Failure Load of Monolithic Lithium Disilicate Implant-Supported Single Crowns Bonded to Ti-base Abutments versus to Customized Ceramic Abutments after Fatigue

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Keywords
Ceramics; dental implants; fracture; implant supported dental prosthesis; lifetime; monolithic crowns; titanium bases.

Abstract
Purpose: This laboratory study analyzed the influence of retention mode (screw- vs cement retained) and fatigue application on the failure load of monolithic lithium-disilicate (LDS) implant-supported single crowns (ISSC).

Material and Methods: A total of 72 samples of monolithic LDS (*Ivoclar Vivadent) ISSC were divided into three groups (n = 24) according to their type of retention mode: Group Ti-CAD: Titanium base (SICvantage CAD/CAM Abutment red (SIC invent AG), screw-retained milled monolithic LDS (IPS e.max CAD*); Group Ti-P: Titanium base (SICvantage CAD/CAM Abutment red), screw-retained pressed monolithic LDS (IPS e.max Press*) and Group Ti-Cust: Titanium base with cemented press LDS (IPS e.max Press*) crown on a LDS (IPS e.max Press*) custom abutment. A mandibular first molar implant-supported single crown model was investigated (Titanium implant: SICvantage-max, SIC invent AG, diameter: 4.2 mm, length: 11.5 mm). Half of each group (n = 12) were exposed to fatigue with cyclic mechanical loading (F = 198 N, 1.2 million cycles) and simultaneous thermocycling (5-55°C). Single load to failure testing was performed, before (Subgroups Ti-CAD, Ti-P, and Ti-Cust) and after (Subgroups Ti-CAD-F, Ti-P-F, and Ti-Cust-F) fatigue. Weibull distribution was used to determine the characteristic strength and Weibull modulus differences between groups. Probability of survival at 900 N load was calculated.

Results: No samples failed during fatigue. Characteristic strength values were as follow: Ti-CAD: 3259.5N, Ti-CAD-F: 2926N, Ti-P: 2763N, Ti-P-F: 2841N, Ti-Cust: 2789N, Ti-Cust-F: 2194N. Whereas no difference was observed between pressed or milled monolithic crowns cemented to Ti-base, regardless of loading condition, fatigue decreased the characteristic strength of crowns cemented to custom abutments. Probability of survival at 900 N was not significantly different between groups.

Conclusions: Screw-retained pressed or milled monolithic LDS ISSC, cemented directly to Ti-base abutments or LDS crowns cemented to custom ceramic abutments resist physiological chewing forces after simulated 5-year aging in the artificial mouth and presented equally high probability of survival. However, a significant decrease in load to failure was observed in LDS crowns cemented to custom ceramic abutments after fatigue. Prospective clinical trials are needed to confirm the results of this laboratory investigation.
abutment crown are nowadays the most commonly used abutment solutions. Numerous studies have shown that two-piece ceramic abutments with a titanium interface resulted in higher stability and reduction of damage at the abutment-implant connection than one-piece ceramic abutments. Hybrid abutments combine the positive mechanical properties of a titanium substructure with the esthetic optical benefits of a ceramic abutment. Further advantages of hybrid abutments are diminished risks of screw loosening (conical geometry of the screw head – depending on manufacturer), a possible reduction of tensile stresses inside the ceramic abutment and CAD/CAM facilitated fabrication. However, a prosthetically driven implant placement to allow screw-retention is especially required in hybrid abutment crowns. Recent meta-analyses reported high prosthetic survival rates for all-ceramic ISSC of 93% to 97.6% after 5 years and 94.4% after 10 years of service. However, after 5 years, frequent technical complications, such as chipping incidences (9%), framework fractures (1.9%), screw loosening (3.6%), and debonding (1.1%) have been reported. To overcome the shortcomings of bi-layer systems monolithic CAD/CAM fabricated all-ceramic restorations evolved. In particular, lithium disilicate (LDS) ceramics appear to fulfill esthetic and mechanical demands for single-unit reconstructions on teeth and implants. Short-term evaluation of screw-retained LDS ISSC revealed survival rates of 100% after 1 year and 2 years of follow-up. Yet, robust clinical long-term data on monolithic LDS and other monolithic all-ceramic implant-supported reconstructions are still lacking.

