.Mu	Multilink Automix	Ivoclar AG	Dual-polymerized resin cement. MultiLink Automix Cement: Dimethacrylate and HEMA, barium glass, ytterbium trifluoride, spheroid mixed oxide. Multilink Primer A and B: Multilink Primer A: Aqueous solution of proprietary initiators. Multilink Primer B: HEMA, phosphonic acid and acrylic acid monomers.	Restoration etched with 5% hydrofluoric acid for 20 s and rinsed thoroughly. Mixed Multilink Primers A/B applied to all preparation surfaces with slight pressure for 15 s Cement dispensed directly into restoration and seated with steady vertical force.
T.Ca	Calibra	Dentsply Sirona	Self-adhesive dual-polymerizing resin cement. UDMA, di- and tri-methacrylate, phosphoric acid modified acrylate, initiators, accelerators, stabilizer, BHT, Barium boron fluoroaluminosilicate and amorphous silicon dioxide	Restoration prepared similarly to Groups E.Mu and T.Mu* 2 coats of Prime & Bond Active coupling agent applied to intaglio surface of restoration. Cement applied to restoration and seated with steady vertical force.
T.Un	Unicem	3M	Self-adhesive dual-polymerizing resin cement. Methacrylate phosphoric esters, dimethacrylate, acetate, initiators, stabilizers, glass fillers, silica, and calcium hydroxide	Restoration prepared similarly to Groups E.Mu and T.Mu* Cement applied to restoration and seated with steady vertical force.
T.Sp	Speedcem	Ivoclar AG	Self-adhesive dual-polymerizing resin cement. UDMA, TEGDMA, PEGDMA, DDDMA, MDP, dibenzoyl peroxide, stabilizers, barium glass and silica ytterbium trifluoride	Restoration prepared similarly to Groups E.Mu and T.Mu* Monobond Plus applied to intaglio surface and allowed to react for 60 s Cement applied to restoration and seated with steady vertical force.

BHT, butylated hydroxytoluene; DDDMA, 1,10-decanediol dimethacrylate; E.Mu, e.max CAD with Multilink Automix; MDP, methacryloyloxydecyl dihydrogenphosphate; HEMA, 2-hydroxyethyl methacrylate; PEGDMA, polyethylene glycol dimethacrylate; T.Ca, Tessera with Calibra; TEGDMA, triethyleneglycol dimethacrylate; T.Sp, Tessera with Speedcem; T.Mu, Tessera with Multilink Automix; T.Un, Tessera with Unicem; UDMA, urethane dimethacrylate.

RESULTS

Table 3 displays the fracture resistance results. The mean fracture load of traditional lithium disilicate and lithium disilicate containing virgilite for anterior crowns significantly differed depending on the resin cement used. Group e.max CAD with Multilink (E.Mu) had the highest values, whereas the lowest values were in the group Tessera with Calibra (T.Ca). Statistical differences between groups are presented in Table 3, and detailed information on pairwise comparisons is available in Supplemental Table 1 (available online).

DISCUSSION

The present comparative in vitro study aimed to determine whether the type of cement used for lithium disilicate-containing virgilite and traditional lithium disilicate crowns affected their fracture resistance. The null hypothesis that there would be no difference in fracture resistance between crowns fabricated with lithium disilicate and virgilite lithium disilicate with 1 control cement, was rejected. Group E.Mu lithium disilicate crowns displayed significantly different values (P=.003) compared with lithium disilicate crowns with virgilite cemented with the same cement (Multilink Automix). The null hypothesis that there would be no difference in fracture strength between the lithium disilicate crowns containing virgilite cemented with 4 different resin cements was also rejected. Significant differences were found among groups, with group E.Mu having the highest values, followed by group Tessera with Unicem (T.Un), Tessera with Speedcem (T.Sp), and Tessera with Multilink Automix (T.Mu), and the lowest value being found in group T.Ca (Table 3).

A maxillary right central incisor was selected in this study because it is in the esthetic zone, and lithium disilicate ceramic crowns are popular for restoring maxillary anterior teeth to improve esthetic outcomes.[7–9] A national dental practice-based study that surveyed American dentists found that ceramics are the most prevalent materials used for anterior crowns, with lithium disilicate as the first option (54%), followed by porcelain-fused-to-zirconia (17%) and leucite-reinforced ceramic (13%).[10] A recent German survey also showed that lithium disilicate is the most common ceramic choice for maxillary right central incisor crowns (46.7% supragingival margin), followed by porcelain-fused-to-zirconia (28.9% supragingival margin) and zirconia-reinforced lithium disilicate (13.0% supragingival margin).[11]

The authors are unaware of previous studies that assessed the fracture resistance of anterior restorations made of traditional and virgilate-containing lithium disilicate ceramics. The results of the present study

Table 3. Mean fracture resistance of chairside CAD-CAM lithium disilicate ceramic crowns with different resin cements

