Fracture Resistance of a Selection of Full-Contour All-Ceramic Crowns: An In Vitro Study

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This study aimed to evaluate the fracture resistance of monolithic single crowns made from zirconia (ZI), lithium disilicate (LS2), or feldspar ceramic (FC). Five groups of crowns representing a maxillary first molar were made with the appropriate dimensions according to the manufacturer's instructions. The ZI and LS2 crowns were luted adhesively or cemented conventionally on a metal abutment tooth analog. The feldspar ceramic crowns were luted adhesively. All specimens underwent axial loading until fracture. The crowns in the ZI groups possessed the highest fracture resistance independent of the mode of fixation. *Int J Prosthodont 2014;27:264–266. doi: 10.11607/ijp.3815*

Monolithic zirconia crowns were recently introduced[1] and offer a simple computer-aided design/computer-assisted manufacture (CAD/CAM) model, exhibit high fatigue resistance, and can withstand the mean molar masticatory forces without superficial fracturing of the layering ceramic as frequently observed with veneered zirconia restorations.[2–4]

The purpose of this in vitro study was to evaluate the fracture resistance of adhesively luted or conventionally cemented monolithic posterior single crowns made from zirconia, lithium disilicate, or feldspar ceramic using standardized laboratory conditions. The hypothesis was that full-contour zirconia crowns have a greater fracture resistance than lithium disilicate or feldspar ceramic crowns.

Materials and Methods

A total of 53 all-ceramic single crowns were made based on anatomical design and with equal standardized external geometry from zirconia (ZI) (Cercon ht, DeguDent) (n = 21), lithium disilicate (LS2) (emax-CAD, Ivoclar Vivadent) (n = 21), or feldspar ceramic (FC) (TriLuxe, VITA Zahnfabrik) (n = 11). Three additional crowns (one for each type of ceramic) were included to reflect the material's correct and specific dimensions (Fig 1). The minimum occlusal layer thickness for the crowns was adjusted according to the manufacturer's specifications.

A classic crown preparation with a 6-degree convergence angle, an abutment height of 4 mm, and a circular 0.5-mm chamfer was performed using a plastic maxillary left first molar (Frasaco). The preparation was digitized using a computed tomographic (CT) scanner (Desktop-CT exaCT XS, Wenzel Volumetrik). Metal tooth analogs were designed with a cylinder and a hemispherical socket on the bottom using CAD software (CAD Magics, Materialise) and manufactured via laser sintering (Compartis, DeguDent) with a cobalt-chrome (CoCr) alloy. With respect to their socket dimensions, holes were drilled into an aluminum base plate (length: 10 cm, width: 6 cm, height: 2.8 cm), which enabled the positioning of the tooth analog with a clearance fit. The metal analogs were digitized using a laser scanning system (Cercon eye scanner, DeguDent). Construction of the respective crowns was performed using CAD software (Cercon art v3.2; DeguDent). The ZI crowns were milled using the Cercon brain expert milling device (DeguDent). The LS2 and FC crowns were milled using the inLab MC XL system (Sirona). The physiologic lateral mobility of the metal abutment tooth analogs was simulated using a 0.3-mm rubber shell interposed between the abutment socket and the aluminum base plate (Fig 2a). The specimens for all groups were divided into the subgroups as shown in Table 1.

All of the tooth analogs were degreased with 80% ethanol and conditioned with an alloy primer (Kuraray) if adhesive cementation was applied.

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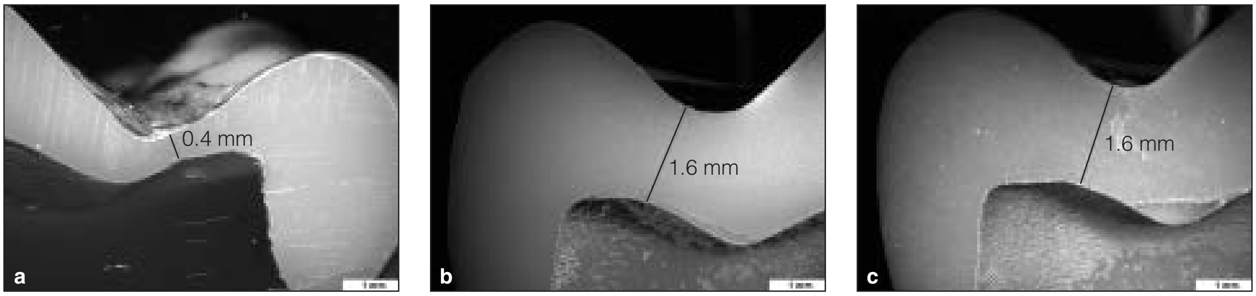

Fig 1 Cross-section surfaces from an additional crown for each material group were viewed using a stereomicroscope and photographed with a digital camera, and the occlusal thickness of the crowns was measured and recorded in millimeters using imaging software. Minimum layer thickness as measured at the presumed thinnest occlusal region of the crowns made from **(a)** zirconia, **(b)** lithium disilicate, or **(c)** feldspar ceramic according to the manufacturer's instructions.