In vitro studies with applied fatigue tests and accelerated aging protocols can predict lifetime estimations and potential sources of failure of all-ceramic restorations. So far, only a few studies tested cemented LDS ISSC in the molar region under laboratory conditions with fatigue application. However, a current trend toward screw-retention, especially for single-unit restorations can be observed, as these have fewer biological complications than cemented solutions and allow easier access in case of technical complications. When testing such scenarios, it is important to acknowledge that since it is the largest and most critical flaw, and not the average size flaw, that controls the lifetime of restorations, as well as the great variability in strength-controlling flaws within ceramic materials and adhesively bonded interfaces, it is common that load to failure data do not fit the Gaussian distribution. Thus, the Weibull distribution may be used for probability of survival calculation at a target load of clinical relevance, eventually delivering information also on the characteristic strength (which indicates the load at which 63.2% of the specimens of each group would fail) and on the Weibull modulus which reflects data scatter.

Taking the above-mentioned criteria into consideration, this in vitro study investigated the effect of retention mode on Ti-base abutments (screw-retained vs cemented) and fatigue application on the failure load of monolithic lithium disilicate implant-supported single crowns. The tested null hypotheses were that (i) type of retention mode (screw- vs cement retained) and (ii) fatigue application do not influence the fracture resistance of posterior LDS ISSC.

Material and methods

A total of 72 titanium implants (SICvantage max, SIC invent AG, Basel, Switzerland) with a diameter of 4.2 mm and a length of 11.5 mm in the endosseous part, with an internal conical connection, were divided into three groups (n = 24 specimens each) to receive monolithic LDS ISSC (Ivoclar Vivadent®, Schaan, Liechtenstein) according to their manufacturing process and type of retention mode:

- **Group Ti-CAD** – hybrid abutment crown: screw-retained, milled monolithic LDS crown (IPS e.max CAD Abutment Solutions*) bonded to a prefabricated titanium base (SICvantage CAD/CAM Abutment red, SIC invent AG, gingival height 1 mm, titanium base height 4.7 mm).
- **Group Ti-P** – hybrid abutment crown: screw-retained, pressed monolithic LDS crown (IPS e.max Press*) bonded to a prefabricated titanium base (SICvantage CAD/CAM Abutment red, SIC invent AG, gingival height 1 mm, titanium base height 4.7 mm).
- **Group Ti-Cust** – hybrid abutment with separate crown: LDS pressed crown (IPS e.max Press*) cemented on an individually designed LDS abutment (IPS e.max Press*) bonded to a prefabricated titanium base (SICvantage CAD/CAM Abutment red, SIC invent AG, gingival height 1 mm, titanium base height 4.7 mm).

All titanium implants were embedded in an autopolymerizing acrylic resin (Technovit 4000, Kulzer, Hanau, Germany) in a special specimen holder up to the first thread. The resin, with a modulus of elasticity of nearly 12 GPa, close to human bone (10-18 GPa), simulates the elastic reaction of the surrounding bone during loading.

The study design simulated the replacement of a mandibular molar. For standardization of all ISSC and simulation of a clinically realistic situation one implant was embedded in the position of a mandibular first molar in the prosthetically correct position for a screw-retained restoration in a master model (frasaco-Model, frasaco, Tettang, Germany). The master model was digitized (InEos X5, Dentsply Sirona, York) and a standardized molar crown was designed in a CAD/CAM software (InLab 15.1, Dentsply Sirona) (Fig. 1). All restorations used the identical crown design and were milled from either IPS e.max CAD Abutment solutions LT A2* (Group Ti-CAD) or ProArt Wax blue* (Group Ti-P and Ti-Cust) in a five-axis milling machine (InLab MC X5, Dentsply Sirona). ISSC of Group Ti-P used wax milling and were subsequently press-fabricated (IPS e.max Press LT A2*). Group Ti-Cust had its abutment and crown milled from a wax blank with a screw hole. Afterwards abutment and crown were separately pressed with IPS e.max Press. All implant crowns were finally finished with glaze firing (Ti-CAD: IPS e.max CAD Crystal/Glaze; Ti-P and Ti-Cust: IPS e.max Ceram Glaze). The same master dental technician produced all ISSC in a commercial dental laboratory. Monolithic restorations of Group Ti-CAD, Ti-P and the LDS abutment of Group Ti-Cust were adhesively bonded with a composite resin cement (Multilink Hybrid Abutment*) to the corresponding titanium base (SIC base) after pretreatment with...
4.9% hydrofluoric acid (IPS ceramic etching gel*) for 20 seconds followed by washing with water, cleaning in an ultrasonic bath and drying with oil-free air stream for 60 seconds, and application of a silane (Monobond Plus*, for 60 seconds). After steam cleaning, surface conditioning of titanium bases were as followed: sandblasting with 50 µm aluminum-oxide (2 bar pressure, 10 mm distance, until dull surface was achieved) and silanization (Monobond Plus*, 60 seconds). The hybrid abutment crowns of Group Ti-CAD and Ti-P and the hybrid abutment of Group Ti-Cust were tightened up to 20 N.cm using a torque control and retightened after 10 minutes to avoid screw loosening.28,29 The access channels were filled with Teflon tape (Kirchhoff GmbH, Wallenhorst, Germany) and sealed with composite resin (Tetric Evo Bulk Fill*). Surface treatment of the separate crown of Group Ti-Cust was performed accordingly and afterwards bonded with a self-adhesive luting agent (SpeedCEM Plus*) to the LDS abutment. After excess cement removal, a glycerin gel (Liquid Strip*) was applied and each side light cured for 20 seconds (Bluephase Style*). The dimensions of the hybrid abutment crown and the hybrid abutment with a separate crown are displayed in Figure 2.