Group	Ceramic Type (Manufacturer)	Cement Type (Manufacturer)	Mean ±Standard Deviation Force at Complete Fracture (N)
E.Mu	e.max CAD	Multilink Automix	946.35 ±155.85[a,b,d]
T.Mu	Cerec Tessera	Multilink Automix	656.95 ±193.31[a]
T.Ca	Cerec Tessera	Calibra	567.943 ±184.95[b,c]
T.Un	Cerec Tessera	Unicem	819.59 ±232[c]
T.Sp	Cerec Tessera	Speedcem	675.52 ±153.13[d]

CAD-CAM, computer-aided design and computer-aided manufacture; E.Mu, e.max CAD with Multilink Automix; SD, standard deviation; T.Ca, Tessera with Calibra; T.Sp, Tessera with Speedcem; T.Mu, Tessera with Multilink Automix; T.Un, Tessera with Unicem.

Same lowercase letter in column indicates significant difference ($P<.05$).

For detailed information on pairwise comparisons, see Supplemental Table 1 (available online).

showed that, compared with Cerec Tessera, e.max CAD presented similar values for group T.Un but higher values for groups T.Mu, T.Ca, and T.Un. These mixed results were consistent with those of recent studies comparing traditional and recently introduced lithium disilicate ceramics on posterior teeth, including a study[12] that evaluated the fracture resistance of molar crowns made of lithium disilicate containing virgilite (Cerec Tessera) versus lithium disilicate (e.max CAD) cemented with adhesive resin cement (AB), glass ionomer (GIC), and hybrid glass ionomer cement (HGIC). The authors reported no significant differences in fracture force values between the 2 ceramics (2101 ±752 N for AB; 2808 ±1162 N for GIC; 2579 ±783 N for HGIC for Cerec Tessera and 2529 ±468 N for AB; 2995 ±880 N for GIC; 2598 ±614 N for HGIC for e.max CAD). Similarly, another study[13] that evaluated the fracture resistance of lithium disilicate strengthened with aluminosilicate (n!ce; Institut Straumann AG) and traditional lithium disilicate (e.max CAD; Ivoclar AG) for molar crowns reported no significant differences between the newer glazed ceramic (1324 ±498 N) and the traditional ceramic (1550 ±317 N), concluding that their survival rate was comparable.

The fracture resistance of the lithium disilicate maxillary anterior crowns containing virgilite cemented with different types of resin cement displayed significant differences. The cements used in this study are commonly used in clinical practice.[15–17] However, the authors are unaware of studies evaluating the fracture resistance of virgilate-containing lithium disilicate ceramics for anterior crowns with different types of cement, although studies have evaluated traditional lithium disilicate posterior crowns.[19–21] The present study was consistent with previous in vitro studies[18–21] reporting differences in fracture resistance using different dental cements. One study[21] evaluated the fracture resistance of chairside milled lithium disilicate (e.max CAD; Ivoclar AG) molar crowns cemented with resin-modified GIC (RMGIC) (RelyX Luting Plus; 3M) and resin cement (RelyX Unicem 2; 3M) after 100 000 mastication cycles at 100 N. The results suggested that the crowns cemented with resin cement can withstand up to 3765 N. However, the crowns with RMGIC did not withstand the mastication process before the fracture testing.[21] A study[18] evaluating the fracture toughness of flat lithium disilicate specimens with airborne-particle abraded and etched treatment with different types of resin cement evaluated 2 dual-polymerizing resin cements (Panavia F2; Kuraray Dental, and Variolink II; Ivoclar AG) and 1 self-adhesive resin cement (Multilink Sprint; Ivoclar AG), reporting significant differences among them: Variolink II (S: 372 J/m^2; E: 470 J/m^2), Panavia F2 (S: 374 J/m^2; E: 805 J/m^2), and Multilink Sprint (S: 33 J/m^2; E: 357 J/m^2).[18] The authors concluded that the fracture toughness of lithium disilicate glass-ceramic was affected by the surface treatment and type of luting agent.[18]

Limitations of the present study included the use of resin dies instead of natural dentition; although resin dies have been used in several in vitro studies,[5,19,20] natural teeth should yield more clinically realistic results. In addition, only 1 new type of lithium disilicate ceramic was tested. Future studies should evaluate more options for dental clinicians. Lastly, this study only evaluated the fracture resistance of maxillary central incisor crowns. Other anterior teeth (such as canines) could also be evaluated to provide more information regarding the behavior of the ceramic.

CONCLUSIONS

Based on the findings of this in vitro study, the following conclusions were drawn:

1. Lithium disilicate ceramics exhibited higher fracture resistance compared with lithium disilicate ceramics containing virgilite.
2. The fracture resistance of maxillary central incisor crowns made with lithium ceramics containing virgilite was influenced by the type of cement used.
3. The choice of cement used for anterior teeth with glass-ceramic restorative materials should be considered to ensure optimal performance of these restorations.

APPENDIX A. SUPPORTING INFORMATION

Supplemental data associated with this article can be found in the online version at doi:10.1016/j.prosdent.2023.08.019.

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