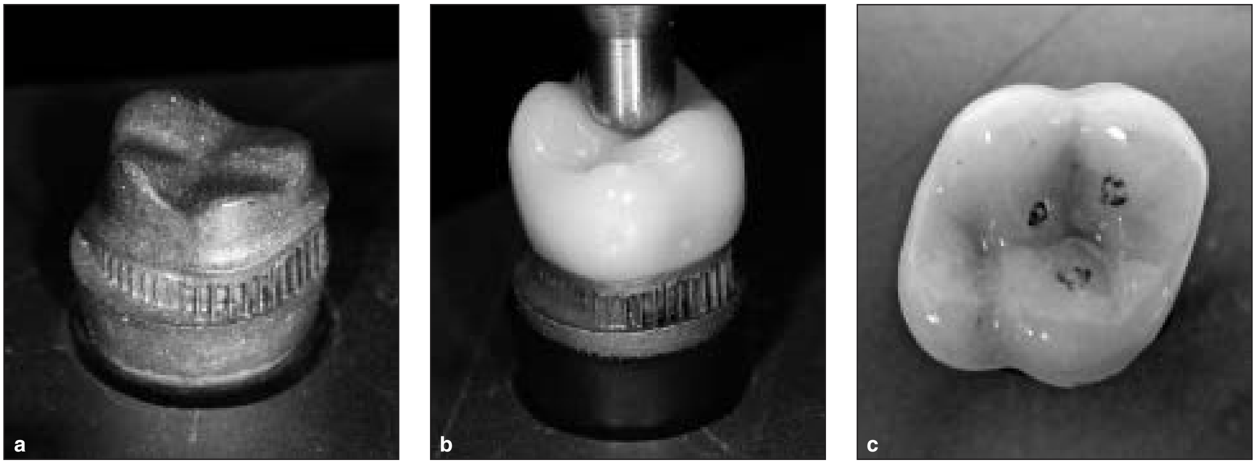

Fig 2 **(a)** A lateral-deflectable metal tooth analog mounted on an aluminum base plate. **(b)** An all-ceramic single crown undergoing axial static loading in a universal testing device. **(c)** The spherical stainless steel piston had a diameter of 4 mm and was positioned on the central fossa with contact at the three cusps. The crosshead speed was set at 0.5 mm/minute.

Table 1 Overview of Materials, Cementation Modes, and Testing Procedures

Group	n	Ceramics	Cementation	Procedure
ZI-1	10	Zirconia, Cercon ht	Panavia F2.0	Static loading, evaluation of the fracture site
ZI-2	10	Zirconia, Cercon ht	Ketac Cem	Static loading, evaluation of the fracture site
ZI-0	1	Zirconia, Cercon ht	None	Measurement of the occlusal layer thickness
LS2-1	10	Lithium-disilicate, emaxCAD	Panavia F2.0	Static loading, evaluation of the fracture site
LS2-2	10	Lithium-disilicate, emaxCAD	Ketac Cem	Static loading, evaluation of the fracture site
LS2-0	1	Lithium-disilicate, emaxCAD	None	Measurement of the occlusal layer thickness
FC-1	10	Feldspar-ceramic, TriLuxe	Panavia F2.0	Static loading, evaluation of the fracture site
FC-0	1	Feldspar-ceramic, TriLuxe	None	Measurement of the occlusal layer thickness

All of the crowns were cleaned by short air abrasion and an ultrasonic bath and degreased with 80% ethanol. The crowns in groups ZI-1, LS2-1, and FC-1 were adhesively luted with Panavia F 2.0 (Kuraray Europe). The crowns in groups ZI-2 and LS2-2 were cemented with glass-ionomer cement (Ketac Cem Aplicap, 3M ESPE). All of the fixation procedures followed the manufacturer's instructions.

All of the crowns were stored in water at a temperature of 37°C for at least 24 hours until they underwent axially static loading until failure (Figs 2b and 2c).

Nonparametric tests were used to analyze the load-bearing capability (ie, Mann-Whitney U and Kruskal-Wallis tests).

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Table 2 Mean Force at the Fracture Site with the Maximum and Minimum Values (N)*

Group	n	Mean	Minimum	Maximum	SD
ZI-1 (zirconia, luted)	10	5,620[a]	4,680	7,260	757
ZI-2 (zirconia, cemented)	10	4,340[a]	3,190	6,550	911
LS2-1 (lithium disilicate, luted)	10	2,700[b]	2,210	3,120	344
LS2-2 (lithium disilicate, cemented)	10	2,710[b]	2,110	3,390	396
FC-1 (feldspar ceramic, luted)	10	1,340[c]	1,120	1,620	163

*The same letters indicate statistically insignificant values ($P > .05$). The ZI crowns showed the highest values for the fracture load, independent of the mode of fixation. Adhesive fixation led to a significantly higher load-bearing capacity in the ZI groups but not in the LS2 groups.

Results

The results from the load-bearing capacity tests are presented in Table 2. The ZI crowns showed the highest values for the fracture load, independent of the mode of fixation, which was significantly different compared with the groups with crowns made from LS2 or FC.

Discussion

For better standardization, metal tooth analogs were used in this study to support the tested crowns. Being aware of the strong influence of the abutment material and its mechanical properties on the fracture resistance results, the authors decided not to work with natural teeth to avoid the natural heterogeneity of biologic samples. Nevertheless, a certain simulation of adhesive fixation was possible due to the effective bonding between the resin cement and nonprecious metal alloys.[5]

The occlusal layer thickness for the tested zirconia crowns was approximately one-third of the dimensions of the crowns in the glass-ceramic groups. Nevertheless, the zirconia crowns showed the highest fracture resistance.

Conclusion

Unfortunately, the limitations of the experimental setting in this in vitro study do not allow conclusions for clinical practice to be drawn from the obtained results. Nevertheless, these initial findings support the conduction of clinical studies to verify that full-contour zirconia crowns may have clinical advantages concerning the reduction of dental hard tissue loss during abutment preparation.

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