Half of the specimens (n = 12) of each group (Ti-CAD-F, Ti-P-F, Ti-Cust-F) were exposed to cyclic mechanical loading and simultaneous thermocycling (5-55°C, dwell time 120s) in a chewing simulator (CS-4.8 professional line, SD Mechatronik, Feldkirchen-Westerham, Germany). An occlusal load of 198 N at 1.2 million chewing cycles with a frequency of 1.6 Hz was applied to the mesio-lingual cusp of the restoration, which corresponds to 5-year of clinical exposure.30,31 A horizontal movement of 0.5 mm (from the mesio-lingual cusp toward the central fossa) and a vertical movement of 2 mm for each chewing act was used. A 6 mm steatite ball (Hoechst CeramTec, Wunsiedel, Germany) was used as an antagonist indenter. The material and size of the antagonist were chosen, as

Figure 1 (A, B) CAD/CAM design of hybrid abutment crown (Group Ti-CAD and Ti-P). (C) CAD/CAM design of hybrid abutment with separate crown (Group Ti-Cust). (D) Ti-base and LDS crown (Group Ti-CAD and Ti-P). (E) Ti-base, hybrid abutment and separate LDS crown (Group Ti-Cust).

Figure 2  Schematic diagram and dimensions for (A) hybrid abutment crown (Group Ti-CAD, Ti-P) and (B) hybrid abutment with separate crown (Group Ti-Cust).
it has been shown that steatite is a suitable substitute material for enamel in wear tests\textsuperscript{32,33} and the size resembles a cusp of a molar.\textsuperscript{33} Specimens were checked twice a day for cracks and mobility of the prosthetic suprastructure.

All specimens were subjected to single load to fracture (SLF) in a universal testing machine (Zwick Z010/TN2S, Zwick Roell, Ulm, Germany) before and after fatigue. A steel ball with a diameter of 6 mm served as an indenter and was aligned at the same contact point as the dynamic loading with a crosshead speed of 1.5 mm/min. Chip-off fractures as wells as catastrophic bulk fractures were considered as failure.

Most representative fracture modes were subjected to qualitative fractographic analyses. Samples were first inspected in a polarized light microscope (AxioZoom V.16, Zeiss, Oberkochen, Germany). To improve depth of field, Z-stack imaging was used to capture different depths of the fracture plane along the surface by capturing several images (every 50 µm) and stitching the planes within the same image (ZEN software, Zeiss). Subsequently, samples were gold sputtered for evaluation at a scanning electron microscope (Vega 3, Tescan, Kohoutovice, Czech Republic).

The minimum sample size calculated to obtain a power of 80\% in a linear regression analysis, a 10\% error, and an effect size of 0.65 was 10 per group, thus 12 specimens were evaluated in the study to account for possible losses (G*Power 3.1, HHU University, Düsseldorf, Germany). The data analysis indicated a correlation coefficient (Rho - ρ), which measures how well the linear regression model (the probability line) fits the data, of 0.957, indicating an adequate model and sample size.

