A new class of computer-aided design/computer-assisted manufacture (CAD/CAM) materials called nanoceramic resins, indicated for single-tooth restorations, has been introduced to the dental market. The materials, developed with the aim of combining the mechanical and esthetic advantages of composite and ceramic materials,1 consist of a composite matrix embedded with different ceramic particles. In vitro studies have shown a higher resistance to fracture of nanoceramic resins compared to some glass-ceramics and a low antagonist wear due to their polymer phase.1–3 However, long-term clinical data are lacking.

The sealing ability of the luting system has a strong impact on the long-term success of a restoration.4,5 Studies investigating the sealing between CAD/CAM composites and their corresponding luting systems (ie, the luting systems provided by the block manufacturer for the respective CAD/CAM materials) showed that light curing of adhesive and dual-curing composite result in a significantly lower microleakage compared to solely chemical curing systems.4,5 In daily practice, many clinicians prefer to use only one luting system instead of the corresponding luting system for each material for practical reasons. However, the effect of noncorresponding material/luting systems on microleakage has not been yet investigated. Therefore, the aim of this in vitro study was to investigate whether the curing mode and the use of the corresponding or noncorresponding crown luting system have an impact on the microleakage of CAD/CAM composite crowns after chewing simulation.
MATERIALS AND METHODS

For the manufacturing of standardized test specimens (n = 40), one standard tessellation language (STL) dataset for the abutments (4.0-mm height, 9.5-mm mesio-distal width, 7.5-mm bucco-oral width, 6-degree convergence angle, 1.0-mm chamfer) and one for the crowns (1.5-mm occlusal layer thickness, 1.0-mm cervical thickness) were designed (Rhino 5 SR 12, McNeel Europe). The abutments were CAD/CAM-milled third molars, and the crowns were made of two different CAD/CAM composite blocks (LuxaCam Composite [LX], DMG [n = 20]; Lava Ultimate [LU], 3M ESPE [n = 20]).

Before adhesive cementation, the inner surfaces of the crowns were sandblasted with aluminum oxide powder (50 µm, Edelkorund, Hannisch+Rieth) at 2.0-bar pressure according to the manufacturer’s instructions. The test abutments were etched with 37% phosphoric acid (Etching Gel, DMG) for 15 seconds. Specimens were divided into four groups (n = 10):

1. LX crowns with LuxaBond Universal/PermaCem Universal (DMG)
2. LX crowns with Scotchbond Universal/RelyX Ultimate (3M ESPE)
3. LU crowns with LuxaBond Universal/PermaCem Universal
4. LU crowns with Scotchbond Universal/RelyX Ultimate

Each group was divided into two subgroups, in which half of the specimens (n = 5) were light cured (LC) and the other half (n = 5) were chemically cured (CC) (Fig 1). Before chewing simulation, all specimens were stored in distilled water at 37°C for 24 hours. Thereafter, cyclic loading (50 to 500 N) was applied in distilled water at 37 ± 2°C in a chewing simulator (prematec F1000, WL-tec) for 1 million cycles with a standardized stainless steel antagonist (R1, SD Mechatronik). Finally, a dye penetration test with 0.5% aqueous fuchsin solution (C.I. 42510, Carl Roth, batch no.: 276244301) was used to detect microleakage. For the measurement of the penetration depth, the specimens were sectioned mesiodistally in equidistant slices (IsoMet 1000, Buehler) and inspected under a digital microscope (Smartzoom 5, Zeiss). The percentage of microleakage was calculated for each specimen with microscopy analysis software (Smartzoom 5, version 1.1, Zeiss).

For statistical analyses, SPSS Statistics (version 24, IBM) was used. Because some test groups showed distribution differences, values of zero, and wide scattering, a nonparametric median test was performed. The level of statistical significance was set at $P < .05$.

RESULTS

All specimens survived chewing simulation. Regardless of the luting system and CAD/CAM block, the LC specimens showed a significantly lower microleakage compared to the CC specimens (Fig 1, $P < .05$). All CC groups exhibited a reduction of microleakage (significant only for LX, $P < .05$) if the corresponding luting system and block were used. Group 1 showed the lowest microleakage of the CC groups (mean ± standard deviation $1.57% ± 0.65%$), followed by group 2 (8.26% ± 6.49%), group 4 (11.42% ± 6.23%), and group 3 (29.28% ± 16.64%). Figure 2 shows an example of specimens with and without microleakage.

DISCUSSION

Because of the pilot nature of this study and the low number of specimens, the results must be interpreted with care. Nevertheless, CAD/CAM composites showed almost no microleakage if the LC mode was applied, which is in good agreement with the literature. A higher microleakage rate was found for the CC groups, which can be readily accounted for by a lower degree of conversion for the sole CC mode. Furthermore, the specimens with a corresponding luting system and block showed a significantly lower microleakage. This finding leads to the assumption that manufacturers optimized
their adhesive luting systems for their composite blocks. As loss of adhesion may result in secondary caries or inflammatory pulp irritation, the avoidance of microleakage is extremely important for the long-term success of restorations.\(^9\) Thus, it is advisable in daily practice—despite the extra effort—to use a CAD/CAM material with its corresponding luting system.

**CONCLUSIONS**

Within the limitations of this pilot study, the results support the use of a CAD/CAM composite with its corresponding luting system from the same manufacturer, especially if the CC mode has to be applied. Overall, the LC specimens showed significantly lower microleakage compared to CC specimens.

**ACKNOWLEDGMENTS**

The authors would like to thank the dental company DMG for donation of their materials. In addition, they gratefully acknowledge the support of their biostatistician, Dr Johannes Herrmann, for the statistical analyses. The authors reported no conflicts of interest related to this study.

**REFERENCES**


**Performance and Outcome of Zirconia Dental Implants in Clinical Studies: A meta-Analysis**

The purpose of this study was to evaluate implant survival, peri-implant marginal bone loss, technical and biologic complications, and esthetic outcomes of zirconia implants in clinical studies. Electronic (MEDLINE, EmBase) and hand searches were performed to identify clinical studies published between January 2004 and March 2017 investigating zirconia dental implants with a mean follow-up of at least 12 months. Primary outcomes were implant survival and peri-implant marginal bone loss. Secondary outcomes included technical and biologic complications, as well as esthetic outcomes. Meta-analyses were performed to estimate implant survival and marginal bone loss. From 943 titles, 264 abstracts were selected. Subsequently, 80 full-text articles were screened, and 18 studies were included for data extraction. One-piece (14 studies) and two-piece (4 studies) zirconia implants were investigated. Commercially available (CA) (510 implants, 398 patients) and not commercially available (NCA) (618 implants, 343 patients) zirconia implants were identified. For CA implants (follow-up: 12 to 61.20 months), technical complications (1.6%), implant fractures (0.2%), and biologic complications (4.2%) were reported. Meta-analyses estimated 1- and 2-year survival rates of 98.3% (95% confidence interval [CI] 97.0% to 99.6%) and 97.2% (95% CI 94.7% to 99.7%), respectively, and a mean 1-year marginal bone loss of 0.7 mm (95% CI 0.4 to 1.0 mm). Since 2004, the survival rates of CA implants have significantly improved compared to NCA implants. CA one-piece zirconia implants showed similar 1- and 2-year mean survival rates and marginal bone loss after 1 year compared to published data for titanium implants. However, more clinical long-term data are needed to confirm the presently evaluated promising short-term outcomes.