Data were statistically analyzed using a Weibull 2-parameter distribution (Weibull++ 9, Synthesis 9, Reliasoft, Tucson, AZ) (90\% CI) to determine the characteristic strength and Weibull modulus differences between groups. Differences between groups were also depicted in a contour plot. The probability of survival as a function of characteristic strength at 900 N, representative of maximum bite force at molars,\textsuperscript{35} was presented and also graphed.

### Results

All specimens of both monolithic hybrid abutment crown groups (Ti-CAD, Ti-P) and all samples of group hybrid abutment with separate crown (Ti-Cust) presented no failures after completion of fatigue application and thermal cycling. No cracks, fractures or mobility of the ceramic suprastructures or implant fractures could be detected resulting in a survival rate of 100\% after 5-year chewing simulation.

Characteristic strength values after static loading were as follows: Ti-CAD: 3259.5 N, Ti-CAD-F: 2926 N, Ti-P: 2763 N, Ti-P-F: 2841 N, Ti-Cust: 2789 N, Ti-Cust-F: 2194 N (values with confidence intervals are detailed in Table 1). The non-overlap between upper and lower confidence intervals indicated a significantly lower value only for Ti-Cust-F group. No significant differences were observed between the other groups, as shown in the table and depicted in the contour plot, also for Weibull modulus (Fig 3A). The probability of survival plot (Fig 3B) with a target load set at 900 N shows that a decrease in survival percentage only occurred at higher load levels. The probability of survival calculated at 900 N was 100\% for all groups (Table 2).

All test samples revealed catastrophic bulk fractures after SLF. Group Ti-CAD (Fig 4) and Ti-P (Fig 5) showed similar fracture patterns, both originating from the occlusal surface where the load was applied and propagating through the screw access channel. Telltale marks were observed in the fractured surface, such as hackle lines and arrest lines corroborating with the findings of direction of crack propagation from occlusal toward the fracture margins. In contrast, group Ti-Cust (Fig 6) most commonly presented fracture of the crown only, whereas the custom abutment remained in place. Similarly, fractographic marks including twist hackles were observed along with hackle lines eventually allowing the diagnosis of fracture origin and direction of crack propagation, similar to the other groups.

### Discussion

In this laboratory study different designs of monolithic LDS ISSC were tested under artificially aged and non-aged conditions. The null hypothesis was partially rejected as retention
mode (screw- vs cement retained) had a significant effect on the characteristic strength, whereas fatigue application only affected Group Ti-Cust.

Dynamic loading and artificial aging tests are a reliable method to provide essential information on limitations and lifetime predictions of ceramic restorations. Implant-supported restorations have to withstand bite forces of 100 to 300 N in the anterior and 200 to 900 N in the posterior region during chewing.

In this study, a load protocol of 198 N was applied, and all specimens did not fracture during thermomechanical fatigue which simulated 5-year aging. Potential reasons are that the fatigue loads were either below the stress intensity factor threshold \( K_{II} \), where cracks do not grow, or that an unknown number of additional cycles would be required to result in a fracture. The mean failure loads (>2000 N) of all tested groups, before and after fatigue, surpassed normal physiological bite forces. The results presented as probability of survival calculation allow therefore the conclusion that monolithic LDS shows a high reliability as a prosthetic material for screw-retained hybrid abutment crowns and hybrid abutment with cemented crowns. The applied fatigue protocol resulted in a significant reduction of failure loads only for Ti-Cust. The mechanical stability and resistance to fatigue is also largely determined by the complexity of the restoration. The hybrid abutment with a separate crown not only has two cement layers (with 4 interfaces, between Ti and custom abutment intaglio surface, and between LDS abutment external surface and crown intaglio surface), increasing the possibility of inclusion of cementation flaws that may act as stress raisers, but also a thinner layer thickness of the cemented crown compared to the full-contour monolithic Press or CAD design.

The present data are in line with other studies on screw-retained LDS CAD (IPS e.max CAD) and cemented LDS CAD (IPS e.max CAD) ISSC in the posterior dentition where no events and complications were observed. Other published in vitro studies compared the fracture resistance after thermomechanical loading of various CAD/CAM materials on molars. Investigated cemented ISSC were: feldspathic (VITA Mark II: 1130 ± 220 N), resin-matrix ceramic (Lava Ultimate: 2490 ± 510 N), LDS (IPS e.max CAD: 2645 ± 545 N) (45 N, 1.2 million cycles); resin-matrix ceramic (Lava Ultimate: 1755 ± 124 N) and LDS (IPS e.max CAD: 2804 ± 303 N) (250 N, 1 million cycles). For screw-retained ISSC fracture loads after 1.2 million chewing cycles with 50 N at 1.6 Hz and thermal cycling (5-55°C) of lithium silicate ceramic (Celtra Duo: 2302 ± 798 N), resin-matrix ceramic (Cerasmart: 977 ± 129 N), LDS (IPS e.max CAD: 3070 ± 376 N) and polymer-infiltrated ceramic network (Enamic: 1750 ± 277 N) were recorded. LDS crowns showed the highest fracture load in the above mentioned studies. The recorded fracture values for LDS CAD (IPS e.max CAD) are comparable with this study. Screw-retained LDS CAD (IPS e.max CAD) ISSC also revealed the highest fracture loads after chewing simulation (100 N, 1.2 million cycles) and aging (5-55°C) when compared to different configurations of bi-layer zirconia crowns. However, the values of the monolithic LDS CAD (1049.9 ± 145 N) were lower than the failure load values of this study (Ti-CAD-F: 2722 ± 497 N). The difference may be due to angulation of test specimens at 30° during loading, whereas in this study the test sample were axially loaded. Furthermore, the smaller diameter of the antagonist of 4 mm, compared to 6 mm in our study, is associated with a more concentrated force application and thus leading to a higher load on a smaller surface.

Clinical trials confirm these in vitro results and show promising survival rates of 100% for posterior monolithic screw-retained Press LDS ISSC after 1 year and CAD/CAM fabricated ISSC after 2 years of observation. No technical or biological complications could be observed. Nevertheless, an increase on the criterion surface roughness of 20.5% Bravo ratings after 12 months, limited to functional contact points and wear of the glaze, was detected.

Regarding the retention of ISSC recent systematic reviews could not detect a superior method over the other, since both options showed specific advantages and disadvantages. Easier access and retrievability, in case of screw loosening, screw fractures and repair or even exchange of the whole reconstruction are in favor of screw-retention. However, the occlusal access channel might compromise the fracture resistance of implant-supported restoration due to structural complications.
Figure 4  (A) Polarized light micrograph overview of a representative Ti-CAD fractured sample showing arrest lines (pointer) with their concave portion pointing toward the origin, i.e. indentation area (asterisk). (B) SEM backscattered magnification of indentation area (asterisk) shows a cone crack (delimited by solid arrows) extending until the Ti-base occlusal surface. C and D are magnifications of left and right respective cusps shown in A, where the dotted lines indicate the direction of crack propagation. E and F are left and right magnifications of margins shown in A, where hackle lines confirm the direction of crack propagation from occlusal toward the margins of the fractured surface.
Figure 5  Representative fracture of a Ti-P crown. (A) Polarized light micrograph taken in z-stack imaging mode that stitches several images along the z plane to obtain the fracture planes in the same depth of focus. (B) Backscattered SEM micrograph shows loaded area (asterisk) and right underneath the screw access channel with composite resin remnants. C and D are SEM left- and right-hand side magnifications of the cusps in A depicting the direction of crack propagation (dotted arrows). E and F are respective left- and right-hand side magnifications showing hackle lines (dotted arrows) which confirm the direction of crack propagation toward the margin of the fracture.
Figure 6  (A) Backscattered SEM overview of a Ti-Cust sample showing the indentation area (asterisk) and fracture that lead to crown fracture and custom abutment exposure. (B) With light polarization, a radial cone crack (black pointer) is observed from the cementation surface toward the occlusal area and also an inner cone crack (white pointer) likely originating from water pumping into the crack during fatigue. C and D are magnifications of the left and right cusp regions shown in A, showing twist hackle lines (solid arrows) and hackle lines (dotted arrows). The direction of crack propagation toward the margin of the fracture is shown in pictures E and F (dotted arrows).

Yet, a laboratory study could not find a significant influence of screw channels on fatigue behavior of monolithic LDS, zirconia or bi-layer zirconia crowns. This supports the result of our study where the highest numeric fracture loads could be observed for screw-retained ISSC of Group Ti-CAD. Occlusal access channels seem therefore not to be a vulnerability of ceramic ISSC and the occlusal discontinuity can be counteracted with monolithic ceramics, such as LDS. Different results were probably detected due to different study designs and set ups, as varying geometries and loading conditions influence stress distribution.

Monolithic screw-retained Ti-CAD and Ti-P specimens showed similar fracture patterns in our study. Polarized light microscope that allows multiple light incidences enabled the observation of cracks originating either from the indentation area by fatigue in water (inner cone crack) and also originating from the intaglio surface (radial crack). Subsequent SEM evaluation revealed several telltale fractographic marks such as arrest lines, hackle lines, twist hackles that suggested that, regardless of group, most fractures originated from the occlusal surface and propagated toward the margins of the fracture. Backscatter imaging was interesting to reveal surface discontinuity.
features in great detail such as cone crack not observed in light polarized microscope, some evident twist hackles and also the observation of composite resin remnant along the fractured screw access channel. Therefore, fractographic analyses benefited from the combination of different imaging techniques that eventually complemented each other.

No fractures or bending occurred at the titanium substructure. The complication of chipping is generally considered a rare risk in monolithic LDS restorations as these have a high crystal content and a homogeneous material thickness. In 45.8% of the specimens, part of the preparation margin also fractured cervically of the abutment.

A study that tested structural changes in ceramic implant-supported restorations under static and dynamic loading concluded that cemented restorations under static loading caused damage, particularly in cervical regions, which were not observed under dynamic loading. Under static load, one-piece screw-retained restorations exhibit significantly fewer cracks in the cervical region. A possible explanation for this phenomenon could be the wedge-shaped design of the abutment in the cemented version, so that chip-off fractures in this region are in favor.

A recent study observed similar fracture patterns to those described in this study. Compared to the hybrid abutment with cemented crown, monolithic hybrid abutment crowns not only fractured under higher loads, but more catastrophic bulk fractures occurred. Whereas for hybrid abutments with separate crown more than 50% of the abutments were still intact in half of the specimens and the crown fractured in 80% of the cases. Therefore, from a clinical point of view, more bulk fractures of the cemented crown are expected.

One limitation of this in vitro study is the missing control group of well-established porcelain fused to metal restorations and their direct comparison to LDS ISSC. Moreover, extended simulated service times of up to 10 to 20 years (up to 5 million chewing cycles) could potentially already lead to fatigue fractures during artificial loading. This assumption was confirmed clinically for monolithic LDS fixed dental prostheses in service of up to 15 years, where decreased survival rates were observed.

The above findings suggest that LDS hybrid abutments with a separate cemented crown comply with physiological masticatory forces, however occlusally screw-retained hybrid abutment crowns using both Press and CAD/CAM fabrication provide significantly higher fatigue load results. Furthermore, CAD/CAM facilitated fabrication of monolithic hybrid abutment crowns in a complete digital workflow appears to be a time and cost-efficient treatment option for posterior implants. With respect to the surrounding peri-implant soft tissues, zirconia materials seem to be in favor compared to LDS. However, post-processing in terms of polishing or glazing of LDS might affect its biocompatibility. Therefore, a combination of a subgingival zirconia material and a supragingival LDS restoration for screw-retained hybrid abutment crowns should be further elucidated.

Based on the research question, this study only evaluated different configurations of LDS on implants from a mechanical point of view. Further research should focus on the influence of different heights of titanium bases and the surrounding ceramic layer thickness on the fracture behavior and their impact on biological reactions. First evidence suggests a direct correlation of crestal bone stability and the height of the titanium base as well as the choice of restoration material. Clinical long-term trials are needed to assess besides further technical complications also biological impairments.

**Conclusion**

Screw-retained pressed or milled monolithic LDS ISSC, cemented directly to Ti-base abutments or LDS crowns cemented to custom ceramic abutments resist physiological chewing forces after simulated 5-year aging in the artificial mouth and presented equally high probability of survival. However, a significant decrease in load to failure was observed in LDS crowns cemented to custom ceramic abutments after fatigue. Clinical long-term studies are needed to corroborate the results of this in vitro investigation.

**Acknowledgments**

The authors would like to thank MDT Sonja Ganz, Reichel Zahntechnik, for her help and design of the all-ceramic LDS crowns. This study was supported by SIC invent AG, Basel, Switzerland and Ivoclar Vivadent, Schaan, Liechtenstein.

Open access funding enabled and organized by Projekt DEAL.

**Funding**

Dr. E.A. Bonfante gratefully acknowledges the FAPESP grant 2012/19078-7, CNPq grants #304589/2017-9 and 434487/2018-0, and CAPES Finance Code 001.

**Conflict of Interest**

The authors declare no conflict of interest.

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